Проведено дослідження можливості застосування соєвого борошна збагаченого на йод у виробництві хліба для споживання осіб, які страждають на йод дефіцитні стани, хворіючи на цукровий діабет та целіакію. Досліджено органолептичні, фізико-хімічні, мікробіологічні показники, вміст токсичних елементів та вміст йоду у розробленому борошні. Експериментально обґрунтовано та впроваджено раціонально можливе рецептурне дозування розробленого борошна до борошна зеленої гречки у рецептурах із використанням порошку із моркви та порошку із буряку. За визначеними показниками якості підтверджено можливість виготовлення хліба із використанням збагаченого на йод соєвого борошна у виробництві хліба для спеціального дієтичного споживання.

Проведений комплекс досліджень надає рекомендації для технологів по виробництву хліба із спеціальними дієтичними властивостями. Це дозволить розширити асортимент та заповнити ринок продукцією, нехватка якої сягає близько 15 % від загального виробництва хлібобулочних виробів.

В результаті досліджень встановлено, що вміст йоду у розробленому борошні сої становить 50 мкг на 100 г. За показниками якості та безпеки розроблене борошно відповідає нормативно-технічній документації на борошно соєве харчове. Раціональне дозування розробленого борошна сої до борошна зеленої гречки у нових рецептурах хліба становить 10 %. У виробах з використанням овочевих порошків 15 % гречаної муки замінюють 10 % розробленим борошном сої, та 5 % порошку моркви чи буряку.

За органолептичними і фізико-хімічними показниками хліб, розроблений за новими рецептурами, відповідає ДСТУ 4588 на «Вироби хлібобулочні для спеціального дієтичного споживання». Вміст органічно зв'язаного йоду у хлібі, розробленому за новими рецептурами, через 72 години після випікання становив 48,9; 49,4; 50,0 мкг на 100 г.

Проведений комплекс досліджень дає підстави стверджувати, що хліб, розроблений за новими рецептурами, задовольняє 1/3 % добової потреби в йоді.

Ключові слова: борошно сої, целіакія, хлібобулочні вироби спеціального дієтичного споживання

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SUBSTANTIATION OF THE EXPEDIENCY TO USE IODINE-ENRICHED SOYA FLOUR IN THE PRODUCTION OF BREAD FOR SPECIAL DIETARY CONSUMPTION

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1. Introduction

A share of special dietary products will make up to 30 % of the total food market in the coming decades in developed countries according to the forecasts of the world's leading experts in the field of nutrition and medicine [1]. Products developed for the category of people with thyroid disease, diabetes and celiac disease take special place among flour products for special dietary consumption [2].

About 4 % of people worldwide suffer from diabetes and concomitant iodine deficiency according to WHO official data. 75 % of Ukrainians, which suffer from type II diabetes, suffer from a lack of iodine. The number of patients increases every year despite the success of medicine in the treatment of endocrine diseases [3, 4].

A range of food products for persons, which suffer from endocrine disorders, is not wide enough in the country. It is about 2.0 %. The shortage of bread for dietary consumption makes up about 15 % of the total production of bakery products [5].

The issue of development of technologies for special diet products is very acute and relevant. Bakery products are promising raw material for creation of this type of products, taking into account their mass consumption by the population [6].

2. Literature review and problem statement

Development of bakery technologies for special dietary consumption, expansion of bread range, fortification and increase of nutritional value are urgent problems for the baking industry [7]. There is an increasing demand for competitive products, which meet generally accepted standards, for export to European countries [8]. Over one billion people are at risk of development of iodine-deficient diseases in the world according to WHO and UNICEF experts. The risk leads to the inclusion of measures for prevention and control of iodine deficiency diseases in the number of priority international programs [9]. Celiac disease is a disease accompanied by the development of mucosal atrophy of the small intestine in response to gluten consumption. The term "gluten" means a protein fraction of some cereals, such as wheat (gliadin), rye (secalin), and barley (hordein) [2, 10]. The rate of manifestation of celiac disease in the Indo-European race is about 1 % according to the research carried out by the Association of European Unions of Celiac Diseases. The number of people, which suffer from celiac disease and gluten intolerance, is approaching 400,000 people in Ukraine. Only 2,500 have the proven diagnosis. According to the requirements of WHO Codex Alimentarius, we can consider products as gluten-free products if they contain gluten in the amount of not more than 20 mg/g [10, 11].

