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RESEARCH ARTICLE

Innovative Technology for the Production of Gluten-free Food Products of a New Generation

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Abstract: ***Background*:** The global market for gluten-free food products is constantly growing. Consumers are increasingly choosing a gluten-free diet voluntarily or due to gluten intolerance (celiac disease).

***Objectives*:** The purpose of the research is scientific substantiation of the technology and recipe of gluten-free bakery products and determination of the optimal ratio of corn and rice flour in the production technology.

***Methods*:** The work used general scientific research methods, analysis of literary sources, analysis of patent and technical literature, and comparative analytical and laboratory analyses.

***Results*:** Research results have shown that replacing wheat flour with a high gluten content in the recipe for gluten-free, namely corn and rice flour, allows obtaining high quality indicators. On the basis of the conducted organoleptic tests, it was established that according to the results of the total indicators of the organoleptic evaluation, experimental sample 3, with a ratio of corn and rice flour of 80:20, has the same average score as the control sample. The analysis of physico-chemical quality indicators confirmed the organoleptic results of the research. It was established that the ratio of corn and rice flour is the most rational (experiment 3). An increase in the amount of rice flour leads to an increase in the porosity of gluten-free bakery products. Thus, in test sample 3 compared to test sample 1, the value of this indicator increased by 7%, which can be explained by a favorable nutrient environment for yeast cells due to additional water-soluble proteins and sugars present in rice flour, which is confirmed by previous studies. The acidity of gluten-free bakery products of experiment 3 also increased compared to the control sample by 0.5 degrees, which is explained by the positive effect of increasing the dosage of rice flour on the development of yeast cells in the dough. After characterizing the moisture content of the pulp after 48 hours of storage, it should be noted that increasing the amount of rice flour allows you to preserve more moisture in the finished product by an average of 1-2%. In our opinion, this is due to the fact that when rice flour is added, an additional amount of insoluble fibers is added, which by their structure have the ability to bind free moisture, which is retained by them more firmly, and when baking, a larger amount of moisture remains in the product of moisture, which is confirmed by previous studies of gluten-free raw materials. Therefore, test sample 3 with a ratio of corn and rice flour of 80:20 is recommended for the production of new-generation food products for certain groups of the population who choose a gluten-free diet by their own choice or due to gluten intolerance, namely celiac disease.

***Conclusion*:** The rational ratio of corn and rice flour was determined, taking into account the physicochemical properties and organoleptic indicators of the quality of finished gluten-free bakery products. It was established that the rational ratio of corn and rice is 80:20 - experiment 3. This proportion ensures proper physico-chemical indicators and high organoleptic indicators of finished gluten-free bakery products. It was established that the manufactured gluten-free bakery products exceed the control sample in terms of physico-chemical parameters, namely, porosity, acidity, dimensional stability, and moisture content of the crumb.

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1. INTRODUCTION

Today, the basis of treatment for people suffering from gluten intolerance is dietary nutrition, aimed at the complete exclusion from the diet of all gluten-containing products containing wheat, rye, barley, and oats, as well as hybrids of these cereals [1-4].

Today, the basis of treatment for patients with gluten intolerance is dietary nutrition, aimed at the complete exclusion from the diet of all gluten-containing products, namely wheat, rye, barley, oats and mixtures of these cereals.

It is known that the existing technologies of gluten-free production are based on the replacement of traditional flour containing gluten with flour that does not contain it, namely corn, buckwheat, rice, amaranth, *etc*.

The necessity and expediency of developing technologies and recipes for the production of gluten-free products is due to the increase in the number of allergic diseases caused by the intolerance of certain food compounds, in particular gluten. Gluten intolerance is often associated with conditions other than those with celiac disease and celiac disease.

The reason gluten consumption is at risk is because of the consumption of high-gluten wheat cultivated in the 20th century. Cereals with the highest gluten content are wheat, rye, barley and products containing them.

