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Preparation and examination of the quality of gingerbread made with composite flour and sugar beet

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ABSTRACT

The production of confectionery products is one of the most in-demand industries. Due to this, various assortments of confectionery products and production technologies have expanded. Following modern requirements, the product's appearance, taste, aroma, and nutritional value should be appropriate. Accordingly, to create a new range of gingerbread products, chickpea and bean flour, and sugar beet powder as a sugar substitute were introduced into the recipe: 10%, 15%, and 20% of the wheat flour in the original recipe were replaced by chickpea flour and bean flour; also, 30 and 60 g of the 125 g of sugar in the recipe was replaced by beet powder. A fully factorial experimental design was created to perform the work. According to this plan, control and 8 research samples of gingerbread were cooked and prepared. Organoleptic and physicochemical analysis of these finished products was performed. Sample No. 6, the sample with 5% chickpea flour, 10% bean flour, and 30 g of sugar beet powder, had the best organoleptic indicators. It is evenly light golden in colour, smooth in shape, undamaged, and well cooked. The taste and smell are sweet and are not inferior to the control sample in all parameters. Moisture content, water absorption properties, ash, acidity, fat, vitamins, toxic elements, and microbiological indicators were determined from the physicochemical parameters. Analysing the research results, gingerbread product No. 6 was the optimal regimen, because it contained a high amount of mineral elements and vitamins, and no toxic elements or microbiological indicators were found. In addition, the density and water absorption were relatively close to the control sample.

Keywords: gingerbread, sugar beet, chickpeas, beans, organoleptic and physicochemical parameters

INTRODUCTION

Nowadays, mass nutrition is gradually turning towards industrialization. Modern companies with advanced technological tools and various factories and workshops are being created. They use advanced technologies, introduce scientific organization of work and production, and use new types of service.

The confectionery industry is an important branch of the food industry. Confectionery products are characterized by a high caloric content and quick absorption by the body. These properties are characteristic of confectionery products due to the use of sugar, caramel syrup, oils, milk and milk products, egg products, cocoa beans, fruits, and nuts, as well as flours from various grains **[1]**, **[2]**, **[3]**.

In general, confectionery production is divided into two main groups: sugar and flour confectionery production.

Confectionery products made of flour are of great importance in the people's diet. Their basis is flour, which contains many carbohydrates from starch and vegetable proteins.

Confectionery made from flour generally includes products made with flour, sugar, milk, butter, eggs, and yeast. These products contain proteins, fats, minerals, carbohydrates, and vitamins. These will not be the same in all products; it will vary depending on the type of flour used and the recipe used.

Confectionery made from flour makes up 40% of the total confectionery production **[4]**, **[5]**, **[6]**.

Their chemical composition influences the nutritional value of confectionery products made from flour. This determines the group of substances that form the main and additional raw materials used in their production. But not all substances that enter the body with food remain stable; not all of them are completely absorbed. Some substances change, some become less digestible. Therefore, energy, biological, physiological, and organoleptic values are considered in assessing overall nutritional value. On average, flour confectionery products contain 5% to 29% water, 3% to 10.6% protein, 3% to 74% carbohydrates, and 40% fat.

Nutritional value describes the completeness of the necessary parameters of the product and its taste benefits due to the various nutrients it contains. The higher the nutritional value, the more the product meets the body's physiological needs for these substances and ensures its normal functioning.

Confectionery products are characterized by high nutritional value because they are the main source of carbohydrates and fats in the human diet **[7]**, **[8]**, **[9]**, **[10]**.

The assortment of this group of products is constantly expanding and being updated; new types of products appear, which means that the industry has developed somewhat.

This work aims to use composite flour from chickpeas, beans, and sugar beet powder to increase the nutritional value of gingerbread products.

Adding chickpea flour makes it possible to expand the range of confectionery products made from flour and increase the nutritional value of the products. It contains 31.0% protein, 7.0% fat, and 5.2% fibre. Chickpea protein is close to animal proteins in its biological value, as it contains all essential amino acids. In addition to biologically valuable proteins, chickpeas contain elements such as potassium, phosphorus, manganese, selenium, and zinc **[11]**, **[12]**, **[13]**, **[14]**.