Production of bakery products for special dietary consumption should make up about 35 % of the total production of bakery products [12].

There is a known method for making bread with high nutritional and biological value using the isolates of vegetable proteins of peas and soy in a combination with corn flour. Their usage is recommended for people with overweight and gluten intolerance. Bread produced by the developed technology has high protein content and low fat content, but it is not a carrier of vitamins and microelements [13]. There is a method of production of bread of rice, corn, and buckwheat flour together with dried vegetable powders for patients with diabetes and celiac disease. The content of vegetable powders provides ready-made products with A, B, E vitamins. The bread produced by the developed technology contributes to a significant reduction in sugar content, an increase in vitamins content and lack of gluten [14].

Technological approaches applied by scientists solve the problem of bread consumption by patients with diabetes and celiac disease without taking into account the concomitant iodine deficiency. It is a proven fact that 75 % of people with diabetes have the concomitant iodine deficiency [15].

Scientists developed the technology for production of iodine-enriched bread. It uses the organic iodine carrier – "Elamin" as iodine-containing raw material. However, we should note that the paper describes significant iodine losses during a baking process (up to 80 %). It does not investigate iodine content during a storage process. Therefore, we cannot classify them as products for special dietary consumption, which should provide 1/3 % of the daily need according to nutritional principles. Researchers noted a change in organoleptic parameters towards the greenish color and aftertaste of iodine [16]. Authors of work [17] propose using inorganic iodine carriers, such as iodized salts, which are more heat resistant and organoleptically acceptable, to overcome the mentioned problem. The use of inorganic iodine carriers in bread production can lead to an overdose of microelements in the body. Clinical trials of iodination of products by inorganic iodine carriers in Zimbabwe reported cases of hypertereosis [18].

All the above technological approaches applied by researchers for the development of bakery products for people with diseases of the thyroid gland, diabetes and celiac disease have several disadvantages. The disadvantages are significant losses of microelements during baking, unspecified content of microelements during storage, deterioration of organoleptic characteristics and use of inorganic iodine carriers [19].

Paper [20] proposes a technology for production of soy flour with accumulation of iodine in a cotyledon in a protein fraction in organic bound [20]. Authors did not investigate the quality of the developed soy flour in their paper. They did not establish rational acceptable formulation dosage for bread production. They did not study a change in the quality of finished products at combined use of iodine-enriched soy flour and vegetable powders of carrots and beets as formulation components. They did not determine the iodine content in the finished product.

Since there is no sufficient data on the use of iodine-enriched soy flour and vegetable powders of carrots and beets for bread production, it is necessary to carry out more research in this area.

3. The aim and objectives of the study

The objective of the study is to substantiate the expediency of using enriched soy flour in the production of bread for special dietary consumption.

We set the following tasks to achieve the objective:

– to study quality indicators of the developed soy flour to determine the iodine content;

– to establish a rationally permissible formulation dosage, taking into account the requirements of DSTU 4588 for "Bakery products for special dietary consumption";

– to investigate the iodine content of bread produced according to new formulations 72 hours after baking.

4. Materials and methods to study quality of the developed soy flour and new bread for special dietary consumption

4. 1. Methods used in the study of quality indicators and determination of the iodine content in the developed soy flour

We prepared experimental samples of iodine-enriched soy flour using early-ripening "Kyivska 98" soy grain grown at the "Agrotec" collection seed plot in Kyiv region (Ukraine), 2018 harvest. The soy grains were germinated in a solution of potassium iodide at a concentration of 3 μg/ml for 48 hours at a solution temperature of 14...16 °C, dried to the relative humidity of 6...8 % and ground (passage through #38 sieve).

We determined indicators of the flour quality in accordance with the requirements set out in the following regulations and methodologies.

The organoleptic parameters, such as color, smell and taste, were determined according to DSTU 7662.