As a result of the analysis of the literature on the topic of this work, it was established that the development of the technology for the production of gluten-free bakery products is based on the replacement of gluten-containing flour with gluten-free flour. It is known that in addition to the use of gluten-free flour, functional ingredients are also added to enrich and increase the biological nutritional value during recipe development [5-19]. Functional ingredients include hydrocolloids of various origins, modified starch, and food fibers of vegetable origin, for example, flax meal. Flaxseed has been widely used in Europe since the Middle Ages as a food additive and is considered an important functional ingredient that is a source of alpha-linoleic acid, high-quality proteins, phenolic compounds, fiber and minerals [20-25]. Flax seeds are well known for their content of chemical compounds with specific biological activity and functional properties: polyunsaturated fatty acids (PUFAs) of the omega-3 family, soluble dietary fibers, lignans, proteins and carbohydrates. However, flaxseed contains several harmful compounds, such as cadmium, protease inhibitors, and cyanogenic compounds [18]. Of all lipids in flax seeds, 53% is α-linolenic acid (ALA), 17% linoleic acid (LA), 19% oleic acid, 3% stearic acid and 5% palmitic acid, which provides an excellent ratio of fatty acids [26-28].

Currently, there are known recipes and technologies for the development of various functional gluten-free products based on corn and rice flour. The main reason for using corn flour is that it contains all the necessary nutrients and vitamins, its chemical composition is close to wheat flour, and the taste of rice flour bread is very close to wheat [29].

Thus, in Bulgaria, a gluten-free recipe for bread, pancakes, muffins and cookies has been developed based on the use of rice flour, corn starch, pectin and dry milk [30]. The Kyiv National University of Food Technologies developed a technology for gluten-free bread based on corn and potato starch with the addition of 30% rice and 15% buckwheat flour [31].

Recipes for gluten-free cookies using sugar substitutes (isomalt and lactyl) were developed at Kyiv National University of Trade and Economics [32]. In Belarus, at the Scientific and Production University of Food Technologies, Unitehprom BRU and Beltechnohlib, gluten-free “Vita” series mixtures were developed for the production of bakery and confectionery products. These include gluten-free types of cereals - corn, buckwheat, rice, soy protein isolate, as well as corn, potato and wheat starches, the protein content of which is reduced, dry skimmed milk, thickeners - guar gum and xanthan gum. When choosing the ingredients of the mixtures, both the absence of gluten and the minimum protein content were taken into account [33].

Today, most of the recipes and technologies for gluten-free flour products developed in the world belong to the largest companies in America and Europe: Dr. Schaer, Aproten, Glutano farmo - Italy; Gullon – Spain; Bezglutenex, Balviten, Glutenex - Poland; Maddys - USA; Milupa, Hammermühle, camidaMed – Germany; Taranis - France; Beam, Bridge - Great Britain. All products have patents and “gluten-free” labeling on the packaging. But the main problem for the manufacturers of gluten-free products is the high cost, which is 2-2.5 times higher than the cost of similar traditional products [34].

Thus, the analysis of global and domestic technologies for the production of gluten-free bakery products allows us to draw a conclusion about certain shortcomings of existing technologies. It was noted that when corn and buckwheat flour are added, the specific amount of bread decreases, the porosity becomes denser, and the plasticity of the crumb decreases [35]. The flavor profiles of rice blend bread are very close to wheat bread. Bread from a rice mixture for baking has a pronounced taste of rice flour. The taste characteristics of corn and buckwheat bread differ from wheat bread. The taste and smell of corn and buckwheat flour is pronounced, the color is softer, and the color of the crust is more intense [36].

The production of gluten-free products, based on the replacement of traditional flour containing gluten with flour that does not contain it, will contribute to the production of a new generation of food products for certain groups of the population who voluntarily or due to gluten intolerance, namely celiac disease, choose a gluten-free diet. In addition, the implementation of the proposed technology will allow to expand the range of bakery products manufacturers, as well as to replace expensive imported gluten-free products with our own for dietary and preventive nutrition and will contribute to the expansion of the range of cafes, restaurants and other public catering establishments in connection with the development of the tourist business [37-41].

The purpose of the research is the scientific substantiation of the technology and recipe of gluten-free bakery products and the determination of the optimal ratio of corn and rice flour in the production technology.

To achieve the goal, the following tasks were set:

- determine the rational ratio of corn and rice flour;

- to investigate the physical and chemical indicators of gluten-free dough;

- to determine the organoleptic and physicochemical parameters of the finished gluten-free product.

2. MATERIALS AND METHODS

In the work, general scientific research methods were used, along with the analysis of literary sources, analysis of patent and technical literature, as well as statistical, comparative-analytical and laboratory analysis was carried out. Laboratory studies were carried out in the laboratory of food quality and safety control of the Department of Food Production Technology of the Kherson State Agrarian and Economic University.

Three experimental samples with different dosages of rice flour in relation to the weight of corn in the ratios 10%, 15%, and 20% were chosen as the object of the study.

