

Technology of functional bread using sorghum flour

Olga Temnikova, Elena Rudenko, Galina Mukovnina, and Anna Ruzyanova*

Samara State Technical University, Samara 443100, Russia

Abstract. The production of functional bread is considered in this paper. It is suggested to make bread using mix of wheat and sorghum flour. Mathematical modeling of experiment in order to calculate the optimal dosage of sorghum flour in the recipe was carried out. It was established that introduction of sorghum flour allows decreasing the amount of sugar in the recipes. The determination of physical-chemical properties of bread samples was conducted. Acidity, wet content and porosity of bread samples were determined. Obtained bread can be classified as functional because the portion of the bread contains more than 15 % of magnesium, manganese and silicon daily intake.

1 Introduction

In the modern world special attention is paid to the quality of food products. According to the several scientific studies proper nutrition is one of the factors necessary to maintain people's health and ensure long life.

Functional food is one type of food products that are considered in modern scientific researches. Functional food products must contain at least one of the functional ingredients such as food fiber, vitamins, minerals, polyunsaturated fat acids, probiotics, probiotics and sinbiotics.

The issue of making functional food products based on new types of cereals is of particular relevance in Russia. The reason is that products based on flour and grains are the base of Russian people nutrition [1].

2 Literature review

According to the work [2] functional product is the one the portion of which contains no less than 15 % of functional ingredient daily intake. The production of functional foods is the subject of several modern studies. This subject is considered by either Russian and foreign scientists. Let us review scientific papers dealing with the production of functional food products.

The scientists of St. Petersburg State University of Trade and Economics consider possibility of making baby food containing functional ingredients isolated from fruits and vegetables [3]. Samples of mashed pears, pumpkins and broccoli were bought for analysis. Ascorbic acid content was determined. It was revealed that ascorbic acid was additionally added to increase nutritional value of food products. Content of potassium, iron, carotene and phenolic compounds was determined. It allowed identifying brands of mashed fruits and vegetables that suits the best way for making baby food.

Resistant starch is considered is functional ingredient in [4]. It is noted that resistant starch has the low speed of splitting and the low glycemic index. In this way, starch is not digested in small intestine. Thus resistant starch is a food fiber. It helps to remove toxic compounds from the gastrointestinal tract. Researchers of Orel state agrarian University suggest to use resistant starch isolated from peas in production of sausages. Several samples containing resistant starch were obtained. Basing on analysis that was carried out it was revealed that the optimal dosage of pea starch is 4 %. It is partly substitute potato starch and allows increasing the viscosity of minces meat.

Great attention is paid to production of functional breads and pastries containing functional ingredients. Bakery products obtained according to classical recipes are often unbalanced in terms of energy and nutritional values. This is why it is a subject of current interest to search functional ingredients that allows obtaining functional bakery products.

Scientists of Far Eastern Federal University solve this problem by using biologically active food additive isolated from kelp *Fucus evanescens* [5]. It was established that the introduction of this additive has a positive effect on the bread quality, its organoleptic properties, shape stability and volume.

The production of functional foods is a subject of current interest for Europe and Asia too. It is specially noted in [6] that Japanese people are well-known for their longevity. Consuming of different functional food products is one of the possible reasons. Nutrition of Japanese people is highly balanced. Functional foods contain fats having a high level of biological activity; compounds that control GI tract, level of cholesterol and that normalize blood pressure.

The design of novel functional food products enriched with bioactive extracts from holothurians is considered in [7]. The method of holothurians hydrolysis was developed. Obtained hydrolysates present high antioxidant

* Corresponding author: ruzanova96@mail.ru

and antihypertensive activity. That is why it is suggested to use obtained hydrolysates in production of products for elderly people. It is noted that consuming of these products allows elderly people having active lifestyle.

The way of making functional bread is studied in this research. There are two methods of bread production. Direct method allows baking bread after mixing all of the ingredients. The advantages of this method are speed and simplicity. It takes about 3.5 hours to bake bread using direct method.

The second method is called method using sourdough. It is a mixture consisting of partially taken flour, water, sugar and yeast. This sourdough ferments for 3 or 4 hours which is why production of bread using sourdough method takes much longer than using direct method. The fermentation time of the sourdough depends on the temperature, consistency, quality and quantity of yeast and the quality of the flour. Both of methods were used in this research.

Sorghum flour was used as functional ingredient in this research. It is a type of gluten-free flour. According to [8] sorghum cereals have high yields in arid climates and are resistant to frost, which is especially valuable for farmers in Russia.