The physical-and-chemical parameters were determined according to the following methodologies:

– the mass fraction of moisture was determined using a "Super Matic" automatic hygrometer, a "Brabender" drying chamber and a "OVZ-1" vacuum-thermal device according to the method described in DSTU 7621;

– the mass fraction of fat was determined by the fat content in the fat-free residue by the Rushkovsky method described in DSTU 7458;

– the mass fraction of raw protein was determined using the device Kjeltec Auto 1030 Analyzer system according to the method described in DSTU 7169;

– the mass fraction of total ash was determined by the method of incineration according to the method described in GOST 13979.6. We used nitric acid as an accelerator. We incinerated a sample of soy flour by roasting with free air. Carbon, hydrogen, nitrogen and partially oxygen evaporated, leaving minerals in the form of oxidizing compounds only;

– the mass fraction of fiber was determined by treating a sample of soy flour with 1.25 % sulfuric acid in a liter volumetric flask with distilled water. We poured 7.1 ml of concentrated sulfuric acid with a density of 1.84 g/cm^3 in and brought the solution to the mark with water; – 2.5 % sodium hydroxide solution. The alkali was dissolved at the rate of 30 g per 1 liter of distilled water. We set the concentration of sodium hydroxide solution as follows: 2.5 % sodium hydroxide solution is 0.64 N solution; – ethyl alcohol, 96 %; – diethyl ether;

– the gluten mass fraction was determined using a "Glutomatic" device according to the procedure described in DSTU ISO 21415-1: 2009;

– the content of toxic elements, such as lead, cadmium, copper, and zinc, were determined according to the methods described in DSTU 31262. Mercury content was determined according to MU 5178; an arsenic content – according to GOST 30178;

– the microbiological parameters, that is, a number of mesophilic aerobic and optional-anaerobic microorganisms, were defined according to the methodology described in DSTU 8446. Bacteria of the group Escherichia coli were determined according to DSTU ISO 4832. The content of pathogenic microorganisms Salmonella bacteria was determined according to the methodology described in DSTU 12824, and mold fungi and yeast content – according to the methods described in DSTU 8447;

– the iodine content was determined by the method measurement technique No. 081/12–0092–03 "Inversion – VAWmetry".

4. 2. Methods and raw materials used for determination of a rationally possible formulation dosage for the study on the quality of new bread for special dietary consumption

The organoleptic and physical-and-chemical indicators of finished products were determined according to DSTU-P 4588:2006 "Bakery products for special dietary consumption". We used a formulation for production of buckwheat bread (of green buckwheat flour) as a control sample for the development of new bread formulations. The samples were produced by replacing buckwheat flour with soy flour in accordance with the rules of fortification. According to the rules, a consumption of a daily norm of a product should satisfy at least 1/3 % of the daily need in substances, with which we enriched the product. The daily requirement for iodine is 150–200 μg. Sesame seeds (white and black) were used as "powder" for bread. We considered it as a natural source of physiologically active polyunsaturated fat w_3 and w_6 families, tocopherols. We used Daucus carota carrot powder, Beta vulgaris L beet powder and Sesamum indicum L sesame as raw materials for the study.

4. 3. Methods used to study iodine content of the developed new bread formulations 72 hours after baking

The mass fraction of iodine was determined by measurement technique No. 081/12–0092–03 "Inversion – VAWmetry" method using an "Ecotest – VA" voltammetry analyzer. The base of the principle of iodine determination is an electrochemical oxidation of iodine ions to molecular iodine, a deposition of a poorly soluble iodine-containing compound, followed by electrochemical dissolution on a surface of an operating electrode.

5. Results of studies of quality indicators of the developed flour and bread

5. 1. Study of quality indicators of the developed soy flour and determination of the iodine content

Tables 1–4 give the results of studying quality indicators of the developed soy flour and determination of the iodine content.

One can see from the data in Table 1 that the developed soy flour has a light-yellow color, an aroma, which is characteristic to soy flour, and a taste without bitterness and sour flavors. The color of the sample differs from the control sample, which has a lighter, cream color, but regulatory and technical documentation for soy meal (DSTU 4543) admits such deviations. Table 2 shows physical-and-chemical indicators of the developed soy flour. They differ from the control sample in terms of mass fraction of moisture (1 % less than in the control sample) and mass fraction of fat, which decreases by 2 %. We observe differences in mass fraction of total ash and mass fraction of fiber towards a decrease of 0.5 % for two indicators. Tables 3, 4 show the results of determination of the content of toxic elements and microbiological parameters in soy flour enriched with iodine.