- control - manufactured according to DSTU 7517:2014 «Bread from wheat flour. General technical conditions»;

– sample Nº 1 – 10% of rice flour in relation to the mass of corn;

– sample Nº 2 – 15% of rice flour in relation to the mass of corn;

− sample Nº 3 – 20% of rice flour in relation to the mass of corn.

The research hypothesis is the possibility of ensuring the high quality and high biological value of gluten-free products by determining the rational ratio of corn and rice flour in the production technology of gluten-free bakery products of the new generation.

For conducting research, wheat flour TM «Aris», manufactured according to DSTU 46.004-99 «Wheat flour», fine--ground corn flour TM «Skvyryanka» was selected, obtained from corn grain cleaned of gluten-containing impurities on a modern optical separator Sortex of the Swiss company «Buhler», recommended for feeding people with special needs and children, produced according to GOST 14176-69 «Flour corn Technical conditions», as well as rice flour TM «One Hundred Pouds» according to TU 15.6-00952737-006-2002. «Rice flour. Technical conditions», DSTU 4623:2006 «White sugar. Technical conditions», DSTU 4492:2017 «Sunflower oil. Technical conditions», DSTU 3583-2015 «DSTU 3583-97. Kitchen salt. General technical conditions», DSTU 4812:2007 «Pressed baker's yeast. Technical conditions», DSTU 7525:2014 «Drinking water. Requirements and methods of quality control» [37-39]. The research objects are marked with a crossed-out ear of wheat, which indicates that these products do not contain gluten and meet the international requirements of the AOECS standard.

The quality of bakery products was evaluated organoleptically, namely: taste and smell, color and appearance, shape, elasticity, porosity, freshness of the pulp and total weight of the product. Taste, smell, freshness, and crispness were determined by tasting. The color and porosity of the skin when pressing a finger on the cut and the total weight when weighing 100 g were evaluated. Physico-chemical properties were also determined: moisture, acidity, porosity, and swelling. The assessment is based on the average sample.

2.1. The Method of Determining Humidity

Samples weighing 200 g are cut across into two parts, in one piece 1-8 cm thick, the pulp is separated from the crust, at a distance of 1 cm, and the filling is removed. The weight of the sample should be at least 20 g. The sample is crushed with a knife, mixed and weighed in previously prepared, dried and tared metal cups with lids. Samples with the lids placed under the bottom are sent to the drying cabinet. They are dried in cabinets at a temperature of 130°C for 45 minutes. Time in drying cabinets at t=130°C should not exceed 20 minutes. When drying in cabinets of all brands, a deviation of no more than ±2°C is allowed at a constant temperature. After drying, the samples are removed, quickly closed with lids and transferred to desiccators for cooling. The time should not exceed 2 hours, but not less than 20 minutes. After cooling, the cups are removed and weighed [40].

2.2. The Method of Determining Acidity

Acidity is determined by the presence of lactic and acetic acids in the product, which contribute to the formation of fermentation processes in the dough and during its subsequent baking.

To determine the acidity, a 25-g sample is placed in a 500-ml conical flask, then 250 ml of distilled water at a temperature of 60°C is added. Approximately ¼ of the volume of water is poured into the measuring cup and rubbed well with a spatula until a homogeneous mass of the measuring cup is obtained. After some time, the obtained mass is poured with the remaining water, the flask is closed with a cork and shaken vigorously for 3 minutes. Then, the mixture is left to rest for 10 minutes. The layer formed during settling is carefully poured through cheesecloth into another flask. Take 50 ml of the solution from a beaker, add 2-3 drops of 1% alcoholic solution of phenolphthalein and titrate with a 0.1 N solution of caustic soda or caustic potash to a pale pink color that does not disappear in a calm state within a minute.

2.3. Porosity Determination Methodology

It is determined by the formula 1:

$$\mathrm{P} = \left(\frac{1-m}{pV}\right), \tag{1}$$

where m and V are the mass and volume of the recesses;

p - density.

Research is carried out on Zhuravlev's apparatus: first, the crust is cut, then the pulp is removed with the sharp cylindrical side of the device at a distance of at least 1 cm from the crust. The cylinder filled with pulp is placed in the tray so that the side fits tightly to the cut. The pulp is squeezed out of the cylinder by 1 cm with a wooden sleeve, and the uneven edges are cut with a knife. The pulp remains in the cylinder, which is squeezed out with a sleeve so that it touches the walls of the tray and cuts off the edge [41].

