Technology of functional bread using buckwheat flour

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Abstract. Buckwheat flour contains valuable protein, flavonoids, rutin. It is characterized by proper balance of nutrients. It was revealed that the most common sources of functional ingredients are flour as well as plant raw materials which are added powdered or extracted. Microbiological analysis of sourdough used in production of rye-wheat bread was conducted. One control sample and five test samples of bread were made. Control sample contains wheat flour, rye flour, salt, yeast, water and sourdough. Test samples contain 3, 5, 7, 10 and 15 % of buckwheat flour as well as wheat and rye flours. The content of buckwheat flour was calculated as a percentage of the total mass of flour according to the recipe. Sensory and physical-chemical properties of test samples were determined. Each sample was rated on a five-point scale by five quality indicators which are taste, colour, aroma, texture and bread surface. The average score for each indicator for each sample was not less than 4.5 points. Specific loaf volume, acidity, moisture content and porosity were determined. It was revealed that along with increasing of buckwheat flour mass, the porosity and specific loaf volume of the bread samples decrease. Acidity and moisture content of control and test samples are the same. Content of nutrients in bread sample containing 15 % of buckwheat flour was calculated. Taking into account calculated content and daily intake of nutrients it can be concluded that obtained bread can be regarded as functional which provides the human body with iron.

1. Introduction

Modern technology allows making healthy food products. One of these type products is functional foods.

According to [1], the ingredients that make up the functional products are divided into several types such as food fibers, vitamins, minerals, fats, polysaccharides, secondary plant compounds, probiotics, prebiotics, synbiotics.

Bakery products form the basis of people’s nutrition in Russia. While making bakery products different types of flour and plant raw materials are the most common sources of functional ingredients. Production of bakery enriched with functional ingredients and nutrients is the subject of current interest.

A.Wirkijowska in [2] establishes the way of using by-products from flaxseed industry for functional bread production. Flaxseed flour and marc were used. Wheat flour was partly replaced by these by-products. 5, 10 and 15 % of flour and marc were used. It was revealed that addition of flax
components decreases the stability of dough according to conducted farinograph analysis. It can be explained by the fact that the flax components hinder the hydration and extension of gluten peptides.

Analysis of chemical composition of bread samples revealed the following. Addition of flaxseed flour and marc causes the increase of content of food fiber, protein, fat, minerals. The optimal dosage of flaxseed by-products is 10%. Structural properties of bread crumb were analyzed. It was established that addition of flax components increases hardness of bread and decreases its porosity.

The possibility of using leaves extract of stinging nettle Urtica dioica in bread production is studied. Dried nettle leaves were subjected to microwave extraction. Obtained extracts were added into dough. An antioxidant activity was determined by the assessment of the activity of the analyzed samples toward the DPPH radicals. It was established that addition of nettle extracts in bread allows making functional product containing micro and macro nutrients and having antioxidant activity [3].

In paper [4] the way of using powdered cloudberry Rubus chamaemorus in bakery production is reviewed. Cloudberry powder was made from dried cloudberry marc. Wheat flour was partly replaced by this powder. Content of cloudberry powder was from 1 to 7%. It was established that addition of powdered cloudberry allows keeping the specific volume of dough while being frozen. Antioxidant activity using FRAP method was determined. The addition of cloudberry increases antioxidant activity of bakery products due to hydrolysis of ellagitannin.

Types of chemical compounds that improve the structure of whole wheat bread and give it functional properties are reviewed in [5]. It is specially noted that despite the associated health benefits of whole grains, consumption of whole grain products remains far below recommended levels. It can be explained by features of whole grain bread such as low loaf volume, firm texture, rough crust and reduced shelf-life. This is why it is necessary to make new types of quality functional bread containing whole grains.

Types of compounds that are recommended to be added in whole white bread are described. These compounds are enzymes, emulsifiers, hydrocolloids, oxidants. Among enzymes the most recommended are xylanase, phytase, amylase, amyloglucosidase, cellulase, transglutaminase. The effect of xylanase addition on dough properties, hardness and crumbling of bread is studied. It was revealed that xylanase addition reduces water absorption of whole wheat flour and increases volume and softness of bread due to hydrolysis of arabinoxylans. The effect of emulsifiers on dough properties, loaf volume, hardness and sensory properties of crumb is studied.

According to [6] seeds and husk of plantago can be used in production of bread. Two species of plantago such as Plantago psyllium and Plantago ovata were used. The amount of seeds and husk was 4 g and 8 g. It was established that the greatest effect was obtained when Plantago ovata husk was added into dough. Obtained dough is characterized by high stability, increased development time. The probability of polysaccharides retrogradation decreases. The addition of plantago seeds and husk causes the increase of protein content. Also Plantago psyllium seeds increases antioxidant activity of bread.