Table 1

Organoleptic characteristics of the iodine-enriched soy flour

Indicator	Acceptable norm	Control sample	Study sample	Compliance with norms
Color	from light-yellow to cream-colored	cream-colored	light-yellow	complies
Aroma	characteristic to soy flour, without foreign smells	without extraneous smells	without foreign smells	complies
Taste	without bean taste, without bitterness and sourness	without bitterness, sourness and foreign tastes	without bitterness, sourness and foreign tastes	complies

Table 2

Physical-and-chemical characteristics of the iodine-enriched soy flour

Indicator	Acceptable norm	Control sample	Study sample	Compliance with norms
Moisture, %	9.0	7.0	8.0	complies
Mass fraction of fat, %	15.0	14.0	12.0	complies
Mass fraction of protein, %	40.0	42.0	40.0	complies
Mass fraction of ash, %	7.0	7.0	6.5	complies
Mass fraction of fiber, %	4.5	4.5	4.0	complies
Iodine content, µg /g	150	0.02	50.0	complies

Table 3

Content of toxic elements in the iodine-enriched soy flour

Indicator	Acceptable norm, not more than	Actual amount	Compliance with norms
Mercury, mg/kg	0.02	≥0.02	complies
Arsenic, mg/kg	0.2	≥0.2	complies
Copper, mg/kg	10	9	complies
Lead, mg/kg	0.5	≥0.5	complies
Cadmium, mg/kg	0.1	–	complies
Zinc, mg/kg	50.0	50.0	complies

Table 4

Microbiological indicators of the iodine-enriched soy flour

Indicator	Permissible norm	Actual amount	Compliance with norms
Number of mesophilic aerobic and optional-anaerobic microorganisms, CFU per 1 g	0.1×105	0.1×105	complies
Escherichia coli bacteria	not acceptable	not detected	complies
Pathogenic microorganisms, Salmonella bacteria, per 25 g	not acceptable	not detected	complies
Mold fungi, CFU per 1 g	0.1×102	0.1×102	complies
Yeast, CFU per 1 g	0.1×102	0.1×102	complies

One can see in Table 3 that the content of mercury, arsenic and lead does not exceed the permissible levels for human consumption in the developed flour. The developed flour does not contain cadmium and has a lower copper content than the permissible level, which is 1 mg/g. The results of the study of microbiological parameters of the soy flour enriched with iodine make possible to state that the test samples of the developed flour are safe for consumption by the number of mesophilic aerobic and optional-anaerobic microorganisms, molds, and yeast. It does not contain Escherichia coli bacteria and pathogens of *Salmonella* bacteria.

The generalization of the studies gives reason to state that the developed flour improved amino acid composition due to vegetable protein and enrichment with iodine. The developed flour developed exceeds the control sample in terms of the iodine content by 49.89 µg/g (Table 2).

The developed flour is within acceptable standards. It meets the requirements of the regulatory technical documentation for soybean meal flour (Tables 1–4) according to all quality indicators in accordance with DSTU 4588.

It is possible to use it as a formulation component in bread production for special dietary use.

5. 2. Determination of the rationally permissible formulation dosage taking into account the requirements of DSTU 4588 for "Bakery products for special dietary consumption"

We baked test samples of bread to determine the rationally permissible formulation dosage of the developed flour taking into account the requirements of DSTU 4588 for "Bakery products for special dietary consumption". Fig. 1 shows images of the sample masses before baking.

a *b* *c*

Fig. 1. Images of sample masses before baking of bread: *a* – with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of carrot powder; *b* – with replacement of 10 % of green buckwheat flour with 10 % of the developed soy flour; *c* – with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of beet powder

One should note a good water absorption capacity of flour. We kneaded the dough quickly (2 minutes) and it had good consistency for about 1 minute, after which it was liquefying actively. Fig. 2, 3 show the bread immediately after baking and after 6 hours.

The samples with the use of soy flour as a formulation component have cracks and different colors on the surface of the products.

Vegetable powder contained anthocyanin pigments and had a pronounced color. The cracks appeared in the finished products due to the absence of gluten in flour, as gluten is responsible for the smooth and uniform structure of bread products common to wheat bread.