2.4. Determination of Specific Volume

The specific volume is determined for any small grain: millet, sorghum, rapeseed, *etc*. Grain must be sifted on metal sieves with round holes with a diameter of the upper sieve of 2.2 mm and the lower sieve of 1.2 mm.

The product is placed in a measuring cylinder and covered with millet until the product is completely covered with millet, the surface is leveled, and the volume value is recorded, after which the product is removed, the surface of the millet is leveled, and its volume is equalized. The volume of the product is found as the difference between the volume occupied by the product placed in the millet and the volume of the millet. The specific volume is determined by dividing the volume of bread in cubic centimeters by its mass [42].

2.5. Determination of Specific Diameter

Dimensionality is expressed as the ratio of the height to the diameter of the floor product. To do this, determine the diameter of the product [43]. The product is cut across the diameter into two equal parts, and the height is measured at the largest point of the cut. Dimensional stability is calculated according to formula 2:

$$X = \frac{H}{D} \quad \textbf{(2)}$$

where H is the highest height of the product, mm;

D - the average diameter of the product, mm.

The average diameter of the product is calculated according to formula 3:

$$X = \frac{D_{max} - D_{min}}{2} \quad \textbf{(3)}$$

where D_{max} is the largest diameter of the product, mm;

D_{min} is the smallest diameter of the product, mm.

2.6. Determination of the Lifting Force of Yeast by the Accelerated Method - the Floating of the Ball

To do this, weigh 0.31 g of pressed yeast and transfer it to a porcelain cup, add 4.8 cm^3 of a 2.5% salt solution heated to 35°C and mix until a homogeneous mass is obtained. Add 7 g of flour and knead the ball of dough. The ball is immersed in a glass of tap water with a temperature of 35°C and placed in a thermostat with the same temperature. Record the time it takes for the ball to float to the surface. The obtained data are multiplied by a correction factor of 3.5 [44].

3. RESULTS

Currently, scientists from many countries of the world are engaged in the development and improvement of technologies for the production of bakery products for various functional purposes. Among the domestic scientists, it should be noted: V.I. Drobot, A.M. Hryshchenko, V.V. Dorokhovych, O.V. Babich, V.I. Sabluk., N.V. Prytulska. Scientists abroad: H. Doman, Institute for the Development of Human Potential (USA), D. Perlmutter and others' work describe the effect of dietary nutrition on improving the condition of patients suffering from gluten intolerance [44-53].

Recently, in Europe and other countries of the world, there has been an increased interest in the introduction of innovative technologies for the production of food products for various functional purposes. Based on extensive global experience, we can conclude that the creation of innovative technologies of functional formulations is possible thanks to the use of our own, annually renewed plant raw materials and the use of scientific achievements of industry specialists.

With the appropriate preparation of raw materials at various stages of production based on theoretical and experimental research on the development of innovative formulations and technologies, it is possible to provide the market with gluten-free products of a new generation of functional purpose. However, there are certain technological and marketing obstacles to the industrial implementation of innovative recipes and technologies. There are no necessary production contacts between producers of agricultural raw materials and industrial enterprises to compete with well-known global manufacturers of products of various profiles. For this, it is necessary to consult with specialists and industry specialists who are engaged in the development and study of the biological and functional value of raw materials and know their properties [54-58].

To substantiate the recipe of gluten-free dough of various functional purposes, the chemical composition of various grain crops was studied, which, as is known, depends on the soil and climatic conditions of cultivation, the region, genetic characteristics and characteristics of the variety. The chemical composition of cereals is shown in Table **1**.

Table 1. Chemical composition of grain crops.

Grain crops	Proteins, g	Fats, g	Water, g
Oat	9.8	6.1	13.8
Millet	11.4	3.7	13.9
Barley	10.1	2.1	14.2
Sorghum	10.4	4.0	13.9
Corn	8.1	4.2	14.1
Spring wheat	11.4	2.0	14.1
Rice	7.4	2.6	14.0

Table 2. Carbohydrate content in grain crops, %.

Quality Indicator	Wheat	Corn	Buckwheat	Rice
Starch	52-55	57	63-64	55
Sugars	2-3	2,5-3	2	3
Cellulose	8-14	6-10	1-2	4-10
Together	60-70	67-70	67-68	63-64

Table 3. Biological value of cereal proteins.

