

## ТЕХНОЛОГИЯ ПРОДОВОЛЬСТВЕННЫХ ПРОДУКТОВ | TECHNOLOGY OF FOOD PRODUCTS

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### ОБОСНОВАНИЕ ОПТИМИЗИРОВАННОЙ РЕЦЕПТУРЫ И ТЕХНОЛОГИЧЕСКОЙ СХЕМЫ ПОЛУЧЕНИЯ БЕЗГЛЮТЕНОВОГО ХЛЕБА С СЕМЕНАМИ МАША И ЧИА

### SUBSTANTIATION OF OPTIMIZED FORMULA AND TECHNOLOGICAL SCHEME OF OBTAINING GLUTEN-FREE BREAD WITH SEEDS MUNG BEAN AND CHIA

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**Аннотация** В статье представлено обоснование новой оптимизированной рецептуры и технологической схемы производства безглютенового хлеба с добавлением семян **маша** и **chia**. Дана оценка показателей качества и безопасности нового безглютенового хлеба с семенами **маша** и **chia**, подтверждено его соответствие требованиям действующих регламентов и нормативов, показана перспективность создания рецептур безглютеновых хлебобулочных изделий повышенной пищевой ценности с добавлением нетрадиционного растительного сырья – семян **маша** и **chia**.

**Ключевые слова:** оптимизированная рецептура, технологическая схема производства, безглютеновый хлеб, семена **маша**, семена **chia**.

#### **Abstract**

The article presents the rationale for a new optimized recipe and technological scheme for the production of gluten-free bread with the addition of seeds mung bean and chia. An assessment of the quality and safety indicators of new gluten-free bread with seeds mung bean and chia is given, its compliance with the requirements of current regulations and standards is confirmed, and the prospects for creating recipes for gluten-free bakery products of increased nutritional value with the addition of non-traditional vegetable raw materials - seeds mung bean and chia are shown.

**Key words:** optimized recipe, production flow chart, gluten-free bread, mung bean seeds, chia seeds.

Undoubtedly, bread has long been one of the main products of daily and mass consumption by the population and the oldest product made by man [1]. The first version of the bread was a kind of baked gruel made from cereals and water, which could be the result of accidental preparation or deliberate experiments. It is believed that wheat bread made from yeast dough first appeared in ancient Egypt, which was due to favorable local conditions for the growth of wheat. For the first

types of bread, leavening of the dough was used as a way to loosen the dough, for which they used bacteria present in the air as an alternative to yeast, in this case the dough was only left for a while in the open air before baking. In those areas of the ancient world where wine was produced, a mixture of grape juice and wheat flour, which was allowed to ferment, or wheat bran soaked in wine, was used as a leaven for dough. The most common approach to leavening the dough seemed to be to leave a piece of dough from a previous dough preparation and use it the next day as a source of fermentation in the preparation of a new bread dough.

Since ancient times, the assortment of bread among different peoples has been formed and differentiated depending on the type of the main raw material component - cereal flour. So among the ancient Egyptians, Jews, Greeks and Romans, bread made from barley, which is still popular and widely used in southern Germany, Switzerland and Greece, was very common. Oatmeal bread is very common in Scotland and Sweden; from corn - in Hungary, Romania, North and South America, from rice - in India, South China and some other countries; from sorghum - in the countries of Africa and Asia. Durra bread is used in Egypt (durra, durro [Arabic durra - pearl] is a variety of sorghum cereal, cultivated mainly in Africa, Southeast Asia, the USA). In the modern culture of bread in all modern cultural countries, food products obtained exclusively from wheat and rye are known under bread, and during the 19th century in Western Europe, rye bread was replaced by wheat bread as the most easily digestible by the human body, while the use of rye bread is widespread manner in Russia.

Most grains, especially wheat, rye, and barley, contain gluten, a high molecular weight protein made up of glutenin and gliadin molecules that gives even texture and elasticity to bread dough. Gluten is a toxic substance, an allergen and causes the development of an immune - mediated disease of the small intestine - celiac disease in genetically susceptible people, and therefore represents a certain danger. Getting into the gastrointestinal tract as part of food, gluten breaks down into fractions, one of which, namely, gliadin, is perceived by the immune system as a foreign protein, and in response it produces immune complexes that damage the intestinal walls. Approximately every hundredth person suffers from this disease. In the modern world, gluten intolerance and celiac disease are quite high, especially in Europe [2]. The main symptoms of the disease are: diarrhea, weight loss and height, severe abdominal pain, anemia, irritability, as a comorbidity - cancer. The main treatment for this disease is aimed at eliminating all foods containing gluten from the diet. Foods that are sources of easily digestible proteins, fats and carbohydrates must be introduced into a gluten-free diet, since the role of a gluten-free diet can hardly be overestimated, because a properly composed diet prevents the recurrence of the disease and prevents the risk of serious complications [2].