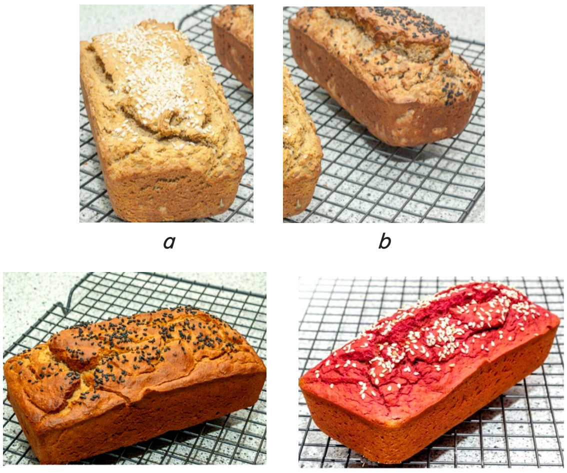


Fig. 2. Images of bread after baking: *a* — control sample; *b* — with replacement of 10 % of green buckwheat flour with 10 % of the developed soy flour; *c* — with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of carrot powder; *d* — with replacement of 15 % of green buckwheat flour with 10 % of the developed soy flour and 5 % of beet powder

a *b* *c* *d*

Fig. 3. Images of the bread 6 hours after baking: *a* — bread with 10 % of soy flour and 5 % of carrot powder; *b* — control sample of buckwheat flour; *c* — bread with 10 % of soy flour, *d* — bread with 10 % soy flour and 5 % of beet powder

It was established that bread made according to the new formulations had an uneven surface with cracks. The crumb was elastic. It restored its original shape quickly. It was well baked. It was not moist to the touch, not sticky with developed uniform porosity and without hardenings. The taste and smell were characteristic to the bread type.

Tables 5, 6 show the results of organoleptic and physical-and-chemical evaluation of the quality of the bread made of the developed iodine-enriched soy flour by different formulations.

The samples with 10 % of the developed soy flour and 5 % of vegetable powders had a bread-like aroma with a light aroma of the additive and an inherent taste of buckwheat bread with a light taste of the additive. The bread with 10 % of soy flour and vegetable powders had an excellent rate (4.8 and 4.9 points). Whereas the sample with the addition of 10 % of iodine-enriched soy flour had a good rate (4.4 points) (Fig. 3, Table 5).

An increase in the content of the developed soy flour by more than 10 % of the total weight of flour led to a deterioration of organoleptic characteristics. Large cracks and gaps appeared. The crust became gray. The specific volume of products reduced (Table 5)

Table 5

Organoleptic indicators of the quality of iodine-enriched soy flour bread

Sample	Crust color	Appearance	Crumb color	Aroma	Taste	Rate
Control sample (without additives)	yellow-gray	cracks on crust	grey	bread, buckwheat	buckwheat	4.6
10 % of the developed soy flour	yellow-gray	cracks on crust	light-gray	bread, buckwheat	buckwheat	4.4
10 % of the developed soy flour and 5 % of carrot powder	yellow	cracks on crust	light-yellow	bread, carrot	additional carrot taste	4.8
10 % of the developed soy flour and 5 % of beet powder	red	cracks on crust	yellow	bread, vegetable	additional vegetable taste	4.9
15 % of the developed soy flour	gray	cracks and gaps on crust	grey	bread, buckwheat	buckwheat	3.5
15 % of the developed soy flour and 7 % of carrot powder	yellow-gray	cracks and gaps on crust	yellow-gray	bread, carrot	additional carrot taste	4.0
15 % of the developed soy flour and 7 % of beet powder	red-gray	cracks and gaps on crust	red-gray	bread, vegetable	additional vegetable taste	4.1

Table 6

Physical-and-chemical indicators of the bread with iodine-enriched soy flour made by new formulations

Sample	Weight, g	Humidity, %	Acidity, grad.	Volume, cm3	Specific volume, cm3
Control	33.2	46.3	3.1	2.77	0.083
10 % of soy flour	33.3	47.0	3.2	2.82	0.085
10 % of soy flour and 5 % of carrot powder	33.7	45.9	4.5	3.21	0.095
10 % of soy flour and 5 % of beet powder	32.6	45.3	4.7	3.02	0.092
15 % of soy flour	34.0	47.0	3.2	2.43	0.071
15 % of soy flour and 7 % of carrot powder	34.7	48.1	6.5	2.32	0.066
15 % of soy flour and 7 % of beet powder	34.6	46.7	6.7	2.51	0.072

The use of vegetable powders is advisable at a concentration of 5 % to the total content of flour. An increase in the content of vegetable powders above the specified concentration led to an increase in acidity, which is unacceptable because it is normalized by DSTU4588, and should be no more than 5 degrees (Tables 5, 6).