Quality Indicator	Wheat	Corn	Barley	Millet	Rice
Protein, %	12.2	11.0	12.9	13.3	8.5
Lysine, g/16 g of nitrogen	2.4	2.9	3.0	2.9	3.8
Threonine, g/16 g of nitrogen	2.5	3.0	2.7	3.4	3.6
Protein digestibility, %	96.3	95.1	88.1	93.1	99.0
Biological value, %	55.4	61.3	70.0	60.1	74.1
Tannins in grain, %	0.4	0.5	0.8	0.7	0.1

Table 4. Main elements in various grain crops, mg/100 g.

Grain Culture	Na	K	Ca	Mg	P	Fe
Wheat	8	325	62	114	368	5.3
Rye	4	424	59	0	366	5.4
Buckwheat	4	325	70	258	334	8.3
Rice	30	314	40	116	328	2.1
Sorghum	28	246	99	127	298	4.4
Corn	27	340	34	104	301	3.7

Analyzing the Table **1**, it can be concluded that according to the chemical composition, gluten-free cereals, such as corn and rice, contain the largest amount of starch and have a high nutritional value compared to other cereals. Table **2** shows the carbohydrate content of various cereals.

Analyzing the data in Table **2**, it can be concluded that corn and wheat have the same carbohydrate content, which indicates that corn as a gluten-free grain crop is a valuable product and can be used in the food industry as the basis of functional recipes for the production of gluten-free food products of a new generation. Based on the content of starch, it can be concluded that most of it is in buckwheat, which is also characterized by a high content of carbohydrates.

Table **3** shows the biological value of grain crops. Analyzing the data in the table, it can be concluded that compared to other grain crops, corn has a fairly high biological value - 61.3%, which is explained by the high content of essential amino acids and the low content of tannins.

Along with other indicators, one of the most important is the content of vitamins since they are regulators of metabolic processes in the human body. Corn contains a large amount of vitamins, namely A and C, and vitamins of groups B and K. The content of pectins is quite high, which has a positive effect on the human body. Pectins contained in corn have a positive effect on digestion (Horach O.; 2022, a). The main content of mineral substances largely depends on the chemical composition of the soil. Table **4** shows the content of mineral substances in corn, rice and other grain crops [29, 59-63].

On the basis of theoretical and experimental research on the development of functional gluten-free dough, corn and rice flour was chosen, which, in terms of chemical composition, biological, and energy value, is not inferior to wheat flour, which is traditionally used in the food industry.

4. DISCUSSION

To determine the rational ratio of the use of corn and rice flour in the laboratory conditions of the Department of Food Production Technology of the Kherson State Agrarian and Economic University, preliminary studies of the effect of corn and rice flour on the baking properties of the dough were conducted (Horach O.; 2022, b).

The first stage was the study of flour strength, as it is one of the main properties that affects the quality of finished products. The technological properties of flour allow for predicting the behavior of the dough. Therefore, it is important to establish the main properties of gluten-free raw materials, which will allow for predicting the technological process of production. Table **1** shows the technological properties of various types of flour.

Table 5. Technological properties of different types of flour.

No.	Raw	Swelling temperature°C	Viscosity, conditional units	Water absorption capacity (WAC), %
1.	Rice flour	79±2	1040±2	3,5±0,2
2.	Cornflour	82±2	762±2	2,3±0,2
3.	Wheat flour	79±2	206±2	1,7±0,2

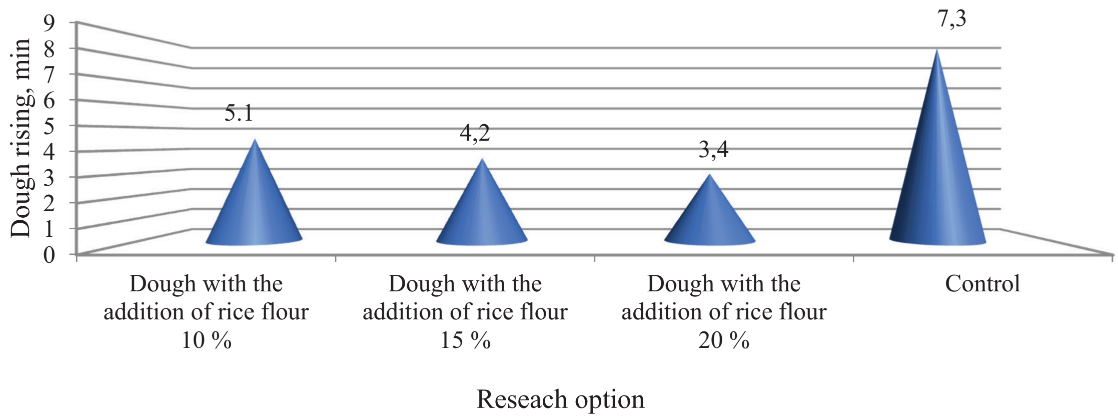

Fig. (1). Diagram of the lifting force of dough with different ratios of corn and rice flour.