As the practice of obtaining gluten-free products shows, non-traditional types of raw materials are used for their production, such as pseudo-cereal flour (amaranth, buckwheat, quinoa), from root crops and tubers (potato, sweet potato, etc.), fruits of shrubs and trees (chestnut, bird cherry, banana, carob), as well as starch in its natural form and its modified types [2].

The main difficulty in replacing traditional wheat flour with other raw materials is the need to form and mimic the viscoelastic properties imparted to the dough by gluten in wheat flour. Gluten creates the texture of wheat bread, provides the usual porous structure of the bread crumb.

The most common compounds used as structurants in gluten-free doughs are hydrocolloids, which by coating the starch granules delay the absorption of water and thereby improve the elastic and viscous properties of such dough. They also increase the specific volume, softness, slow down the staleness of bread and bakery products.

Gluten-free products tend to be low in vitamins and minerals. To enrich gluten-free bread, various additives of seeds and nuts are also often used, which are known to be sources of vegetable protein, polyunsaturated fatty acids, vitamins, macro- and microelements. For example, poppy and sesame are a source of calcium, turmeric - iron and copper, amaranth - iron and magnesium. In addition, it is known that seeds and nuts used to enrich bread contain a large amount of biologically active components, such as phenolic substances, essential oils, and fiber [3, 4].

**Research objects.** The main object of research is a new gluten-free bread with the addition of non-traditional vegetable raw materials - mung bean and chia seeds.

Mash (mung beans, golden beans) ( *lat. Vigna radiata* ) is an annual herbaceous plant; species of the genus *Vigna* of the legume family; leguminous crop originating from India. It is actively cultivated and used for food in China, Turkmenistan, Uzbekistan, Korea, Japan and countries of Southeast Asia. Mung bean seeds are eaten whole, shelled, sprouted, they extract starch from them and make noodles. There are many recipes for cooking: based on mung bean seeds: cereals, salads, soups. Mung beans are a good prophylactic that prevents diseases of the kidneys, heart and blood vessels, as well as respiratory and autoimmune diseases. Like all legumes, this is a fairly high-calorie product: 100 grams of mung bean seeds contain 323 kcal. The chemical composition of the seeds of this plant is represented by the content of 23.5 g of protein, 2.0 g of fat, 46.0 g of digestible carbohydrates, 11.5 g of dietary fiber; water is 14.2 g. The rest in the seeds of these legumes is occupied by minerals (K, Ca, Mg, Na, Ph, Fe) and vitamin compounds (a lot of vitamins C, E, PP and group B [3, 4].

According to the content of iron and a number of macronutrients, mung bean seeds are comparable to the meat of slaughtered animals. Mung bean seeds are a very useful product for the nutrition of athletes involved in various sports, especially power ones, due to their high protein content. Mung beans also contain a lot of magnesium, phosphorus, potassium - this is of great importance for the functioning of the brain, heart and nervous system [3, 4].

Chia (Spanish sage) ( *lat. Salvia hispanica* ) is an annual herbaceous plant belonging to the Lamiaceae family up to 1 m high. The leaves are opposite 4-8 cm long and 3-5 cm wide. The flowers are white or purple. The seeds are small oval, about 1 mm in diameter, brown, gray, black or white, mottled on the surface with a relief pattern (Fig. 1.).



**Figure 1. Appearance of chia seeds [11]**

Chia seeds have nutritional value due to their high content of dietary fiber and fat (Table 1).

The chemical composition of chia seeds is represented by the content of 16.5 g of protein, 30.7 g of fat, 42.1 g of carbohydrates, including 34.4 g of dietary fiber, of which insoluble dietary fiber is 85-93%, soluble dietary fiber is approximately 7-15%; water is 6.0 g, calorie content - 486 kcal. In terms of dietary fiber content, chia seeds are superior to dried fruits, cereals or nuts.

**Table 1. - Nutritional value of chia seeds [7].**

Name of nutrients	The nutritional value			
	US Department of Agriculture [ 7 ]		Jin et al. [ 8 ]	
Energy	486	kcal	562	kcal
Protein	16.5	g / 100 g	24.2	g / 100 g
total lipid	30.7	g / 100 g	40.2	g / 100 g
Ash	4.8	g / 100 g	4.77	g / 100 g
Carbohydrates	42.1	g / 100 g	26.9	g / 100 g
Alimentary fiber	34.4	g / 100 g	30.2	g / 100 g
Calcium	631.0	mg / 100 g	456	mg / 100 g
Iron	7.7	mg / 100 g	9.18	mg / 100 g
Magnesium	335.0	mg / 100 g	449	mg / 100 g
Phosphorus	860.0	mg / 100 g	919	mg / 100 g
Potassium	407.0	mg / 100 g	726	mg / 100 g