In previous studies [9] it was noted that using sorghum flour in production of gluten-free pastries allows reducing amount of sugar by three times. It is explained by the fact that sorghum flour contains sweet taste carbohydrate compounds. In this regard, it was our great interest to find out whether it is possible to reduce the containing of sugar in bread, if the wheat flour in the recipe is partly replaced with sorghum flour. Excessive sugar intake negatively affects people's health. In particular, it increases the risk of developing type 2 diabetes, slows down the digestion process, and contributes to the development of caries and weight gain. Therefore the production of low sugar food products is a subject of current interest.

3 Methodology

The functional bread production process involves several stages.

3.1 Bread recipe selection and baking of control samples

Two bread recipes were used in this research according to [10]. Control samples were made using only wheat flour.

Direct method of bread production includes the following steps. Dough containing 120 ml of water, 9 g of vegetable oil, 8 g of sugar, 10 g of salt, 187 g of wheat flour and 5 g of yeast was mixed by hands. Fermentation of dough was at 30 °C during 2.5 hours. After first and second hour the dough was punched down. Then the dough was molded and left to rise for another 30 minutes at 35 °C. After that bread was baked at 180 °C during 40 minutes.

Method using sourdough includes the following steps. Sourdough containing 180 g of wheat flour,

120 ml of water, 4 g of sugar and 5 g of yeast was mixed by hands. Fermentation of sourdough was at 30 °C during 3 hours. Then 105 ml of water, 18 g of vegetable oil, 30 g of salt, 12 g of sugar and 220 g of wheat flour were added to the sourdough. Obtained dough was fermenting at 30 °C during 1 hour to increase the volume by two times. Then the dough was molded and left to rise for another 30 minutes at 35 °C. After that bread was baked at 180 °C during 40 minutes.

3.2 Bread baking experiment mathematical modeling

After making of control samples it was necessary to model experiment in order to determine the optimal dosage of sorghum flour and sugar in both recipes using mathematical methods. The studies were carried out using method of mathematical planning using Statistica 10.0. Central composite rotatable design was made to assess the impact of selected factors.

3.3 Production of bread samples using mixture of wheat and sorghum flour

Production of bread samples was according to recipes described in paragraph 3.1. In order to determine the mass of sorghum flour that should be added to the dough, percentage according to the obtained design was calculated from the total mass of wheat flour, after which it was subtracted from the total amount. Thus all of the samples were made using mixture of wheat and sorghum flour. The mixture in each sample had a different ratio of components.

While making bread using sourdough sorghum flour was partially added into sourdough and the rest amount was added later along with the rest of ingredients.

3.4 Determination of organoleptic properties of obtained samples

The assessment of organoleptic properties of obtained samples was carried out by potential customers. There were twenty potential customers. The assessment of organoleptic properties was carried out according to sensory analysis method according to [11]. Each sample was rated on a five-point scale by five quality indicators which are shape, crust, aroma, taste, texture. The obtained scales were summarized, and the average score for each indicator was calculated. The total score was calculated for each sample. The total score reflects the quality of obtained products. Therefore, it was taken as a response in order to make fitted response surface.

3.5 Result analysis and determination of optimal dosage of sugar and sorghum flour using response surface

Two types of response surface were obtained by using total score of organoleptic properties for each of twenty made samples. Obtained surfaces reflect the dependence between content of sorghum flour and sugar and the total

score of organoleptic properties. The optimal dosage of components was determined by using obtained graphs. It was necessary to check the adequacy of regression models using normal probability plot of residuals.

3.6 Analysis of obtained bread samples

One sample was taken from each batch for analysis. Each sample, on the one hand, has the best the total score of organoleptic properties, on the other hand, the maximum content of sorghum flour and the minimum content of sugar.

Control and obtained samples were analyzed. Following properties were determined. All analyzes were established according to the Russian technical standards GOSTs.

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 thermogravimetric method. The milled 5 g sample was dried at 130 °C for 40 minutes at the drying cabinet AKROS 4610.

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.

Content of minerals in analyzed samples was calculated using reference data given in [12]. It allowed revealing whether obtained bread samples can be classified as functional bread.

4 Results

Research of making functional bread was carried out in Food Production Technologies Department of Samara State Technical University. First of all control samples of bread using 100 % of wheat flour were made. Obtained control samples were rated as quality. Potential customers noted that control samples had pleasant taste and aroma. It was also noted that control samples of bread kept their shape well during deformation. Based on this, it was concluded that high quality bread can be made according to these recipes.

