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# STUDY OF THE NUTRITIONAL VALUE OF PLANT MATERIALS USED IN BREAD BAKING

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***Abstract:*** *The purpose of this research was to complete a comparative analysis of the nutritional value of plant materials used in bread baking. It is established that the use of black cumin seed flour for baking wheat and rye bread will allow us to increase the content of dietary fiber and microelements (iron, copper, cobalt, magnesium) in the products; the introduction of sesame flour – the concentration of protein, copper, magnesium, phosphorus, zinc; and the use of cedar nut flour - the content of polyunsaturated fatty acids, manganese, phosphorus, cobalt, copper. In all cases, the substitution of a certain amount of cereal flour with the analyzed non-traditional raw materials will allow us to balance the amino acid composition of bread and reduce the gluten load on the human body.*

***Key words:*** *cereal flour, non-traditional raw materials, nutritional value.*

## 1. Introduction

The search for ingredients and the development of recipes for baked goods with balanced nutrient composition are some of the more promising directions for providing the consumer market with healthy food products. One method of increasing the nutritional value of wheat and rye bread is to introduce non-traditional types of plant materials into the dough [2].

For many centuries, rye and rye-wheat bread has occupied a special place in the diet of the Russian population. Many nutritionists believe that rye bread is superior to other products by its nutritional value and balance; rye flour contains more essential amino acids, minerals, and vitamins than wheat flour [13]. However, the commodity market sells plant materials recommended for use in baking which exceed even rye flour by a set of individual nutrients [2], [7-9], 11]. The purpose of these studies was to provide a comparative analysis of the nutritional value of plant materials used in bake and identify the most promising ones from the perspective of nutritional biology.

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## 2. Materials and Methods

The objects of the research were:

- First grade wheat bread flour and rye bread flour produced by the Magnitogorsk Center of Grain Production (Chelyabinsk region, Magnitogorsk, Russia);
- Black cumin seed flour produced by Altai Cedar (supplier - "VELA" Kedrovy Rai, Moscow, Russia);
- Sesame seed flour produced by Organic Product Factory (Novgorod region, Pankovka, Russia);
- Pine nut flour produced by Dar Altaya (Altai Territory, Barnaul, Russia).

The moisture content of the flours was determined by drying a sample of the raw materials to a constant mass followed by calculation of the indicator being studied. The protein content was determined through sample digestion using the Kjeldahl method; the content of fat – by the extraction method in a Soxhlet apparatus; the content of amino acids - by the capillary electrophoresis method; the content of ash – by a complete burning of the organic portion of the sample of the raw materials with subsequent gravimetric determination of the indicator being studied; the content of phosphorus – by the molybdenum-vanadium method; the content of the remaining mineral elements - by the flame atomic absorption method; and the content of dietary fiber - by hydrolysis and the removal of protein and starchy substances using enzymes analogous to the enzymes of the human digestive tract from plant-based biologically active supplements [10]. The microstructure of the raw materials was determined on a JSM-6460LV scanning electron microscope (JEOL Company, Japan).

All the studies were carried out five times. A statistical analysis was performed using Microsoft Excel XP and Statistica 8.0. The statistical data error did not exceed 5% (at 95% confidence level).

## 3. Results and Discussion

### 3.1. Study of the Chemical Composition of Flour

At the first stage of our research, we studied the physicochemical indicators of the analyzed raw plant materials in a comparative aspect. The test results are shown in Table 1.

Table 1

*Chemical composition of flour made of various types of raw plant materials*

| Name of indicator | Test results | | | | |
|---|---|---|---|---|---|
| | **Wheat flour** | **Rye flour** | **Black cumin seed flour** | **Sesame seed flour** | **Pine nut kernel flour** |
| Moisture content, % | 14.1 ± 0.3 | 11.0 ± 0.4 | 7.2 ± 0.7 | 5.7 ± 0.5 | 3.2 ± 0.3 |
| Mass fraction of protein,% | 10.7 ± 0.5 | 10.0 ± 0.6 | 40.6 ± 1.4 | 58.2 ± 1.5 | 20.8 ± 0.6 |
| Mass fraction of fat,% | 1.5 ± 0.2 | 1.3 ± 0.2 | 10.2 ± 0.5 | 15.8 ± 0.7 | 54.2 ± 1.3 |
| Mass fraction of ash,% | 0.92 ± 0.02 | 1.60 ± 0.02 | 6.46 ± 0.03 | 6.04 ± 0.05 | 3.07 ± 0.02 |
| Content of soluble and insoluble dietary fiber, g/100 g | 12.1 ± 0.5 | 30.8 ± 0.9 | 56.3 ± 1.0 | 50.4 ± 1.2 | 46.5 ± 0.9 |