Sodium	16.0	mg / 100 g	0.26	mg / 100 g
Zinc	4.6	mg / 100 g	6.47	mg / 100 g
Copper	0.9	mg / 100 g	1.86	mg / 100 g
Manganese	2.7	mg / 100 g	3.79	mg / 100 g
Vitamin C	1.6	mg / 100 g		mg / 100 g
Thiamine	0.6	mg / 100 g		mg / 100 g
Riboflavin	0.2		n.d.*	
Niacin	8.8	mcg / 100 g		mcg / 100 g
Vitamin E	0.5			
Folic acid	49.0	mcg / 100 g	n.d.*	mcg / 100 g

(\* n.d. - not determined).

Chia seeds are characterized by a high content of polyunsaturated fatty acids, mainly  $\alpha$ -linolenic acid, which accounts for approximately 60% of all fatty acids. Linoleic, oleic, and palmitic acids are found in smaller amounts. Chia seeds contain more omega-3 acids than flaxseed. As part of the seeds, the optimal ratio of omega-6 and omega-3 is 0.3: 0.35 and has a cardiac, hepatic, hypotensive, anti-allergic and anti-diabetic role. Chia contains vitamins: A, C, E, B<sub>1</sub>, B<sub>2</sub>, PP, and in large quantities minerals - potassium, calcium, magnesium, phosphorus, selenium and zinc. Chia seeds have gained food popularity primarily as a source of vegetable calcium, since 100 g of seeds contain 631 mg of calcium, which is twice as much as in a glass of milk [ 9,10,11 ]. In addition, chia seeds contain many minerals: phosphorus (860-919 mg / 100 g), calcium (456-631 mg / 100 g), potassium (407-726 mg / 100 g) and magnesium (335-449 mg / 100 g). d) are contained in the largest amounts [ 9,10,11 ]. Studies have also confirmed the presence of some vitamins, mainly vitamin B1 (0.6mg/100g), vitamin B2 (0.2mg/100g) and niacin (8.8mg/100g) [9,10, 11 ].

Chia seeds are also a good source of vegetable protein, which accounts for approximately 18-24% of their mass [9,10,11 ]. Amino acid composition: 10 exogenous amino acids, among which the highest content was for arginine, leucine, phenylalanine, valine and lysine. Proteins in chia seeds are also rich in endogenous amino acids, mainly glutamic and aspartic acids, alanine , serine , and glycine [ 9,10,11 ]. Chia seeds do not contain gluten and therefore can be used to produce functional foods for people suffering from celiac disease [ 9,10,11 ]. Chia contains groups of phytochemicals characterized by high biological activity [ 9,10,11 ]. In particular, these are polyphenols: gallic, coffee, chlorogenic, cinnamic and ferulic acids, quercetin, kaempferol, epicatechin, rutin, apigenin and p- coumaric acid. Isoflavones, such as daidzein, glycitein, genistein, and genistin, are found in small amounts. Ciftci et al. showed the presence of campesterol (472 mg/kg lipid), stigmasterol (1248 mg/kg lipid),  $\beta$ - sitosterol (2057 mg/kg lipid), and 5-avenasterol [ 10,11 ]. Moreover, chia seeds have also been found to contain tocopherols:  $\alpha$ -tocopherol (8 mg/kg lipid),  $\gamma$ -tocopherol (422 mg/kg lipid) and  $\delta$ -tocopherol (15 mg/kg lipid).

Chia seeds have probiotic properties, being food and breeding ground for beneficial bacteria, improve the condition of the intestinal microflora of the human body. In 2005, the European Union recognized chia as a promising oilseed crop [3, 4]. Chia seeds are a very useful ingredient for baking whole grain bread. Due to the high fiber content, crushed seeds add volume to bread products due to the stabilization of porosity and original taste, reducing the glycemic index of the finished food product [3, 4].

When developing the recipe composition of gluten-free bread, a gluten-free mixture " Gluten -free universal flour " was used, produced according to RU TU 9195-012 - 89751414-11 . The composition of the gluten-free mixture: flour: rice, amaranth, linen; starch: tapioca, corn, potato; thickener - xanthan gum.

Jerusalem artichoke syrup brand " Royal " Forest ", produced according to TU 9185-003 - 56857055-05 , was used as a natural sugar substitute to form the taste and dietary properties of new gluten-free bread. Jerusalem artichoke syrup has a low glycemic index, improves metabolism, removes toxins from the body and strengthens the immune system, is a rich source of vitamins C, B1, B2, PP and trace elements Mg, K, Ca, it also contains 69.5% carbohydrates; energy value - 267 kcal. Ingredients of the syrup: Jerusalem artichoke tubers, citric acid, water.