Beans contain a lot of vitamins of group B, especially vitamin B6, which affects the function of the immune and nervous systems and improves the skin. Beans are rich in starch, carbohydrates, and proteins. In addition, there are vitamins C, B1, B2, B6, PP, macro- and microelements (especially copper, zinc, and potassium), various acids, and carotene **[15]**, **[16]**, **[17]**.

Sugar beet powder was also used in the work. It is very rich in useful vitamins and minerals. Its energy value per 100 g is 40-45 kcal and it contains 1.5 g of protein, 0.1 g of fat, 8.8 g of carbohydrates, 2 g of fibre, 2.5 g of dietary fibre, and 1 g of ash. In beet growing, the dry matter contains sucrose. In addition, sugar beet contains vitamins A, C, E, PP, B1, B2, B3, B6, and B9.

Scientific hypothesis

Improving the quality and useful properties of gingerbread will depend on the raw materials used, and the mode and technology of preparation. The content of composite flour and dried sugar beets significantly impact the content of vitamins, minerals, and other beneficial properties of flour confectionery.

MATERIAL AND METHODOLOGY

Samples

The study used chickpea, bean flour, and dried sugar beets to make gingerbread from premium flour. Chickpea and bean flour were obtained from raw materials collected in the summer of 2022 from peasant farms of the Zhambyl region (Kazakhstan); sugar beet was obtained from the Koksu Sugar Plant LLP (Koksu village, Almaty region).

Chemicals

All reagents were of analytical grade and were purchased from Laborfarm (Kazakhstan) and Sigma Aldrich (USA).

Instruments

A Chizhov ELEKS-7M Tagler instrument (Sibagropribor, Russia), KVANT-Z-ETA atomic absorption spectrometer (Kortek, Russia), and Agilent 1100 HPLC (Agilent Technologies, USA) were used.

Laboratory Methods

The following indicators of raw materials and the resulting product were studied in the work:

- wettability according to GOST 15810-2014:, The standard applies to gingerbread products: gingerbread. The method is based on a change in the mass of a gingerbread product when immersed in water at a temperature of 20 °C for a certain time. Wetness is characterized by the ratio of the mass of gingerbread products after wetting to the mass of dry gingerbread products and is expressed as a percentage;

- humidity according to GOST 5900-2014: the standard applies to confectionery and semi-finished products and establishes methods for determining the mass fraction of moisture and solids. The essence of the method lies in drying the analyzed sample of the product at a certain temperature and calculating the weight loss in relation to the mass of the analyzed sample before drying. The method is intended for the following products: flour confectionery, muffins, semi-finished products for cakes and pastries, oriental sweets, rolls, halva, chocolate and chocolate icing, praline, marzipan, fondant, milk sweets, toffee, whipped products, products containing alcohol. The method is applicable in the measurement range of mass fractions of moisture from 0.5% to 50.0%.

- organoleptic indicators according to GOST 15810-2014. According to organoleptic indicators, gingerbread products must comply with Table 1.

Table 1 Organoleptic characteristics of gingerbread products.

Name of indicator	Characteristic
Taste and smell	Products with a pronounced sweet taste and aroma characteristic of this name of a gingerbread product, corresponding to the added flavoring additives, without foreign taste and smell.
Structure	Products with a soft, bonded structure that do not crumble when broken.
Color	From white-cream to dark brown with shades of varying intensity. The color of the crumb is uniform throughout the entire volume of the product. The surface may be darker than the crumb, the lower surface is darker than the upper. A darker color of the protruding reliefs of the imprint of a drawing or inscription is allowed. The general color tone of individual products must be the same in each packaging unit.
Split type	Baked products, with a uniform well-developed porosity, without voids, hardening and traces of non-mixing. In gingerbread with filling, the filling must be inside the product; the filling must not leak onto the product's surface. A slight compaction is allowed in places bordering on the filling. Gingerbread with filling consists of layers of semi-finished gingerbread interconnected by filling. The filling should not protrude beyond the edges of the gingerbread product.
Surface	Dry, without large cracks, swellings, or depressions, not burnt, without sagging. The presence of small cracks is allowed no more than 5% of the surface area. The imprint of a drawing or inscription must be clear, not blurry. Finishing of the top surface is allowed.
Form	Correct, varied, not blurry, without dents, with a convex upper surface (except gingerbread products that imprint a pattern or inscription on the surface). The bottom surface is flat. Cavities not more than 5 mm in diameter are allowed in the amount of not more than 10% of the lower surface area. The cut of the gingerbread should be even, without crumpled edges. The filling should not protrude beyond the edges of the gingerbread product.