Table **5** shows the results of research on determining the baking properties of flour.

Analyzing the data presented in the Table **5**, it can be concluded that the water absorption capacity (WAC) is the highest in rice flour and is 3.5%, which is twice as much as wheat flour and 1.2% more than corn flour. Viscosity and pasteurization temperature were determined using Brabender's amylograph of the investigated flour varieties. It was determined that the viscosity of gluten-free flour is higher than the viscosity of wheat paste. Thus, the viscosity of corn flour is 3.5 times higher, and rice flour is 5 times higher. The results of the study of the pasteurization temperature indicate that wheat and rice flour have the same pasteurization temperature; only corn flour has a higher value of this indicator by 3°C. Thus, the obtained results of experimental studies allow us to draw a conclusion about the comparability of water absorption capacity (WAC) of gluten-free flour with wheat flour, which makes it possible to predict the strengthening of the dough structure by gluten. In addition, cornmeal has a higher pasteurization temperature, so it will take longer to cook.

The next stage of research in the development of recipes for gluten-free bakery products was the study of the dough's ability to ferment using different proportions of gluten-free flour. It is known that the fermentation process is one of the most important processes that affects the quality indicators of bakery products. As a result, the products of the metabolism of yeast and lactic acid bacteria accumulate, namely alcohol, carbon dioxide, organic acids and other substances that form the structure, taste and aroma of bakery products. Due to the released carbon dioxide, the dough loosens. The fermentation process significantly affects the processes of swelling, peptization, dough rheology and enzymatic hydrolysis.

A method based on the rate at which a ball of dough rises was used to investigate the ability of the dough to ferment. The vital activity of yeast cells was determined by the accelerated method proposed by A.I. Ostrovsky [42]. For this purpose, in the laboratories of the Department of Food Production Technology of the KhDEU, the dough was kneaded with different ratios of corn and rice flour, respectively, according to the investigated model compositions: experiment Nº1 – 90:10; experiment Nº2 - 85:15; experiment Nº3 - 80:20, wheat flour was used as a control. The results of experimental studies are presented in Fig. (**1**).

On the basis of the conducted experimental studies, it was established (Fig. **1**) that the gluten-free dough with the addition of 20% corn and rice flour has the best lifting power (experiment 3). The time for the dough ball to rise was 3.4 minutes. The dough, with the addition of 10% corn and rice flour, has the lowest lifting force (experiment 1). The dough ball's lifting time was 5.1 min. Therefore, increasing the amount of rice flour has a positive effect on the rising power of the dough. This is attributed to the favorable nutrient environment for yeast cells due to the additional water--soluble proteins and sugars present in rice flour, which is confirmed by previous studies shown in Tables **2** and **3**.

The baking properties of flour can be characterized by bread quality indicators, so test laboratory pastries were baked, and the influence of different ratios of gluten-free flour of the studied samples on the quality of bread was investigated. In the recipe of gluten-free bakery products, to

Table 6. Results of organoleptic evaluation of the developed gluten-free product.

Sample	Taste, Smell	Shape	Color	Surface	Appearance	Average Score
	The Value of the Quality Indicator					
	0.3	0.1	0.2	0.2	0.2	
Sample with the addition of 10% rice flour	3.7	5.0	4.4	4.0	4.0	4.2
Sample with the addition of 15% rice flour	4.1	5.0	4.5	4.7	4.0	4.5
Sample with the addition of 20% rice flour	5.0	4.5	5.0	4.5	5.0	4.8
Control	4.0	5.0	5.0	5.0	5.0	4.8

replace gluten and enrich the dough with vegetable protein and nutrients, as well as to improve organoleptic, physico-chemical and structural-mechanical properties, egg melange was used, which is the safest and most reliable compared to other correctors, and is also available for use in the food industry.

