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Original Article

The use of walnut flour in the recipe of "Fitness" buckwheat bread

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Abstract

We studied the sensory compatibility, physical and chemical parameters and nutritional value of the raw materials – wheat flour, walnut flour and buckwheat mix. We tested several variants of modifying the studied bread recipe. We identified the superiority of the walnut flour over the wheat raw material in providing several nutrients. We determined the priority role of the wheat flour in the formation of porosity and specific volume of bread. We established the practical possibility of substituting 15% of the high-grade wheat flour with walnut flour, and substituting 4% of baking mix with a similar amount of dry wheat gluten in a buckwheat bread. The products with modified composition have good consumer properties and are characterized by high contents of plant lipids, proteins, and soluble and ballast fibers, and are rich in minerals and vitamins.

Keywords: walnut flour, “Fitness” buckwheat bread

1. Introduction

Nutrition is the most important physiological need and is of particular importance for human health. Studies carried out by nutritionists have shown that one of the most effective ways to solve the problem of improving the health of a population is to develop the production of everyday products enriched with micronutrients (Pilipenko, 2016). Due to its excellent taste and aromatic properties, inability to pall on, good digestibility, easy cooking, and low cost, bread is the most often consumed product and can serve as a convenient platform for adjusting the nutritional values of finished products (Egushova & Pozdnyakova, 2018; Guseva, Gulova & Lavrova, 2018; Vershinina, Zernaeva & Bondarenko, 2018).

Today, food technology experts consider walnut flour as a source of native protein, lipids (mono-, di-, triglycerides, free fatty acids, phosphatides), carbohydrates (sugars, starch, fiber), minerals, vitamins, antioxidants (ascorbic acid, tocopherol, carotene), phenolic compounds (tannins, flavonols, catechins), organic acids, etc. (Dmitrieva & Makarova, 2015; Kamzolova, Lipskaya & Borisevich, 2006; Khutsishvili, Druker & Kryuchkova, 2017; Makarenkova, Shevyakova & Bessonova, 2016; Orlova & Nasonova, 2014). In this regard, there are known approaches, using walnut flour in the production of an acidophilic sour-milk product with improved organoleptic and functional properties; the experience of using walnut kernel concentrate in waffle fillings with an increased content of essential amino acids, polysaccharides, and polyunsaturated fatty acids; and there is a recipe for cookies with prolonged shelf-life containing walnut flour, rich in protein, iron, magnesium, potassium, copper, phosphorus (Droficheva, 2014; Khutsishvili, Druker & Kryuchkova, 2017;Mysakov, 2017; Oboznaya, Shilman, Koshel, Bidyuk & Perzevoy, 2017; Shavyrkina & Abramova, 2015). There are approaches for the production of flour confectionery and bakery products (wheat, rye and rye-wheat) with the addition of walnut flour (Vasipov & Vytovtov, 2016). Food products containing walnut shell powder have a low glycemic index (Ponomareva & Odintsova, 2017). The biologically active substances of walnut (Juglans regia L.) have antioxidant, anthelmintic, antimicrobial, antifungal, cytotoxic and antidiabetic activities (Vernikovsky, Dayronas, Zilfikarov & Khadzhieva, 2019).

The purpose of this study was to assess the applicability of walnut flour in "Fitness" buckwheat bread, to expand the product range and to increase the nutritional value of bakery products.

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2. Materials and Methods

2.1. Materials

The objects of the research were:

– first-grade baking wheat flour produced by IE A.A. Mikhailyuta (Russia, Omsk region);

– walnut flour produced by Specialist LLC (Russia, Altai Territory);

– "Fitness Mix" buckwheat baking mix produced by IREKS LLC (Russia, Moscow region). Ingredients: buckwheat flour, wheat bran, dextrose, high-grade baking wheat flour, malt wheat flour, barley malt extract, E472e emulsifier, wheat gluten, fried wheat malt, E341iii, E170 stabilizers, E263 acidity regulator, ascorbic acid antioxidant, enzyme products of microbial origin.

– control samples of "Fitness" buckwheat bread were produced according to the regulated recipe (Table 1) as per the requirements of TU 9110-006-18256266-2005 "Fitness" Bakery Products. Specifications";

– test samples with partial replacement of the first-grade wheat baking flour with an identical amount of the walnut flour – experiment 1 (5% replacement), experiment 2 (10%), and experiment 3 (15%);

– test samples with the replacement of 15% of the first-grade wheat baking flour with the walnut flour and the replacement of "Fitness mix" buckwheat baking mix with the same amount of wheat gluten – experiment 4 (2%), experiment 5 (4%), experiment 6 (6%).