- fat content according to GOST 5668-68: The method is based on extracting fat from a pre-hydrolyzed product sample with a solvent and determining the amount of fat by weighing after removing the solvent from a certain volume of the resulting solution.

- ash content according to GOST 5901-2014: the standard applies to confectionery and semi-finished confectionery products (after this referred to as the product) and establishes methods for determining the mass fraction of ash (total and insoluble in hydrochloric acid solution). The essence of the method lies in charring, ashing the analyzed sample of the product at a temperature of 500-600 °C and the subsequent determination of the mass fraction of total ash.

- alkalinity according to GOST 5898-87: the standard applies to confectionery and semi-finished products and establishes methods for determining titratable alkalinity. For degrees of titratable alkalinity, the number of cubic centimeters of a hydrochloric acid (sulfuric acid) solution with a concentration of 1 mol/dm^3 is taken to neutralize the alkaline substances contained in 100 g of the product.

- iron was determined according to GOSTGOST 26928-86: The standard applies to food products and establishes a colorimetric method for determining iron. The method is based on measuring the color intensity of a solution of a complex compound of ferrous iron with red orthophenanthroline.

- the phosphorus content was determined by GOST 30615-99: the standard applies to raw materials and food products and establishes a method for determining phosphorus. The method consists in dry mineralization of the sample, dissolution of ash, carrying out a color reaction with a molybdenum-vanadium reagent and measuring the

intensity of the yellow color of the solution l = (440 ±5) nm using a photoelectrocolorimeter or spectrophotometer. The presence of macro- and microelements does not interfere with the determination.

- the content of vitamin A was determined by GOST R 54635-2011: the standard applies to functional foods and establishes a method for determining the mass fraction of vitamin A in the form of retinol, retinol acetate, retinol palmitate using high-performance liquid chromatography (hereinafter – HPLC). The measurement range of the mass fraction of vitamin A is from 0.5 to 10.0 ppm;

- the vitamin E content was determined by GOST EN 12822-2014: the standard establishes a method for determining vitamin E in food products by high-performance liquid chromatography (HPLC). The determination of the content of vitamin E is carried out by α-, β-, γ- and δ-tocopherols. The activity of vitamin E can be calculated from the content of tocopherols by applying the appropriate coefficients;

- the content of vitamins B1 and B2 was determined according to Method M 04-41-2005 (Certificate of attestation of the measurement procedure No. 224.04.17.035/2006). This document establishes a methodology for measuring the mass fraction of water-soluble vitamins B1, B2, B3, Bs, C, B6, B5 in the form of nicotinamide and nicotinic acid and, depending on the composition of the analyzed sample and the requirements for measurement accuracy, the latter can be analyzed by two methods of capillary electrophoresis – zone (CEZ) and micellar electrokinetic chromatography (MECH).

Other standard conventional chemicals and organoleptic methods were used to study raw materials and finished products.

Description of the Experiment

The study was conducted following the state standard requirements used in producing gingerbread products. A recipe for the preparation of gingerbread products was created. According to this recipe, 8 samples were obtained by replacing 10%, 15%, and 20% of the wheat flour with chickpea and bean flour, and sugar beet powder was added as a sugar substitute (Tables 2-4).

Table 2 Product formulation of a control sample of gingerbread.

Raw material	Amount of raw material used for the production of 500 g
Flour, g	208
Egg, whole	1
Milk, ml	125
Sugar, g	125
Vegetable oil, ml	25

Table 3 Experimental design parameters.

	x_1- chickpea flour, %	x_2- bean flour, %	x_3- sugar beet, g
Max	10	10	60
Medium	7.5	7.5	45
Min	5	5	30

Table 4 Experimental design draft.

Sample	x_1- chickpea flour, %	x_2- bean flour, %	x_3- sugar beet, g
1	10	10	60
2	5	10	60
3	10	5	60
4	5	5	60
5	10	10	30
6	5	10	30
7	10	5	30
8	5	5	30

Number of samples analysed: 9 samples were analysed.
Number of repeated analyses: All tests were performed in triplicate.
Number of experiment replication: Replications were conducted twice.
Design of the experiment: Samples from the finished product were determined using generally accepted analytical methods. During the research, methods were used to describe the organoleptic characteristics of the studied objects, their chemical composition, and nutritional and energy value.