All options were compared with the control option with a sample of dough made from premium wheat flour of TM «Aris». For this, the traditional method of production was used - the steamless method, organoleptic and physico-chemical indicators were evaluated.

When studying the organoleptic indicators of the finished dough, the calculation was carried out on a 5-point scale, evaluating taste, smell, color, shape, surface, and appearance.

The rating scale based on the obtained indirect data is distributed as follows: 5.0-4.5 – excellent; 4.4-3.7 – good; 3.6-2.6 – satisfactory; less than 2.6 is bad. Table **6** shows the results of the organoleptic evaluation of the developed gluten-free product.

Analyzing Table **6**, it can be concluded that the tested dough samples with different ratios of rice and corn flour had a good appearance and surface. As a result of the determination of organoleptic parameters, it was established that all dough samples have a pleasant taste in terms of taste properties. The sample with the addition of 20% rice flour had a richer, more harmonious taste, even more so than the control sample. The sample with the addition of 10% cornmeal had the taste and smell of cornmeal, and the third sample had a faint off-odor.

Table **7** presents the developed recipe for gluten-free dough functional purposes.

Table 7. A recipe for gluten-free dough functional purposes.

Nº	The Name of the Raw Material	Consumption of Raw Materials, Net, kg
1.	Cornflour	43.96
2.	Rice flour	10.99
3.	Pressed yeast	0.55
4.	Table salt	1.10
5.	Sugar-sandy	1.65
6.	Egg melange	5.49
7.	Sunflower oil	3.30
8.	Water	32.97
Together, %		100.00

When developing the technology for the production of gluten-free dough and bakery products, kneading was carried out on laboratory equipment. To analyze the consumer properties according to the innovative recipe, laboratory baking of the studied samples was carried out in the conditions of the Department of Food Production Technology of the Kherson State Agrarian and Economic University.

Semi-finished products were baked from a mixture of corn and rice flour using a steamless method. The dough mass was mixed according to a new recipe with a defined ratio of rice and corn flour.

The duration of fermentation was 220 minutes at a temperature of 30°C and a relative humidity of air in the thermostat of 75%. The dough was kneaded 110 minutes after the start of cooking.

After the end of the fermentation stage, the dough was divided into several products of the appropriate size and the process of forming the product blank was carried out. Formed semi-finished products from the dough were kept at a temperature of 35-40°C. The studied sample was baked in a laboratory oven at a temperature of 190-220°C for 40-50 minutes. Table **8** shows the technological process of preparing gluten-free dough and bakery products.

Table 8. Technological process of preparing gluten-free dough and bakery products.

Technological Process	Modes
Fermentation time, min	60
Temperature, °C	35-40
Washing the dough, min	3-5
Aging of semi-finished products at t=34-40 °C, min	35-40
Baking temperature,°C	190-220
Baking time, min	40-50

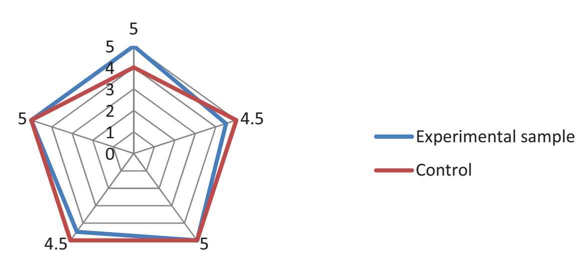

Fig. (2). Profile assessment of organoleptic indicators of gluten-free bakery products according to the developed recipe.

Fig. **2** shows the profile of the organoleptic quality indicators of the finished products according to the developed recipe using corn and rice flour in the amount of 20%. During experimental studies, the appearance, color, smell, and taste of gluten-free bakery products were compared.

After carrying out research on the determination of organoleptic indicators, the studied samples were examined according to physicochemical indicators. The results of the conducted research are presented in the Table **9**.