Our studies showed that the moisture content in cedar nut flour was more than 4 times lower (3.2±0.3%) than in wheat flour (14.1±0.3%). Rye flour (11.0±0.4%) was the closest to wheat flour by the moisture content. The moisture content of the raw material is an important indicator when calculating the amount of water needed for dough kneading.

A significant amount of oil was found in pine nut flour. The content of lipids in it significantly exceeded the concentrations established in the raw material under testing: from three times more than the established amount in sesame flour to 41.7 times more than in rye flour. It is known that the lipid phase influences the plastic properties of dough. The use of cedar nut flour in the production of wheat and rye bread can change the rheological characteristics of this semi-finished product. An increase in the concentration of polyunsaturated fatty acids in bread due to the additional introduction of the non-traditional raw materials being studied will allow us to reduce the risk of developing cardiovascular and oncological diseases and the level of cholesterol, and increase the functions of the immune system, the resistance of the organism to infections and catarrhal diseases, etc. [4].

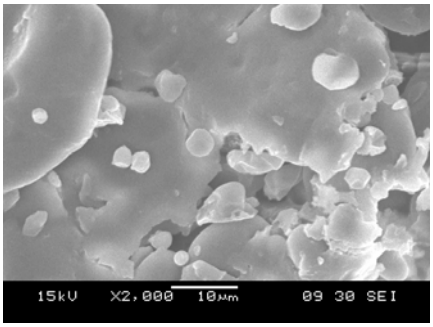
It has been noted in several scientific works that the dietary fibers in rye flour have increased water-absorption, adsorption, ionic and buffer capacities, and increase peristalsis of the intestine and removal of carcinogenic substances and other harmful metabolic products from the body [7-9], [11]. Our studies have shown that rye flour is inferior to the studied types of non-traditional raw materials in terms of the content of soluble and insoluble dietary fiber. Thus, cedar nut flour contains 1.5 times more dietary fiber than rye flour, while black cumin seed flour contains 1.8 times more dietary fiber; wheat flour is significantly inferior.

According to experts, Russia belongs to the group of countries where a large number of citizens (2.5 to 4.0%) suffer from a chronic protein deficiency [6]. Therefore, it is necessary to study the amount of protein contained in the analyzed material and to determine the possibility of increasing the biological value of wheat and rye bread. Our results show that the protein content in cedar nut flour is two times higher than the amount found in rye flour, while it's content in black cumin seed and sesame seed flour is 4 and 6 times more, respectively.

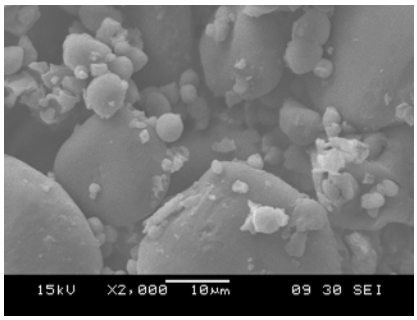
The structure of protein molecules determines the properties of dough and influences the quality of bread. In this connection, we studied the microstructure of the analyzed flour samples of flour, the results of which are shown in Figure 1.

Analysis of the morphology of flour microparticles has shown that all the samples contain spherical protein structures, ranging from 3-4 microns in pine nut flour to 40 microns in wheat and rye flour.

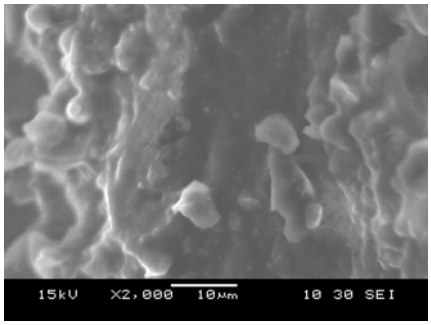
It is also necessary to take into account that the non-traditional raw material under study does not contain gluten [6], which determines the physicochemical properties of dough and influences the quality of the finished product.