We used an accelerated method of making dough, the products were mold-baked with the net weight of 0.5 kg.

Table 1. Recipe of "Fitness" buckwheat bread

Raw material composition and process parameters	Raw material consumption and dough making parameters, kg
First-grade wheat baking flour	80.00
"Fitness mix" buckwheat baking mix	20.00
Pressed baking yeast	3.00
Kitchen salt	2.00
Drinking water	as per calculation
Dough fermentation duration, minutes	15-20
Initial dough temperature, °C	26-28

2.2 Methods

The organoleptic characteristics of the raw materials of the finished products were determined visually and during testing.

The tasting evaluation of the model bread samples was carried out on a 100-point scale. The samples which scored 96-100 points were considered to be of "very good" quality, 84-95 – "good" quality, 75-83 – "satisfactory" quality, 74 and lower – "technical defect" (Koryachkina, Berezina & Khmeleva, 2010).

The moisture contents of the raw materials and the finished products were determined by drying a weighted portion at 130 °C for 40 minutes to a constant weight, with a further calculation of the target parameter. The protein content was determined by the sample mineralization according to Kjeldahl; fat content – using the extraction method in the Soxhlet apparatus; ash content – by a complete burning of the organic part of the weighted portion followed by a gravimetric determination of the target indicator; acidity – by titration with sodium hydroxide; phosphorus content – by the molybdenum-vanadium method; the contents of other mineral elements – by the flame atomic absorption method; fiber content – by hydrolysis and removal of protein and starchy substances with enzymes (Skurikhin & Tutelian, 1998); the microstructure of the weighted portions – using scanning electron microscopy (Pashkeev, 2015).

The amount of gluten in the raw materials was determined by washing it from the dough manually, and the quality of gluten was determined by measuring its elastic properties using a gluten deformation meter (GDM). The specific volume of the model bread samples was determined using a P3-BIO meter, the porosity was determined using a Zhuravlev test probe. The vitamin contents in the bread samples were determined by high performance liquid chromatography (Skurikhin & Tutelian, 1998).

The rates of the daily human demand for food and biologically active substances are taken from Methodical Recommendations 2.3.1.2432-2008 "Norms of the physiological demands for energy and nutrients for various groups of the population of the Russian Federation" (Methodical Recommendations, 2008). All the measurements were made in triplicate. A statistical analysis was performed using the software suite: Microsoft Excel XP, Statistica 8.0. The statistical error of the data did not exceed 5% (with a 95% confidence level).

3. Results and Discussion

3.1. Quality and chemical composition of raw materials

At the first stage of the experiment, we studied the main raw materials. The study of organoleptic indicators and the compatibility of the used raw materials will allow us to prevent the formation of undesirable changes in the consumer properties of the finished bread. It has been established that the wheat flour has no visible deviations in sensory quality indicators (Figure 1) from the regulated standards.

The specific characteristics preconditioned both by the botanical features of the culture and the ingredient composition were determined for the rest of the raw materials. So, the walnut flour is a homogeneous fine powder, gray with a cream tint, with a characteristic odor, a typical sweet taste with a slight astringent flavor. "Fitness Mix" buckwheat mix is a loose powder with the inclusion of small bran particles, which are especially palpable during chewing. It has a light brown color with a reddish tint, uniform throughout the weight, a peculiar smell, without extraneous tones, the taste is characteristic of buckwheat, more sweet, without extraneous flavors. We have revealed an acceptable sensory compatibility of the studied raw material allowing us to use it in the composition of a complex food system.

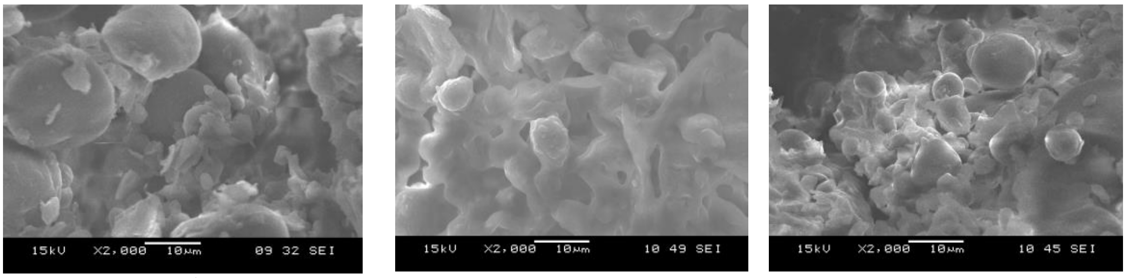
The study of the physical and chemical indicators and the chemical compositions of the raw materials help us understand the formation of the crumb structure, lifting, and nutritional value of bread. It has been determined that the basic physical and chemical quality indicators of the studied raw material samples are characteristic of the quantitative ranges of each of them. The moisture content of the baking mix is slightly different from the analogous indicator of the studied flour samples (Table 2), which should be taken into account when calculating the amount of water needed to make the dough. Despite the content of glutelin in the walnut composition (Vasipov & Vytovtov, 2016; Genzhemuratova, Tanatarov & Khidirova, 2019), and the high-grade wheat flour and wheat gluten in the composition of the baking buckwheat mix, it was impossible to determine the quality and quantity of gluten proteins in these raw material samples using the traditional method.