Statistical Analysis

The data obtained during the experiments were processed using the one-way analysis of variance ANOVA to analyze the data and determine if there were significant differences between samples. The data collected during the study were subjected to independent testing. The analysis used absolute and relative statistical indicators and tabular and graphical methods to present the results. Values were estimated using mean and standard deviations.

RESULTS AND DISCUSSION

The quality of flour confectionery products is evaluated according to the following indicators: appearance (color, shape, finish, surface condition), fracture appearance and structure, taste and smell. When evaluating the appearance by examining the products, the correctness of the shape, the presence of deformed products, fractures, tears, bubbles, cracks, shells, burnt products are noted **[18]**, **[19]**.

Evaluating the product in terms of "kind of fracture and structure", they pay attention to the baked goods, the uniformity of the pores, the presence of voids, non-mixing, hardening. Assessing the taste and smell of products, the presence of unpleasant or unusual odors and tastes, as well as a crunch on the teeth due to the presence of mineral impurities, is established **[20]**, **[21]**.

To give preventive, functional properties to gingerbread, it is a promising direction to introduce flour from leguminous crops into the gingerbread recipe, which will enrich products with biologically active substances **[22]**, **[23]**, **[24]**.

Along with the control sample, 8 samples were analysed for organoleptic indicators, physicochemical properties, and microbiological indicators (Tables 5-10 and Figures 1-9).

Table 5 Organoleptic indicators according to research results.

Sample	Taste and smell	Structure	Colour	Split type	Surface	Form
Control sample	According to the ingredients added to the composition, it has a sweet taste and smell, without foreign odours and flavours.	According to the soft standard, which does not scatter when divided.	The surface layer is bright yellow, and a soft cream.	The product is porous, soft; ingredients are completely mixed.	Dry, without cracks, not burnt.	The given form is preserved.
1	The taste and smell of beans are clearly detectable.	The structure is correct; it does not scatter.	Light yellow, soft yellow.	Porous, soft, standard.	Dry, without cracks.	The format is preserved.
2	The taste and smell of beans are clearly detectable.	Stronger than other models.	Light yellow, not burnt.	Porosity is lower.	Dry, without cracks.	The format is preserved.
3	There is a strange smell.	Has a non-scattering structure, conforming to the standard.	Light yellow, soft cream.	The product is porous, soft and, suitable.	Dry, without cracks.	The format is preserved.
4	The taste of beet sugar can be clearly felt. Slightly acidic.	The structure is non-sprinkling and soft.	Light yellow, soft cream.	Porous, compliant.	Dry, without cracks.	The format is preserved.
5	It has a unique smell and taste.	The structure is solid.	Light yellow, soft cream.	Porosity is low.	Dry, without cracks.	The format is preserved.
6	According to the state standard, it has its own characteristic smell and taste.	Non-scattering, soft, conforming to requirements.	The surface layer is bright yellow, and a soft cream.	The product is porous, soft, and the ingredients are completely mixed.	Dry, without cracks, not burnt.	The format is preserved.
7	It has a taste and smell according to its ingredients.	It has an unbreakable structure.	Light yellow, suitable.	Porous, soft.	Dry, with cracks.	The format is preserved.
8	It has a unique smell and taste.	It has an unbreakable structure.	Light yellow.	Porous, soft.	Dry, with cracks.	The format is preserved.

Figure 1 Gingerbread product prepared according to the control sample.

The results of the control sample were under the requirement.

Figure 2 Gingerbread sample No. 1 (10% chickpea flour, 10% bean flour, 60 g of sugar beet).

The smell and taste of beans were evident in sample No. 1, made with 10% chickpea flour, 10% bean flour, and 60 g of sugar beet.

Figure 3 Gingerbread sample No. 2 (5% chickpea flour, 10% bean flour, 60 g of sugar beet).

The taste and smell of beans were also evident in sample No. 2, made with 5% chickpea flour, 10% bean flour, and 60 g of sugar beet.

Figure 4 Gingerbread sample No. 3 (10% chickpea flour, 5% bean flour, 60 g of sugar beet).

In sample No. 3, made with 10% chickpea flour, 5% bean flour, and 60 g of sugar beet, a foreign smell was detected, apart from the added ingredients.