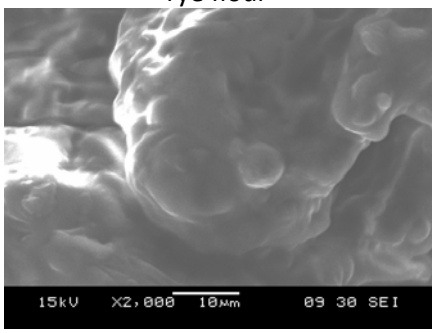

wheat flour



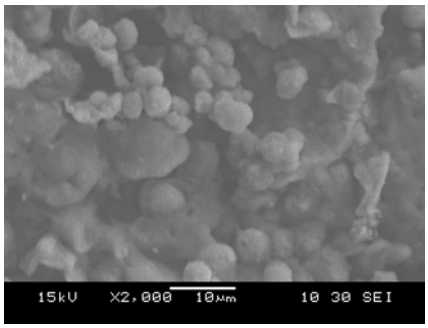

rye flour




black cumin seed flour




sesame flour




pine nut flour

Fig. 1. *Microstructure of flour consisting of various types of raw plant materials (2000x magnification)*

Today, in-depth studies of gluten-sensitive enteropathy allow us to state three forms of gluten-associated reactions: allergic (allergic to cereal proteins), autoimmune (including gluten-sensitive enteropathy, herpetiform dermatitis, and gluten ataxia) and possibly immune-mediated (idiopathic sensitivity to gluten). In just 10 years, gluten-sensitive enteropathy has passed from non-existence to the center of attention of gastroenterologists, pediatricians, and other specialists worldwide [3], [5]. In this regard, decreasing the gluten load on the human body by replacing a certain amount of wheat and rye flour in bread formulas with the analyzed raw plant materials is timely and necessary.

The importance of the protein component of nutrition lies, first of all, in that it is a source of amino acids. However, cereal proteins are far from the

"ideal" protein as they lack certain essential amino acids [1]. If you know the amino acid composition of food products, you can evaluate their nutritional value. The results of studying the amount of essential amino acids in flour are shown in Figure 2.

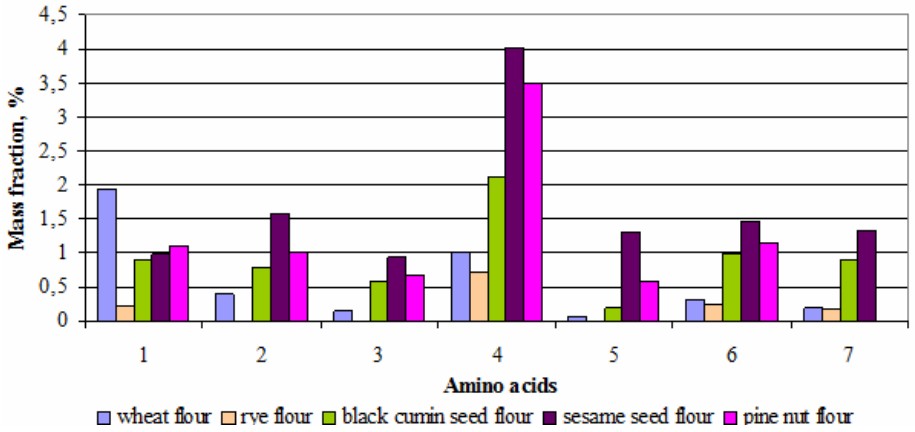



Fig. 2. *The content of essential amino acids (1 – lysine, 2 – phenylalanine, 3 – histidine, 4 – leucine + isoleucine, 5 – methionine, 6 – valine, 7 – threonine) in flour consisting of various types of raw plant materials*

It has been established that wheat flour only significantly exceeds the raw materials under study by the lysine content, while rye flour is greatly inferior, especially due to the lack of phenylalanine, histidine, methionine. The highest amount of essential amino acids is present in sesame flour. Cedar nut flour is rich in leucine, isoleucine, and methionine, but lacks threonine. The limiting amino acid for black cumin seed flour is methionine; according to the content of other amino acids, this raw material is average. Therefore, the most valuable raw material in terms of nutrition is non-traditional raw plant materials.