Thus, in this case, only the wheat flour objectively takes part in the formation of porosity and specific volume of bread. This assumption was also confirmed when studying the microstructure of the raw materials using scanning electron microscopy, showing large quantities of gluten proteins in the wheat flour and in the form of single inclusions in the buckwheat mix (Figure 2).

There were no significant differences in the amounts of protein in the tested raw material samples, which could globally reduce the protein deficiency in the new modification of the bakery products. However, it is well known that the

wheat flour walnut flour baking mix

Figure 1. The appearance of the raw materials



wheat flour walnut flour baking mix

Figure 2. The microstructure of the raw materials

Table 2. Physical and chemical indicators and nutritional value of the raw materials

Target indicator	Test results		
	wheat flour	walnut flour	baking mix
Mass fraction of moisture, %	11.3±0.3	10.7±0.3	7.3±0.2
Mass fraction of protein, %	10.2±0.4	14.7±0.5	11.5±0.4
The amount of gluten, %	32.3±0.9	-	-
Gluten quality, GDI units	68±1,1		
Mass fraction of fat in terms of dry matter, %	1.10±0.02	23.5±0.5	3.03±0.03
The content of dietary fiber, g/100 g, including:	3.71±0.03	8.63±0.04	4.92±0.03
- soluble,	0.90±0.02	2.81±0.03	1.12±0.02
- insoluble	2.81±0.03	5.82±0.05	3.80±0.05
Ash content in terms of dry matter, %	0.57±0.02	4.17±0.07	2.62±0.06
Mineral elements, mg/kg			
P	1040.2±53.4	6110.4±79.6	4210.3±49.2
Ca	237.1±19.2	3007.2±64.7	3100.0±55.2
Cu	2.0±0.3	15.9±1.8	4.5±0.7
Fe	53.1±4.2	113.2±6.1	46.4±2.4
Mg	300.1±21.7	3328.3±58.9	1887.3±33.1
Zn	19.8±2.2	40.5±3.3	24.9±2.3
Se	0.26±0.10	1.6±0.6	1.1±0.4

balance of walnut protein by the amino acid composition significantly prevails over the full value condition of wheat protein (Khutsishvili, Druker & Kryuchkova, 2017).

In our further studies, emphasis was placed on the comparative assessment of nutritional value of the first-grade wheat bread flour and the walnut flour, to establish the effectiveness of substituting the conventional raw materials with the original plant material.

We have established a relatively high oil content in the walnut raw material. So, the content of lipids in the unconventional material exceeds their content in the wheat flour by 21 fold. It is known that essential polyunsaturated fatty acids of ω-3, ω-6 and ω-9 families prevail in the walnut oil (Sorokopudov *et al.*, 2011). The high contents of δ- and γ-tocopherols (natural antioxidants) in the oil protects its lipid complex from oxidation (Dmitrieva & Makarova, 2015; Kamzolova, Lipskaya & Borisevich, 2006; Makarova, Dmitrieva & Valiulina, 2014). It should not go unnoticed that the walnut flour excels both in the total content of dietary fiber and in the amount of insoluble fiber. The increase in the content of dietary fiber in bread due to the substitution of the raw materials can change the rheological properties of the dough and the finished product.

The high ash content of the unconventional raw materials was reflected in its mineral composition. Thus, as compared to the wheat raw materials, the walnut flour contains more of the following mineral elements: calcium (by 12.7 fold), magnesium (by 11.1 fold), copper (by 7.9 fold), selenium (by 6.1 fold), phosphorus (by 5.8 fold), and iron and zinc (by 2 fold). This circumstance will allow us to increase the nutritional density of the modified bread and reduce the deficit of certain minerals in the consumer diet. It is also obvious that the use of the complex of food additives in the buckwheat mix, namely, orthophosphate, carbonate and calcium acetate, added to the content of phosphorus and calcium in the buckwheat flour, contributed to an increase in the content of these macronutrients by 4 and 13.1 fold, respectively. The relatively high level of selenium contained in the baking mix is apparently connected with the inclusion of wheat bran in its composition, since it is known that more selenium is found in wheat bran than in wheat grain, wheat or buckwheat flour (Chernyshev *et al.*, 2017; Kovalevich & Golovatyi, 2010; Ponomareva, Semenova & Subbotina, 2018; Skalnaya *et al.*, 2019).