Table 9. Effect of rice flour on physical and chemical parameters

Qualitative indicators	Sample			
	control	10%	15%	20%
Specific volume, cm^3/100g	248	252	269	278
Ability to keep in shape	0.53	0.52	0.56	0.56
Porosity, %	69.00	69.00	74.00	76.00
Acidity, degrees	2.60	2.80	2.90	3.10
Moisture content of bread after 48 hours of storage, %	43.20	43.40	43.60	44.10

Analyzing the data Table **9**, we can conclude that in the studied samples, an increase in the amount of rice flour leads to an increase in the porosity of gluten-free bakery products. So, in the experimental sample with the addition of 10% rice flour, the value of this indicator was 69.00, and in the experimental sample with the addition of 20% -76.0, that is, it increased by 7%. In our opinion, this can be explained by the favorable nutritional environment for the yeast cells due to the additional water-soluble proteins and sugars present in the rice flour, which is confirmed by the previous studies shown in Table **2**. The acidity of gluten-free bakery products also increased from 2.8 degrees (experimental sample with 10% rice flour) to 3.1 degrees (experimental sample 3 with the addition of 20% rice flour), which is 0.5 degrees more than the control sample, which explains the positive effect of increasing the dosage of rice flour on the development of yeast cells in the dough. Characterizing the moisture content of bread after 48 hours of storage, it should be noted that an increase in the amount of rice flour allows you to preserve moisture in the finished product by an average of 1-2%. In our opinion, this is due to the fact that when rice flour is added, an additional amount of insoluble fibers is added, which, by their structure, have the ability to bind free moisture, which is retained by them more firmly. Thus, when baking, a larger amount of bound moisture remains in the product, which is confirmed by previous studies of gluten-free raw materials, which are listed in Table **1**.

Gluten-free bread retains more moisture than wheat bread, which is explained by the ability to retain moisture of the studied gluten-free raw materials. This affects the increase in water-holding capacity, and viscosity, which accordingly changes the consistency of gluten-free bakery products Table **5** [30, 63, 64].

A unique method of preparing the dough involves simultaneous mixing of all the ingredients according to the recipe. The technological scheme for the production of gluten-free bakery products allows you to obtain a product that has high--quality indicators according to organoleptic and physicochemical indicators [64, 65, 59, 66, 67].

It should be noted that corn flour is introduced together with rice flour at the same stage of production. Therefore, the technological process of production does not require additional changes and changes in production technology, and therefore additional material costs at the stage of production in production conditions [68-73].

CONCLUSION

Based on the research conducted on the development of innovative technology for the production of gluten-free food products for a new generation of people with gluten intolerance, it can be concluded that the presented technology differs from the traditional one, which is based on the preparation of the main and additional raw materials. The difference of the presented technology is that instead of gluten-containing raw materials, local raw materials are used, namely gluten-free corn and rice flour in a rational ratio of ingredients according to experimental sample 3, with a ratio of corn and rice flour of 80:20 according to the recipe (Table **7**) in compliance with all technological parameters and modes of the technological process to obtain high-quality products (Table **8**). According to the results of the total indicators of organoleptic assessment and physicochemical indicators of quality, it was established that the most rational is the ratio of corn and rice flour (experiment 3) (Figs. **1** and **2**, Tables **6** and **9**. An increase in the amount of rice flour by more than 20% negatively affects the quality of the obtained products according to organoleptic and physicochemical indicators. Therefore, the ratio of corn and rice flour in the amount of 80:20% is rational since an increase in the amount of rice flour by more than 20% has a negative effect on the quality of peeled products according to organoleptic and physicochemical indicators. On the basis of physicochemical properties, it was established that an increase in the amount of rice flour leads to an increase in the porosity of gluten-free bakery products. Thus, in experimental sample 3 compared to experimental sample 1, the value of this indicator increased by 7%, which can be explained by a favorable nutrient environment for yeast cells due to additional water-soluble proteins and sugars present in rice flour, which is confirmed by previous studies shown in Table **5**. The acidity of gluten-free bakery products of experiment 3 also increased compared to the control sample by 0.5 degrees, which is explained by the positive effect of increasing the dosage of rice flour on the development of yeast cells in the dough. Characterizing the moisture content of bread after 48 hours of storage, it should be noted that an increase in the amount of rice flour allows you to preserve more moisture in the finished product by an average of 1-2%. In our opinion, this is due to the fact that when rice flour is added, an additional amount of insoluble fibers is added, which, by their structure, have the ability to bind free moisture, which is retained by them more firmly. When baking, a larger amount of moisture remains in the moisture product, which is confirmed by previous studies of gluten-free raw materials, which are shown in Table **5**.

Therefore, taking into account the research results, the possibility and expediency of creating gluten-free products on the basis of a rational ratio of recipe components has been established. Further research will be aimed at enriching gluten-free bakery products with biologically active substances.

LIST OF ABBREVIATIONS

PUFAs	=	Polyunsaturated Fatty Acids
LA	=	Linoleic Acid

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest, financial or otherwise.

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