A high ash content of non-traditional raw materials (from 3.07±0.02% in pine nut flour to 6.46±0.03% in black cumin seed flour) was reflected in the quantitative characteristics of its mineral composition.

### 3.2. Study of the Mineral Value of Flour

It is common knowledge that a large portion of the mineral substances of wheat and rye flour consist of compounds of phosphorus, potassium, magnesium, and calcium. Various microelements - copper, manganese, zinc, etc., are contained in micro amounts [13]. Therefore, the replenishment of the nutritional value of traditional bread by a number of individual microelements is of practical importance. In this regard, we studied the mineral composition of the raw plant materials in a comparative aspect. The results of the studies are shown in Table 2.

We have determined that comparatively, wheat flour is deficient in the minerals being studied, and the analyzed non-traditional raw materials have a rich mineral composition, but do not always exceed rye flour by their

content of phosphorus, iron, manganese, zinc, and nickel. We established that it is possible to significantly increase the content of phosphorus in bakery products made of rye flour with the additional use of cedar nut flour, in which the content of this macroelement is more than 4 times larger than that of rye flour. The use of black cumin seed flour will not give a positive result in solving this issue, since the amount of phosphorus in black cumin is 3.2 times less than in rye.

Table 2

*Mineral composition of flour made of various types of raw plant materials*

| Element | Test results, mg/kg | | | | |
|---|---|---|---|---|---|
| | **Wheat flour** | **Rye flour** | **Black cumin seed flour** | **Sesame seed flour** | **Pine nut kernel flour** |
| P | 1140.0 ± 182.7 | 2543.0 ± 524.2 | 781.0 ± 166.0 | 8773.0 ± 2154.4 | 11256.0 ± 3144.7 |
| Ca | 242.54 ± 68.44 | 630.07 ± 226.83 | 3869.70 ± 1393.09 | 1208.70 ± 435.13 | 717.34 ± 258.24 |
| Cu | 1.81 ± 0.07 | 8.52 ± 0.85 | 19.59 ± 1.96 | 33.49 ± 3.35 | 11.92 ± 1.19 |
| Fe | 19.70 ± 1.65 | 87.41 ± 8.74 | 411.28 ± 41.13 | 137.51 ± 13.75 | 60.37 ± 6.04 |
| Mg | 443.33 ± 37.24 | 1010.70 ± 272.89 | 3720.50 ± 1004.50 | 7260.10 ± 1415.72 | 2286.30 ± 617.30 |
| Mn | 11.40 ± 1.10 | 43.46 ± 14.34 | 41.80 ± 13.79 | 28.05 ± 9.26 | 75.43 ± 24.89 |
| Zn | 10.10 ± 1.04 | 55.09 ± 5.51 | 51.60 ± 5.16 | 121.60 ± 12.16 | 51.80 ± 5.18 |
| Ni | 0.05 ± 0.02 | 0.54 ± 0.03 | 1.02 ± 0.07 | 0.42 ± 0.05 | 0.70 ± 0.09 |
| Co | 0.003 ± 0.002 | 0.007 ± 0.002 | 0.100 ± 0.033 | 0.034 ± 0.006 | 0.130 ± 0.042 |

Wheat grain and pine nuts are inferior to rye flour by their iron content (4.4 times less and 31% less, respectively), while black cumin seed flour is superior (4.7 times more). Relatively low concentrations of manganese were found in wheat (11.40±1.10 mg/kg) and sesame flour (28.05±9.26 mg/kg); high concentrations were observed in cedar nut flour (75.43±24.89 mg/kg).

Zinc was found in one quantitative range (50-55 mg/kg) in rye seeds, black cumin seeds, and pine nut flour. Sesame flour is rich, while wheat flour is poor in zinc.

A relatively high content of nickel was observed in black cumin seed flour (1.02±0.07 mg/kg), low - in wheat flour (0.05±0.02 mg/kg), and medium - in rye flour (0.54±0.03 mg/kg) and sesame flour (0.42±0.05 mg/kg).

Black cumin seed flour can be considered a source of calcium (it contains 6 times more of this macronutrient than rye flour). Compared to rye flour, sesame seeds and black cumin are rich in copper and magnesium – sesame seeds have 3.9 and 7.2 times more, respectively, and black cumin – 2.3 and 3.7 more, respectively; pine nut flour and black cumin seed flour are richer in cobalt (18.6 times more and 14.7 times more, respectively).