3.2. The quality and nutritional value of bread

At the next stage of the research, the walnut flour was introduced into the bread recipe in the dosages of 5, 10 and 15% by substituting it for the wheat flour. It was revealed (Figure 3) that the control and experimental samples had visible differences only in the color of crumbs and the height of the loaves. The color of the control samples is light brown, uniform throughout the weight; the experimental samples have a slight dark brown shade, somewhat increasing with the content of walnut flour. The bread height of the control samples is 13.0±0.2 cm in the cross section; in experiment 1 it is 12.2±0.2 cm, in experiment 2 – 11.1±0.1 cm, and in experiment 3 – 10.2±0.3 cm, which makes the experimental samples somewhat stunted. The taste and smell of all the bread samples contain tones characteristic of the buckwheat culture, without extraneous flavors and smells.

(a) control (b) experiment 1 (c) experiment 2 (d) experiment 3

Figure 3. The appearance of the model bread samples

The use of a 5-point score during the tasting evaluation of the model bread samples allowed us to study in more detail the differences in their organoleptic characteristics (Table 3).

It has been established by the score that the difference between the control and experimental bread samples is insignificant – from 1 to 4 points. At the same time, the experimental sample with the largest substitution of the wheat flour with the unconventional raw materials (experiment 3) has relatively low scores for volume, bread shape accuracy and porosity structure of the crumbs. However, according to the above indicators, the bread containing 15% of walnut flour has a “good” quality, and according to its taste and aromatic characteristics it does not differ from the control sample, which allows us to consider it as an object for further technological research.

The measurements showed that the substitution of the wheat flour with the walnut raw materials in the recommended 15% dosage reduced the porosity of bread by 10.9%, but increased the acidity of the products by 19.4% and brought them outside the regulatory standards in terms of this indicator (Table 4).

To date, there is a positive experience of using dry wheat gluten in the composition of the baking mix for the production of bread from the first-grade wheat flour to increase its porosity and specific volume to the standard levels (Nesterenko & Anisimova, 2015; Sauir, Yusupov & Ivannikova, 2016).

In the production of “Fitness” bread, according to the requirements of TU 9110-006-18256266-2005, the quantity of the buckwheat mix can go up to 20%, with no set lower limit.

Taking into account the aforesaid, we considered several variants of modifying the formulations of experimental samples 3 by substituting 2% (experiment 4), 4% (experiment 5) and 6% (experiment 6) of “Fitness mix” buckwheat baking mix with wheat gluten (brand A, Manufacturer Pervyi Diabeticheskiy LLC, Russia, Moscow) and obtained the following results (Table 5).

It has been established that the modified bread samples with the substitution of 4% of the buckwheat mix with an identical amount of wheat gluten are as close as possible to the control sample by the studied parameters, against the background of the formation of a new taste feature, namely a pleasant nutty flavor, and a lighter crumb tone. Additional studies revealed (Figure 4) that the microstructure of the model bread samples had no visible differences. Based on these observations, the control sample and experiment 5 were used in further tests.

Table 3. Tasting evaluation of the model bread samples

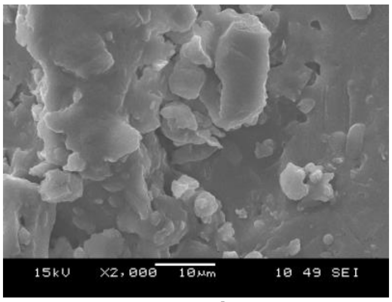
Target indicator	Weight coefficient	Tasting evaluation results, points			
		control	experiment 1	experiment 2	experiment 3
Volume of the pan bread	3.0	14.2±0.2	13.8±0.2	12.6±0.3	11.9±0.3
Structural and mechanical properties of the crumb	2.5	12.5±0.0	12.5±0.0	12.5±0.0	12.5±0.0
Smell	2.5	12.5±0.0	12.5±0.0	12.5±0.0	12.5±0.0
Taste	2.5	12.5±0.0	12.5±0.0	12.5±0.0	12.5±0.0
Crumb color	2.0	10.0±0.0	9.8±0.1	9.7±0.1	9.5±0.2
Porosity structure	1.5	7.5±0.0	7.3±0.2	7.1±0.2	6.9±0.3
Shape accuracy	1.0	5.0±0.0	4.8±0.1	4.3±0.2	4.0±0.2
Crust color	1.0	5.0±0.0	5.0±0.0	5.0±0.0	5.0±0.0
Crust surface condition	1.0	5.0±0.0	5.0±0.0	5.0±0.0	5.0±0.0
Chewability	1.0	5.0±0.0	5.0±0.0	5.0±0.0	5.0±0.0
Quality by the set of the indicators	-	89	88	86	85