**Research methods.** In the work, generally accepted standard and special, published in the literature, research methods were used [5].

**Results.** The main objective of the experimental phase of the study was to develop an optimized recipe and technological scheme for the production of gluten-free bread with the addition of mung bean and chia seeds, called " Dietfito ". To achieve this goal, trial bread baking was carried out in laboratory conditions, which was carried out in accordance with GOST 27669-88.

When developing the recipe for gluten-free bread dough " Dietphyto " was based on the basic recipe for bread made from wheat flour, in which wheat baking flour was replaced with a gluten-free mixture " Gluten -free all-purpose flour " and corn starch with the addition of dried mung bean and chia seed biomass, as well as for strengthening dietary orientation and improvement of the organoleptic characteristics of the new bread, Jerusalem artichoke syrup was introduced into the dough.

On the basis of trial baking, a recipe was drawn up and a technological scheme for obtaining gluten-free bread " Dietfito " was developed with the output of finished bread products - 200 g. The technological scheme for obtaining gluten-free bread " Dietfito " includes the stage of preparing raw materials, dosing and combining dry raw materials mung bean and chia seeds, salt) with Jerusalem artichoke syrup, yeast solution and water; this is followed by kneading and thorough mixing of the dough, then dividing the dough into dough pieces weighing 250 g. Next, the dough products are formed in the form of a brick and placed in molds greased with vegetable oil. Then the molds with dough pieces of products go through the stage of aging in a proofer for 45 minutes at a temperature of 35°C, baking is necessarily carried out with steam humidification for 45 minutes at a temperature of 180°C.

The conducted studies showed that with the addition of 18.75% mung bean seed powder, 12.5% chia seed powder, 25.00% dry corn starch and 12.5% Jerusalem artichoke syrup from the mass of the gluten-free mixture " Gluten -free all-purpose flour ", the obtained samples gluten-free bread had the best physicochemical (table 2) and organoleptic characteristics.

Table 2. - Physical and chemical parameters of the new gluten-free bread " Dietfito "

Name of indicator	Indicator value		
	GOST R 58233-2018 (National standard of the Russian Federation "Wheat flour bread")	Bread products " Dietphyto "	Control sample
Humidity, %	no more than 49	48.4	48.9
Acidity, deg.	no more than 7	6.9	7.0

The evaluation of the organoleptic characteristics of gluten-free bread " Dietfito " was carried out 16-18 hours after baking according to the following indicators: shape, surface condition, color, porosity, sectional view, smell, taste. The results of the organoleptic evaluation and evaluation of the physicochemical and safety indicators of the finished product were compared with the corresponding indicators of the control sample, which was taken as a sample of wheat bread prepared in the traditional way.

The palatability of the new bread was rated quite high on the whole. The tasters noted the attractive appearance of the new bread product, its pleasant taste. Color and texture were determined to be typical for this type of product, the experts indicated the absence of foreign odors.

Hygienic safety indicators of bakery products are regulated by TR TS 021/2011. Table 3 shows the values of individual safety indicators of the new gluten-free bread " Dietfito ".

Table 3. - Hygienic requirements for bread and bakery products

Indicators	Values	
	Permissible level, no more (TR CU 021/2011)	-free bread " Dietfito "
Toxic elements:		
- lead	0.35	0.00123
- arsenic	0.15	0.00144
- cadmium	0.07	0.00045
- mercury	0.015	0.00031
Mycotoxins :		
- aflatoxin B <sub>1</sub>	0.005	footprints

Pesticides:		
- hexachlorocyclohexane ( $\alpha$ -, $\beta$ -, $\gamma$ -isomers)	0.5	footprints
- DDT and its metabolites	0.02	-
- hexachlorobenzene	0.01	-
- organomercury pesticides	not allowed	-
- 2,4 D acid, its salts, esters	not allowed	not determined
Radionuclides:		
- cesium-137	40 Bq/kg	<11.70
- strontium-90	20 Bq/kg	<11.40

As follows from the data presented in tables 2 and 3, the physical and chemical indicators of the quality and safety of the new gluten-free bread " Dietfito " correspond to the standard values for this group of food products, and the tasting assessment confirmed the complementarity of its organoleptic indicators.

**Findings.** The assessment of the quality and safety indicators of the new gluten-free bread with mung bean and chia seeds confirmed its compliance with the requirements of the current regulations and standards and can serve as a justification for the prospects for improving the formulations of gluten-free bakery products of increased nutritional value with the addition of non-traditional vegetable raw materials - mung bean and chia seeds.

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