We established that the experimental samples with 10 % of the developed flour had humidity from 45.3 to 47.0 % by the mass fraction of moisture, and the humidity increased in the experimental samples with 15 % of the developed flour to the range from 46.7 to 48.1, which exceeded the control sample by 0.4...1.8 %.

We determined the increase in the acidity comparing to the control sample by 1.7 and 1 deg., respectively, and by 2 degrees in the samples with an increased content of vegetable powders from 5 % to 7 %. Products containing 10 % of the developed soy flour had a higher specific volume than products containing 15 %. The highest specific volume was in the samples with 10 % of soy flour and carrot powder. It was 0.095 cm^3, which was slightly inferior to beetroot powder and made up 0.092 cm^3. The specific volume of the control sample and the sample with 10 % of the developed soy flour was 0.083 and 0.085 cm^3, respectively. The specific volume decreased by 0.014; 0.029 in products with 15 % of the developed soy flour; 0.02 cm^3 relatively to the products with 10 % of the soy flour and a similar ratio of formulation components (Table 6).

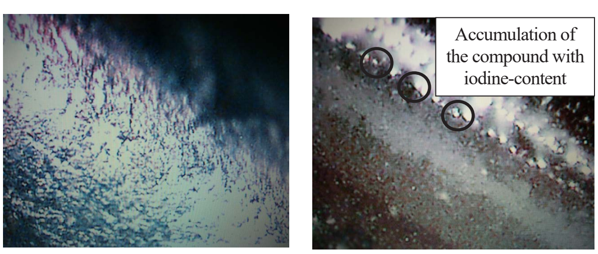
5. 3. Investigation of the iodine content of bread made in line with the developed new formulations 72 hours after baking

The samples of bread were treated with 10 % of the developed soy flour and 5 % of vegetable powders with a solution of potassium hydroxide by combusting using a "PHOENIX" microwave exposure system. We mixed the resulting ash with water and neutralized it to pH 4...6. We centrifuged it and carried out measurements after.

The mass concentration of iodine in the test solution was determined by measuring the magnitude of cathodic current during dissolution of the precipitate.

It was established that bread with 10 % of soy flour had an iodine content of 50.0±0.02 μg per 100 g. The experimental sample with 10 % of soy flour and 5 % of carrot powder had 48.9±0.02 μg per 100 g. The experimental sample with 10 % of soy flour and 5 % of beet powder had 49.4±0.03 μg per 100 g.

Fig. 4 shows the surface of the operating electrode of the "Ecotest–VA" analyzer with a magnification by 1,000 times.



a *b*

Fig. 4. Micro images with the image of the surface of the operating electrode of the "Ecotest-VA" (1,000-time magnification): *a* — control sample (classic formulation); *b* — sample with the soy flour

6. Discussion of results of studying quality indicators of the developed flour and new bread formulations with its content

We studied quality indicators of soy flour and determined the content of iodine (Tables 1–4) to check the possibility of using soy flour enriched with iodine in production of bread for the category of people with thyroid disease, diabetes and celiac disease.

It was established that the developed soy flour was different in color and had a more yellow color compared to the control sample in terms of organoleptic characteristics. We did not feel the content of iodine neither in aroma nor in taste. There was no bitterness, sourness, or foreign taste.

The developed soy flour had 12 % of fat, 40 % of protein, 6.5 % of ash, 4 % of fiber at the humidity of 8 % according to physical-and-chemical indicators. The iodine content was 50 μg per 100 g of flour, which exceeded the control sample by 49.89 μg and provided 1/3 % of the daily need for iodine (Table 2). There was no iodine smell or taste (Table 1).

The developed soy flour contained 0.02 mg/kg of mercury, 0.2 mg/kg of arsenic, 9 mg/kg of copper, 0.5 mg/kg of lead and 50 mg/kg of zinc. The content was within acceptable limits, which indicated that the iodine content of soy flour did not affect safety indicators. The microbiological parameters of the developed soy flour were within 0.1×10^5 CFU per 1 g of mesophilic aerobic and optional-anaerobic microorganisms, 0.1×10^2 CFU per 1 g of molds and yeast, which was within the normal range.