Table 4. Physical and chemical parameters of the model bread samples

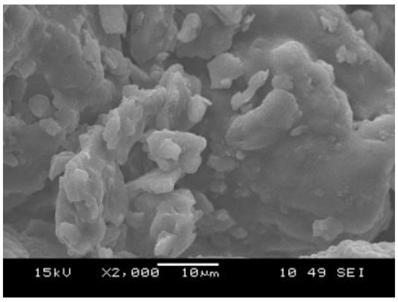
Target indicator	Standard as per TU 9110-006-18256266-2005	Test results	
		control	experiment 3
Specific volume, cm^3/g	no regulated	3.79±0.03	3.37±0.02
Porosity, %		73.5±0.9	65.5±1.1
Acidity, degrees	no more than 4.0	3.6±0.3	4.3±0.2

Table 5. Physical and chemical parameters of the model bread samples after modification

Target indicator	Test results		
	experiment 4	experiment 5	experiment 6
Specific volume, cm^3/g	3.53±0.02	3.82±0.03	3.71±0.02
Porosity, %	69.2±0.8	73.4±0.9	72.2±0.7
Acidity, degrees	4.0±0.2	3.7±0.3	3.4±0.2



control



experiment 5

Figure 4. The microstructure of the model bread samples

It has been determined that the moisture content of the control and modified bread samples corresponds to the established standard - no more than 46.0% (Table 6). The bread of the modified formulation is characterized by increased contents of plant lipids (by 3.9 fold) rich in polyunsaturated fatty acids; proteins (by 46.1%); soluble substances (by 47.5%) and ballast (by 23.6%) fibers stimulating the operation of the gastrointestinal tract; along with mineral elements.

The new products showed a relatively high content of magnesium (by 2.1 fold), calcium (by 1.8 fold), selenium (by 1.7 fold), phosphorus (by 1.6 fold), copper (by 1.4 fold), iron (by 25.1%), and zinc (by 22.5%).

The vitamin value of the experimental sample of "Fitness" buckwheat bread also increased due to a 1.5-1.6 fold increase in the contents of thiamine and riboflavin. The elimination of the vitamin and mineral deficiency in the diet of the employable population is the most important factor in maintaining their health and performance (Dasguta & Klein, 2014). The role of each of these micronutrients in the metabolism of the human body is undeniable (Vdovina, 2019).

4. Conclusions

We have proved the effectiveness and established the feasibility of modifying the recipe of "Fitness" buckwheat

Table 6. Physical and chemical indicators and nutritional value of the model bread samples

Target indicator	Test results	
	control	experiment 5
Moisture content, %	42.6±1.2	44.3±1.3
Mass fraction of protein, %	6.5±0.4	9.5±0.5
Mass fraction of fat in terms of dry matter, %	1.1±0.2	4.3±0.4
The content of dietary fiber, g/100 g, including:	2.45±0.04	3.17±0.05
- soluble	0.59±0.02	0.87±0.03
- insoluble	1.86±0.04	2.30±0.05
Ash content in terms of dry matter, %, %	0.62±0.05	1.15±0.06
The content of mineral elements, mg/kg		
P	1110.1±44.7	1825.8±51.3
Ca	502.2±15.3	920.9±21.8
Cu	1.5±0.3	2.1±0.5
Fe	32.3±2.4	40.4±3.3
Mg	384.4±13.6	825.8±19.8
Zn	12.9±1.9	15.8±1.7
Se	0.267±0.010	0.465±0.025
The content of vitamins, mg/100 g		
B_1 (thiamine)	0.078±0.023	0.120±0.040
B_2 (riboflavin)	0.14±0.03	0.23±0.06

bread by substituting 15% of the first-grade wheat baking flour with the walnut flour and substituting 4% of “Fitness Mix” baking mix with a similar amount of dry wheat gluten. The modified bread has good consumer properties, is characterized by a high content of plant lipids, proteins, and dietary fiber, and is rich in minerals and vitamins.

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