Using Statistica 10.0 two types of design were made. The first central composite rotatable design was made for production of bread using direct method and the second one was made for production of bread using sourdough. The application of Statistica 10.0 allows getting a design of experiments. The implementation of designed experiments allows determining best values of factors that ensure the highest quality of production. In this case the first factor is content of sorghum flour; the second one is mass of sugar. The determination of

whether it is possible to make low sugar bread using sweet taste compounds that are contained in sorghum flour is a subject of interest. Obtained designs are presented in table 1 and 2.

Table 1. Design of experiments of bread production using direct method

№ of sample	Content of sorghum flour, % of wheat flour content	Sugar mass, g
1	1	0
2	1	8
3	50	0
4	50	8
5	9.6	4
6	59.6	4
7	25	1.7
8	25	9.6
9	25	4
10	25	4

Table 2. Design of experiments of bread production using sourdough

№ of sample	Content of sorghum flour, % of wheat flour content	Sugar mass, g
1	1	0
2	1	12
3	50	0
4	50	12
5	9.7	6
6	59.6	6
7	25	2.5
8	25	14.5
9	25	6
10	25	6

Thereby according to these designs it was necessary to make 10 samples of bread using direct method and to make 10 samples of bread using sourdough. Production of bread was according to recipes described in paragraph 3.1.

In order to maintain evaluation of organoleptic properties of obtained samples each of twenty members of the commission filled out a questionnaire. Every sample was evaluated on a five-point scale by five quality indicators. Earned scales were averaged. Thus we calculated average organoleptic quality score for every sample. These scores were used as the response during making response surface in Statistica 10.0. Obtained surfaces are presented on fig. 1 and 2.

The adequacy of the equations describing the obtained models can be verified using normal probability plot of residuals presented on fig. 3 and 4. The normal distribution of residues confirms that obtained models are adequate. There for they can be used to optimize the recipes of functional bread.

The analysis of obtained response surfaces allows drawing following conclusions. The introduction of sorghum flour in bread recipe allows decreasing the amount of sugar without loss of taste and quality. The optimal dosage of sorghum flour is 20–30 % of total wheat flour content.

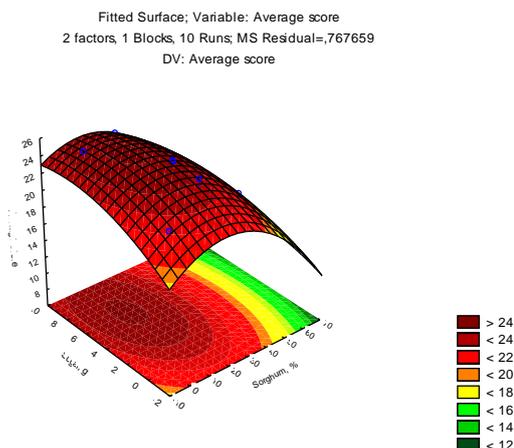


Fig. 1. Response surface using direct method

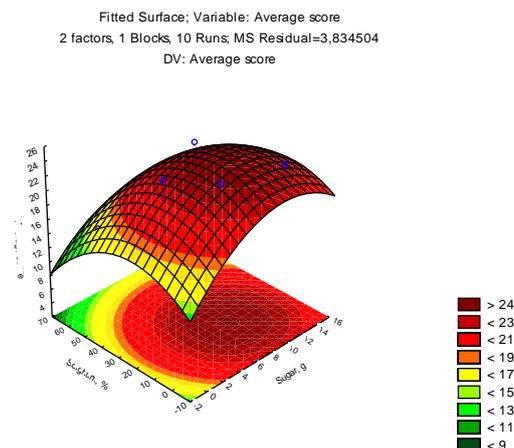


Fig. 2. Response surface using sourdough

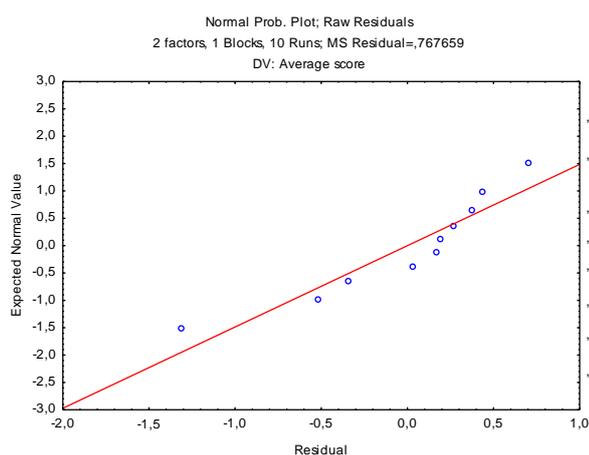


Fig. 3. Normal probability plot (direct method)