Figure 5 Gingerbread sample No. 4 (5% chickpea flour, 5% bean flour, 60 g of sugar beet).

In sample No. 4, made with 5% chickpea flour, 5% bean flour, and 60 g of sugar beet, a clear taste and smell of sugar beet was observed, and it turned out to be slightly acidic.

Figure 6 Gingerbread sample No. 5 (10% chickpea flour, 10% bean flour, 30 g of sugar beet).

In sample No. 5, made with 10% chickpea flour, 10% bean flour, and 30 g of sugar beet, no porosity was observed when dividing the product compared to other samples.

Figure 7 Gingerbread sample No. 6 (5% chickpea flour, 10% bean flour, 30 g of sugar beet).

Sample No. 6, the sample with 5% chickpea flour, 10% bean flour, and 30 g of sugar beet, had the best organoleptic indicators. The sample was uniformly light in colour, smooth in shape, undamaged, and well-cooked. The taste and smell were sweet. No indicators were inferior to those of the control sample.

Figure 8 Gingerbread sample No. 7 (10% chickpea flour, 5% bean flour, 30 g of sugar beet).

Sample No. 7, made with 10% chickpea flour, 5% bean flour, and 30 g of sugar beet, had crusts and cracks.

Figure 9 Gingerbread sample No. 8 (5% chickpea flour, 5% bean flour, 30 g of sugar beet).

In sample No. 8, made with 5% chickpea flour, 5% bean flour, and 30 g of sugar beet, the shape was preserved, and the surface was dry.

According to the organoleptic indicators of the gingerbread products, it was decided that product No. 6 is the optimal mode.

For flour from legumes, a characteristic disadvantage is the smell and taste of legumes, which constrains the norms of its introduction when enriching food systems, since at a specific dosage, the organoleptic characteristics of products obtained with the addition of flour from legumes decrease **[25]**, **[26]**. The introduction of chickpea and bean flour into the gingerbread recipe is justified by its nutritional properties and high biological value, it is an easily digestible product that is balanced in terms of the composition of proteins, carbohydrates and fats and is also rich in fiber. It is known from the scientific literature that chickpea and bean flour is a valuable biological product that contains vitamins (β-carotene, A, B1, B2, PP) and mineral elements (calcium, magnesium, sodium, potassium, phosphorus, iron) **[27]**, **[28]**.

Flour confectionery differs from sugar confectionery in that their recipe includes flour. These products have a high-calorie content and digestibility, have a pleasant taste and attractive appearance. The high nutritional value of flour confectionery products is due to the significant content of carbohydrates, fats, proteins. Due to the low humidity, most products are valuable food product with a long shelf life. All flour confectionery products are characterized by high nutritional and energy value **[29]**, **[30]**. The low humidity of these products allows them to be stored for a long time **[31]**, **[32]**.

Gingerbread products were analysed according to physicochemical and microbiological indicators; the results are shown in Tables 6-10.

Table 6 Physico-chemical indicators of gingerbread products.

Sample	Indicators								
	Humidity, %	**Fat, %**	**Protein, %**	**Carbohydrate, %**	**Ash, %**	**Gluten, %**	**Density, g/cm^3**	**Alkalinity, degree**	**Water absorbency, %**
Control	11.18	9.99	6.43	60.45	0.89	2.77	0.54	1.83	222
1	8.91	14.22	9.09	57.74	0.95	4.42	0.54	2.22	194
2	9.55	12.93	9.03	55.78	0.75	5.51	0.64	0.80	169
3	11.71	15.62	8.44	66.43	1.26	4.46	0.65	1.59	166
4	7.52	11.45	8.20	55.42	0.79	3.31	0.57	1.60	165
5	8.17	13.55	8.49	53.27	1.19	3.88	0.58	2.08	210
6	9.12	13.02	8.95	58.46	0.76	3.96	0.48	1.07	209
7	9.36	12.53	9.84	60.03	1.05	4.12	0.56	1.72	190
8	8.27	12.15	8.08	52.79	1.12	3.38	0.48	2.0	182

As shown in Table 6, the moisture content of the control sample was 11.18%. Samples No. 1, No. 2, No. 3, No. 4, No. 5, No. 6, No. 7, and No. 8 with chickpea and bean flour and sugar beet powder showed a decrease in moisture content compared to the control sample. The content of carbohydrates ranged from 52.79 to 66.43%. The sweet components that make up the chemical composition of gingerbread lead to the release of happiness hormones into the blood, from which, after a sweet snack, the mood rises sharply **[33]**, **[34]**.