Fig. 1–3 show clearly that the use of the developed soy flour in combination with vegetable powders for production of dough provided a good consistency, good water absorption capacity and an attractive color. This evidences that the developed flour with vegetable powders intensify the process of fermentation of dough, apparently due to the introduction of vegetable sugars, macro-, and microelements into the sample masses.

We established experimentally the rationally permissible formulation dosage (Tables 5, 6).

Our studies showed that it is rational to use no more than 10 % of the developed soy flour and 5 % of vegetable powders to the total flour content of a product. The products developed according to the proposed formulations had a pleasant yellow-gray color (10 % of soy flour), yellow color (10 % of soy flour and 5 % of *Daucus carota* carrot powder) and red color (10 % of soy flour and 5 % of *Beta vulgaris L* beet powder). The products had acceptable appearance with a slight disadvantage in the form of cracks on the crust of finished products. The bread had buckwheat and vegetable aroma, pleasant taste with a touch of buckwheat and vegetables. It had no foreign tastes and bitterness of iodine taste. The products made by the developed formulations had the humidity of 47.0; 45.9; 45.3 % at norms up to 50... 53 % by DSTU. The acidity was 3.2; 4.5; 4.7 at norms no more than 6 degrees by DSTU. The specific volume was 0.085, 0.095, 0.092, which exceeded the control sample by 0.002; 0.012; 0.009 %.

The iodine content of bread 72 hours after baking was 50 (the formulation with 10 % of soy flour), 48.9 (the formulation with 10 % of soy flour and 5 % of *Daucus carota* carrot powder) and 49.4 (the formulation with 10 % of soy flour and 5 % of *Beta vulgaris L* beet powder) μg per 100 g. The experiment made possible to confirm that the protein fraction contained from 95 % to 99 % of iodine in the developed soy flour. It indicated the degree of conversion of iodine into organic form. Thermal lability and preservation of the microelement during storage confirm the fact also. Daily consumption of bread (established by the Cabinet of Ministers of Ukraine) is 270 g, so the bread made by new formulations covers up to 80 % of the daily need for iodine without a risk of overdose.

The introduction of the developed formulations in bread production to the public catering system will give a possibility to overcome iodine deficiency for healthy people safely, to expand a range of bread for people suffering from iodine deficiency and type II diabetes, and for people with celiac disease.

7. Conclusions

1. In terms of quality, soy flour is different in color and has a yellower color than the control sample. It has no bitterness and a taste of iodine. Fat content is 12 % protein content is 40 %, ash content makes up 6.5, protein content is 4 % at humidity of 8 %.

The developed soy flour contains 0.02 mg/kg of mercury, 0.2 mg/kg of arsenic, 9 mg/kg of copper, 0.5 mg/kg of lead and 50 mg/kg of zinc, which are within acceptable limits. Thus, we can state that the iodine content of soy flour does not affect safety indicators.

Microbiological parameters are in the range of 0.1×10^5 CFU per 1 g of mesophilic aerobic and optional-anaerobic microorganisms, 0.1×10^2 CFU per 1 g of molds and yeast, which are within the normal range. The iodine content is 50 µg per 100 g of flour.

2. Introduction of the developed soy flour as a formulation component in rational doses up to 10 % and the combined use of 10 % of soy flour with 5 % of *Daucus carota* carrot powder, and 10 % of soy flour and 5 % of *Beta vulgaris L*. beet powder provides an increase in the finished product volume by %. The finished product has pleasant organoleptic characteristics, such as a color of the finished product, absence of smell and taste of iodine. At the permissible humidity 47.0; 45.9; 45.3 % (respectively) at normalization to 50...53 %, and acidity – 3.2; 4.5; 4.7 (respectively) at normalization of no more than 6 degrees.

3. The protein fraction contains from 95 % to 99 % of iodine in the developed soy flour. It indicates the degree of conversion of iodine into organic form. Thermal lability and preservation of the microelement during storage for 72 hours confirm the fact also. The iodine content in bread is 50 (the formulation with 10 % of soy flour), 48.9 (the formulation with 10 % of soy flour and 5 % of Daucus carota carrot powder) and 49.4 (the formulation with 10 % of soy flour and 5 % of Beta vulgaris L. beet powder) µg per 100 g 72 hours after baking.

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