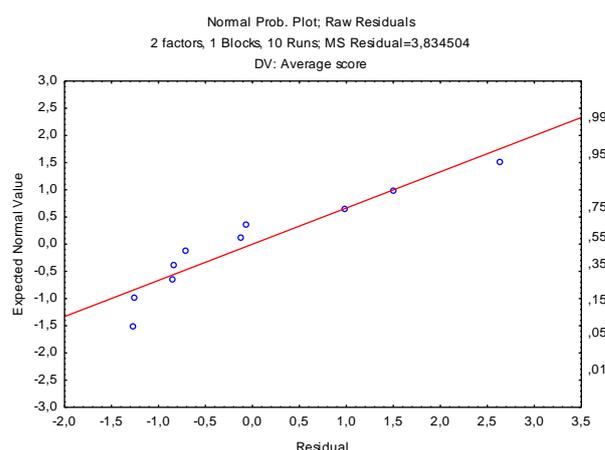


Fig. 4. Normal probability plot (method using sourdough)

Samples №7 from both bathes of bread were selected in order to determine physical-chemical properties. These samples have, on the one hand, the highest content of sorghum flour and, on the other hand, have the lowest content of sugar. Besides, they were highly rated by potential customers. These samples has average organoleptic quality score 24.1 and 24.7 from 25 points.

Acidity, wet content and porosity of these samples were analyzed. The obtained data were compared with the results of control samples analysis. The results of conducted analysis are presented in table 3.

The calculation of the mineral content in the samples was carried out in order to determine whether obtained bread samples can be classified as functional. According to [12] bread portion is 50 g which is why further calculations are carried out on 50 g of bread.

Table 3. Determination of physical-chemical properties of bread samples

Sample	Acidity, deg.	Wet content, %	Porosity, %
Direct method of production			
Test sample	1.2	42	75
Control sample	1.2	43	78
Method of production using sourdough			
Test sample	2.4	43	80
Control sample	2.4	43	84

It is important to take into consideration the fact that content of minerals in sorghum flour is higher that content of mineral in wheat flour. The reason is sorghum flour is a whole meal type of flour. Due to the presence of grain shells particles, the content of several minerals increases. A comparative analysis of the content of micro- and macronutrients in wheat and sorghum flour is presented in table 4.

Table 4. Nutrition content in 100 g of flour

Mineral	Sorghum flour content	Wheat flour content
Micronutrients		
Fe	4.41 mg	5.37 mg
Mn	4.459 mg	3.406 mg
Cu	390 mcg	426 mcg
Zn	2.17 mg	3.46 mg
Macronutrients		
K	246 mg	435 mg
Ca	99 mg	34 mg
Mg	127 mg	90 mg
Si	48 mg	32 mg
Na	28 mg	2 mg
S	98 mg	107 mg
P	298 mg	402 mg

As it is noted in table 4, the content of minerals in sorghum flour exceeds the content in wheat flour by indicators of content of manganese, calcium, magnesium, nitrogen and sodium.

The calculation of minerals content in obtained samples was carried out. It was revealed that bearing in mind recipe components and bread yield portions of obtained samples contain more than 15 % of daily intake of magnesium, manganese and silicon. Therefore obtained bread samples can be classified as functional food products.

5 Conclusion

As a result of the presented research the following conclusions may be drawn. Introduction of 20–30 % of sorghum flour allows obtaining quality food products. They were highly rated by potential customers. During the determination of physical-chemical properties of bread samples it was revealed that acidity, wet content and porosity remain on the same level as the control samples.

Besides, introduction of sorghum flour allows reducing the amount of sugar in recipes. Obtained bread samples are functional products, because they ensure intake of magnesium, manganese and silicon strengthens the immune system, participates in the formation of nails and hair, promotes the synthesis of collagen, and is necessary for the absorption of other nutrients. Magnesium regulates heart rhythm, is involved in controlling blood sugar levels, and is involved in the removal of heavy metal salts from the body.

Manganese is involved in the synthesis of neurotransmitters, is part of cell membranes, and is involved in hematopoiesis. That is why obtained bread samples, if they are included in a person's diet, have a positive effect on the state of human body.

In the future, it is planned to continue developing bakery recipes using sorghum flour, as this is a promising subject.

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