The benefit of flour confectionery products lies in the high content of carbohydrates in the composition of products, which give the human body the necessary energy boost for normal life **[35]**, **[36]**. Due to the special consumer properties of confectionery products, storing certain flour products for quite a long time is possible. In addition, due to their easy digestibility, some sweets and confectionery products are used in sports nutrition **[37]**, **[38]**.

Since the amount of protein in chickpea flour and bean flour is higher than in wheat flour, gingerbread products made with these additives also have a higher protein content.

Sample No. 6 was found to be standard according to physical and chemical indicators.

The study determined the potassium, calcium, iron, and phosphorus content of the control gingerbread products and those made with a mixture of chickpea and bean flour and sugar beet flour.

According to the research results in Table 7, the amount of potassium in samples No. 1, No. 2, No. 4, No. 5, No. 6, No. 7, and No. 8 with the addition of chickpea and bean flour and sugar beet powder was 2% higher than that in the control sample. The potassium content in sample No. 3 increased by 3% compared to the control.

The amount of calcium in the control sample was 20.17 mg, but it increased in the samples with chickpea and bean flour and sugar beet powder. Only the amount of calcium in sample No. 4 was lower than that in the control sample, i.e. 18.59 mg.

The iron content was 1.03 mg in the control sample, increasing only slightly in the samples with chickpea and bean flour and sugar beet powder.

The phosphorus in the control sample was 80.59 mg, increasing several times with chickpea, bean flour, and sugar beet powder.

Table 7 Mineral elements in gingerbread products.

Sample	Indicators, mg/100 g			
	Potassium	**Calcium**	**Iron**	**Phosphorus**
Control	122.24	20.17	1.03	80.59
1	284.79	43.27	2.12	170.11
2	280.11	35.64	1.88	176.07
3	346.52	31.22	1.81	149.16
4	202.35	18.59	1.73	138.24
5	262.59	39.41	1.95	149.09
6	235.09	35.51	2.36	152.94
7	232.59	25.02	1.98	167.81
8	247.77	35.66	1.72	141.19

Table 8 Vitamins contained in gingerbread products.

Sample	Indicators, mg/100 g				
	A	**E**	**B_1**	**B_2**	**PP**
Control	0.009	2.21	0.145	0.047	2.633
1	0.008	2.37	0.218	0.084	3.581
2	0.007	2.44	0.254	0.052	3.243
3	0.013	2.21	0.235	0.079	3.611
4	0.009	2.39	0.174	0.063	3.128
5	0.012	2.47	0.222	0.078	2.951
6	0.015	2.38	0.281	0.094	3.942
7	0.010	2.33	0.288	0.091	3.884
8	0.009	2.27	0.255	0.082	3.219

As we can see from Table 8, samples with chickpea and bean flour and sugar beet powder contained more vitamins than the control sample.

Such vitamins increase immunity, maintain normal metabolism, stimulate brain activity and strengthen the entire nervous system. Even after baking, some vitamins remain in the products and enter the body. The action of mineral elements is closely intertwined with the action of vitamins, strengthening blood vessels, stimulating blood formation and supporting the musculoskeletal system **[39]**, **[40]**.

Considering the chemical composition, high biological value, and composition of vitamins, we can conclude that the use of chickpea, bean flour and sugar beet is promising in producing gingerbread to give them a functional orientation.

No less important are such hygienic requirements for the quality of confectionery products, as indicators of their safety. The packaging must contain data on testing for toxic elements, radionuclides, pesticides and microbiological indicators (food infections, molds, yeasts). The microbiological quality of confectionery products determines the degree of their safety for humans and the exclusion of the risk of poisoning and disease after consumption. In addition to safety for humans, microbiological indicators determine the degree of freshness and shelf life and the correct storage of confectionery **[41]**, **[42]**.

Table 9 shows the content of toxic elements, Table 10 shows the microbiological parameters of gingerbread.