The possibility of using fermented milling by-products as a source of functional ingredients is studied in [7]. Milling by-products were fermented using Lactobacillus plantarum and Lactobacillus rossiae. They were added in dough produced using sourdough. The dosage of fermented milling by-products was 15%. It is noted that the use of these products allows improving biochemical, functional, nutritious and sensory properties of wheat bread. Besides, protein containing in bread has higher digestion rate. Hydrolysis of starch also increased. Obtained bread can be defined as “low glycaemic index”.

Much attention is given to the development of equipment that allows improving properties of functional bakery. Production of mixtures that can be used in functional bread production is studied in [8]. Made mixture includes the following components: several types of flour such as wheat, whole wheat, chickpea, rye and buckwheat, oat bran, powdered gluten, dried milk, sesame, flax seeds, dried onions, salt and sugar.
One of the most important steps in mixture production is thorough mixing of all ingredients. That is why auger mixer was developed. The optimal mixer parameters such as rotor speed, number of turns of the auger, number of holes on the turns of the auger were calculated.

The possibility of partial replacement of wheat flour by buckwheat flour in recipe of rye-wheat bread in order to obtain functional bread is considered in this research. Research was carried out in Food Production Department of Samara State Technical University.

Buckwheat flour has several useful properties. It is known that buckwheat’s proteins are high biological value and well balanced. Besides, buckwheat contains micro and macro nutrients, flavonoids, flavons, phytosterols, phagopyrins. Buckwheat contains plant metabolite rutin which is very valuable. It exhibits biological activity, strengthens the walls of capillaries in living organisms [9].

2. Materials and methods
The functional bread production process using buckwheat flour involves several stages.

2.1 Microbiological analysis of sourdough
According to the methods described in [10], total microbial content, content of lactic acid bacteria, yeast and putrefactive bacteria were determined. The following growth mediums were used: meat peptone, MRS agar, wort agar, milk agar. Cultivation was carried out at 30 °C for 72 hours. Then the number of colonies was counted.

2.2 Production of control and studied bread samples
The following recipe was used in order to make control bread sample. The sourdough was withstanded at 30 °C for 40 minutes to activate its microorganisms. Dough containing 134 g of wheat flour, 64 g of rye flour, 1.5 g of powdered yeast, 4 g of salt and 40 g of sourdough was mixed by hands. Fermentation of dough was at 30 °C during 2 hours. After first and second hour the dough was punched down. Then the dough was molded and left to rise for another 40 minutes at 30 °C. After that bread was baked at 220 °C during 25 minutes.

The bread recipe was changed in order to make studied samples. Five bread samples containing 3, 5, 7, 10 and 15 % of buckwheat flour were made. The amount of buckwheat flour was calculated as a percentage of total flour mass. Calculated amount was subtracted from the mass of wheat flour. Therefore wheat flour content in studied samples decreases. Technology of bread making was the same as the technology used in control sample making.

2.3 Determination of sensory and physical-chemical properties
A commission of ten people assessed sensory properties of bread samples. Each sample was rated on a five-point scale by five quality indicators which are color, taste, aroma, texture, bread surface. Based on the results of the averaged scores, a radar chart was made.

The physical-chemical properties of bread samples such as specific loaf volume, porosity, acidity and moisture content were determined. Control and obtained samples were analyzed. The following properties were determined. All analyses were established according to the Russian technical standards GOSTs.

Specific loaf volume was measured by extrusion method using millet as a bulk filler.

The porosity was examined using the Zhuravlev device consisting of a cylinder of known volume with a sharpened end. By using this cylinder bread was excavated. The porosity was determined by the ratio of the cylinder volume and the mass of the obtained excavation.

To establish acidity 25 g of bread crumbs and 250 ml of water were shaken for 2 minutes. After 10 minutes mixture was shaken for another 2 minutes. After another 8 minutes obtained mixture was filtered. 50 ml of filtrate and 2-3 drops of phenolphthalein were placed in the glass conical flask. The content of flask was titrated using solution of KOH. Concentration of KOH solution was 0.1 mol/dm³.
Moisture content was established using the thermogravimetric method. The milled 5 g sample was dried at 130 °C for 40 minutes at the drying cabinet AKROS 4610.

2.4 Content of nutrients calculation
According to the Russian technical standard GOST 52349-2005 «Foodstuffs. Functional foods. Terms and definitions», food product can be regarded as functional if its portion contains no less than 15 % of any nutrient daily intake. Content of nutrients in bread sample containing 15 % of buckwheat flour which is equivalent 29.7 g was calculated. Reference data on the composition of vitamins, micro and macro elements in buckwheat flour according to [11] were used. The calculation was carried out according to the following formulas:

\[ X = \frac{X_1 \cdot 0.297 \cdot 50}{N} \]  

(1)

where: \( X \) – amount of nutrient in portion of bread, mg; \( X_1 \) – amount of nutrient in 100 g of buckwheat flour according to [11], mg; 0.297 – coefficient for recalculation of nutrient content in 29.7 g of buckwheat flour; 50 – mass of bread portion according to [11], g; N – mass of bread loaf, g.

\[ A = 0.15 \cdot DI \]  

(2)

where: A – minimal amount of nutrient in portion of functional bread, mg; DI – nutrient’s daily intake according to [11], mg; 0.15 – coefficient for calculating 15 % of the daily intake.