From the data in Table 9 it can be seen that cadmium was not detected in all samples. Lead was also found in samples No. 1, No. 3 and No. 7, in a small amount and does not exceed the norm, complies with the standards of the Technical Regulations of the Customs Union TR CU 021/2011 - On food safety products (as amended on July 14, 2021 No lead was found in the rest of the samples.

Table 9 Toxic elements in gingerbread products.

Sample	Indicators, mg/kg	
	Cadmium	**Lead**
Control	Not found	Not found
1	Not found	0.0006
2	Not found	Not found
3	Not found	0.0009
4	Not found	Not found
5	Not found	Not found
6	Not found	Not found
7	Not found	0.0002
8	Not found	Not found

Table 10 Microbiological indicators in gingerbread products.

Sample	Indicators, CFU/g			
	QMAFAnM	***E. coli* in 1.0 g of product**	**Yeast**	**Mould**
Control	8×10^3	Not found	Not found	Not found
1	18×10^3	Not found	4	6
2	2×10^3	Not found	10	4
3	12×10^3	Not found	8	13
4	4×10^3	Not found	Not found	Not found
5	Not found	Not found	Not found	Not found
6	Not found	Not found	Not found	Not found
7	Not found	Not found	2	2
8	5×10^3	Not found	3	Not found

From the data of Table 10, mesophilic aerobic and facultative anaerobic microorganisms were found in the control sample, also in samples No. 1, No. 2, No. 3, No. 4 and No. 8. Yeast was found in samples No. 1, No. 2, No. 3, No. 7 and No. 8, moulds were also found in samples No. 1, No. 2, No. 3 and No. 7. All these data do not exceed the established norm of the Technical Regulations of the Customs Union TR TS 021/2011 – On food safety (as amended on July 14, 2021). The Quantity of Mesophilic Aerobic and Facultative Anaerobic Microorganisms (QMAFAnM), Escherichia coli (E. coli), yeasts and molds were not detected in the remaining samples.

Analysing the data in Tables 6-10, we determined gingerbread product No. 6 to be the optimal regimen because it contained many mineral elements and vitamins, and no toxic elements or microbiological indicators were found. In addition, the density and water absorption were relatively close to the control sample's.

As a result of the research, gingerbread product No. 6 had an optimal mode. Thus, the developed gingerbread product is highly nutritional and can be considered a functionally oriented food.

According to organoleptic indicators, sample No. 6, made with 5% chickpea flour, 10% bean flour, and 30 g of sugar beet powder, had the best indicators. It is evenly light golden in colour, smooth in shape, undamaged, and well cooked. The taste and smell are sweet and are not inferior to the control sample in all parameters. Moisture content, water absorption properties, ash, acidity, fat, vitamins, toxic elements, and microbiological indicators were determined from the physicochemical parameters.

Analysing the research results, gingerbread product No. 6 was the optimal regimen, because it contained a high amount of mineral elements and vitamins, and no toxic elements or microbiological indicators were found. In addition, the density and water absorption were relatively close to the control sample's.

CONCLUSION

In order to expand the assortment of high-nutrition flour confectionery products, it is recommended to market sample No. 6, i.e. the recipe with 5% chickpea flour, 10% bean flour, and 30 g of sugar beet powder, from among the research samples made in this study. This is because it meets standard requirements and has more protein and higher nutritional value than ordinary gingerbread products. As a functional food product, it could be popular among young children and the elderly and for dietary purposes. Purchasing imported equipment has allowed enterprises to expand the types of products produced and improve product quality. The optimal amount of chickpea and bean flour to replace wheat and sugar beet to replace sugar was established experimentally by increasing the percentage of replacement and evaluating the organoleptic characteristics of the finished product. Samples with 5 and 10% replacement of wheat flour for chickpea and bean flour, as well as 30 and 60 grams of sugar replacement for sugar beet were investigated. As a result of the research, it was found that an increase in the percentage of replacing wheat flour with chickpea bean flour has a positive effect on the organoleptic and rheological characteristics of the dough, and also increases the nutritional and biological value of the gingerbread. Based on the results obtained, it can be concluded that the change in prescription ingredients makes it possible to obtain new functional gingerbread with high organoleptic characteristics, with reduced calorie content, with increased nutritional value due to the introduction of high-protein chickpea and bean flour, enrichment with dietary fiber, vitamins, macro- and trace elements of sugar beet, which will undoubtedly be in demand among buyers.

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