Therefore if \( X \geq A \) then bread sample can be regarded as functional due to it provides the human body with any nutrient.

Content of Na, K, Ca, P, Fe, vitamin \( B_1 \) in bread sample containing 15 % of buckwheat flour was calculated.

3. Results and discussion
During the microbiological analysis of sourdough it was established that total microbial content is \( 40 \cdot 10^{10} \) CFU/g (colony-forming units per gram). Content of lactic acid bacteria is \( 12 \cdot 10^{10} \) CFU/g. Yeast content is \( 5 \cdot 10^{10} \) CFU/g. Content of putrefactive bacteria is 0 CFU/g.

By following the recipe described in 2.2 five studied bread samples containing 3, 5, 7, 10 and 15 % of buckwheat flour were made. Control bread sample containing wheat and rye flour was also made.

Sensory properties of bread were assessed by a commission of ten people. Five-point scale was used. The average score for each indicator was calculated. Based on calculated data, the chart presented in figure 1 was made.

![Figure 1. Sensory properties of obtained bread on a five-point scale](image-url)
The crumb of obtained bread samples has brown color with a shade of gray which is common for this type of bread. Buckwheat aroma of the sample containing 15% of buckwheat flour was the most expressed. There were cracks on the surface of this sample which is why the average score on bread surface indicator was reduced. Nevertheless, sensory properties of obtained bread samples were highly assessed. The average score for each indicator is no less than 4.5 points.

Physical-chemical properties of functional bread were determined. The results of this analysis are presented in table 1.

**Table 1. Physical-chemical properties of functional bread**

| Type of sample         | Specific volume, sm$^3$ | Porosity, % | Acidity, $^\circ$ | Moisture content, % |
|------------------------|-------------------------|-------------|-------------------|---------------------|
| Control                | 742                     | 78.1        | 2.3               | 45.4                |
| Studied samples        |                         |             |                   |                     |
| 3 % of buckwheat flour | 734                     | 77.5        | 2.4               | 45.2                |
| 5 % of buckwheat flour | 728                     | 68.7        | 2.1               | 44.7                |
| 7 % of buckwheat flour | 505                     | 67.3        | 2.4               | 45.3                |
| 10 % of buckwheat flour| 460                     | 65.2        | 2.6               | 45.5                |
| 15 % of buckwheat flour| 440                     | 63.7        | 2.4               | 45.7                |

With an increase of the buckwheat flour content in rye-wheat bread, the porosity and specific volume of the resulting products decrease. The acidity and moisture content of all samples are similar.

Using formulas given in 2.4 content of nutrients in bread sample containing 15% of buckwheat flour was calculated. The results are presented in table 2.

**Table 2. Calculation of nutrient content in 15% bread sample**

| Nutrient name | Amount of nutrient in portion of bread, mg | Minimal amount of nutrient in portion of functional bread, mg |
|---------------|-------------------------------------------|-------------------------------------------------------------|
| Na            | 0.12                                      | 360.00                                                      |
| K             | 5.27                                      | 525.00                                                      |
| Ca            | 1.70                                      | 150.00                                                      |
| P             | 1.95                                      | 150.00                                                      |
| Fe            | 10.14                                     | 2.10                                                        |
| $B_1$         | 0.02                                      | 0.27                                                        |

It can be concluded that bread sample containing 15% of buckwheat flour can be regarded as functional which provides the human body with iron. This micro element is very important for human health.

Iron is a component of hemoglobin which is erythrocyte protein. It is responsible for the transfer of oxygen to all organs and systems of human body. Moreover, iron in the human body is a part of many enzymes and proteins that are necessary for metabolic processes such as the destruction and utilization of toxins, cholesterol metabolism, and the conversion of calories into energy. It also helps the body's immune system deal with aggressors.
4. Conclusion
Buckwheat flour has several advantages. It can be used to add in bakery products. Five samples of bread containing wheat, rye and buckwheat flour were made.

Sensory properties of obtained bread are satisfactory. The average score for each sensory indicator is no less than 4.5 out of 5 points.

It was established that introduction of buckwheat flour affects porosity and specific volume of bread. Obtained samples are qualitative.

During the calculation it was revealed that bread containing 15 % of buckwheat flour is a source of iron for human body. Considering that this bread sample also contains flavonoids, flavons, phytosterols, phagopyrins, rutin it can be concluded that obtained product is healthy and exhibits biological activity.

In the future it is planned to continue research and to create new technologies of functional bakery containing nutrients, functional ingredients and different types of flours and non-traditional raw materials.

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