We also studied the degree to which these flours satisfy an adult's daily needs for mineral elements when consuming 100 g of raw plant materials (Figure 3). The daily rate of consuming mineral components was taken from existing standards [12].

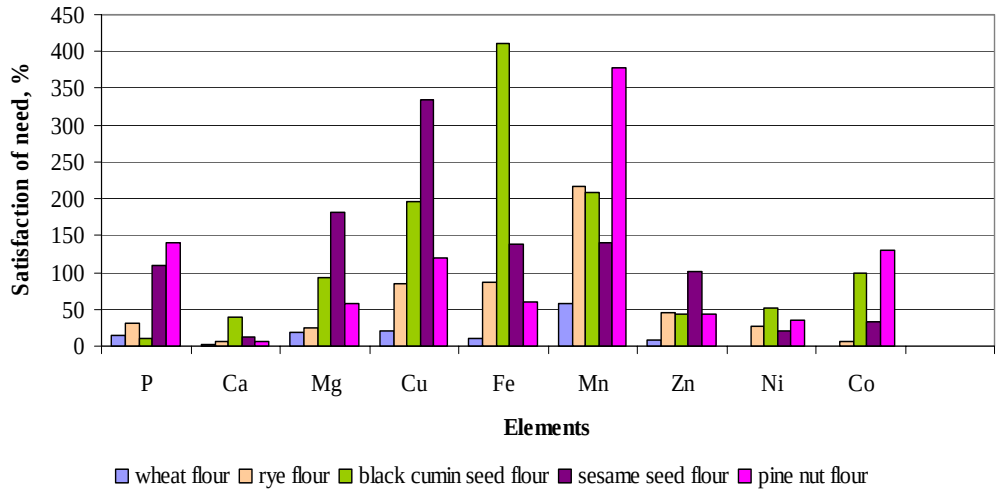



Fig. 3. *Satisfaction of the physiological need for mineral elements when consuming 100 g of raw materials*

We have determined that the use of non-traditional raw materials in the production of wheat and rye bread makes it possible to satisfy a significantly high percentage of daily human need for mineral elements, namely:

- The consumption of products made of black cumin seeds will satisfy a high percentage of the need for such microelements as iron (411.3% for men, 228.5% for women), copper (195.9%), cobalt (100.0%), and magnesium (93.0%);
- The use of sesame flour will contribute to a better diet optimization by the content of copper (334.9%), magnesium (181.5%), phosphorus (109.7%), and zinc (101.3%);
- The use of cedar nut flour will largely reduce the deficiency in manganese (377.2%), phosphorus (140.7%), cobalt (130.0%), and copper (119.2%) in the human body.

## 4. Conclusions

The use of non-traditional types of flour is justified to increase the nutritional value of wheat and rye bread. The introduction of black cumin seed flour will allow us to significantly increase the content of dietary fiber and microelements (iron, copper, cobalt, magnesium) in baked goods; sesame flour – the concentration of protein, copper, magnesium, phosphorus, and zinc; and cedar nut flour - the content of polyunsaturated fatty acids, manganese, phosphorus, cobalt, and copper. In all cases, substituting a certain amount of cereal flour in the baking process with the non-traditional raw materials we have analyzed, will allow us to balance the amino acid composition of bread and reduce the gluten load on the human body.

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**References**

1. Baranovsky A.Yu., 2012. Dietology. Piter, St. Petersburg, Russia, 1024 p.
2. Derkanosova N.M., Ponomareva I.N., Zolotareva N.I. et al., 2016. Studying the baking potential of whole-wheat amaranth flour. In: Bulletin of Voronezh State Agrarian University, vol. 3(50), pp. 175-182.
3. Dudar D.V., 2012. Gluten-sensitive enteropathy of adults: a comprehensive method of treatment and prevention of gluten-sensitive blennosis. In: Crimean Therapeutic Journal, vol. 2(19), pp. 90-97.
4. Ipatova L.G., Kochetkova A.A., Nechaev A.P. et al., 2009. Fatty products for a healthy diet. A modern look. DeLi Print, Moscow, Russia, 396 p.
5. Kamalova A.A., Shakirova A.R., Afraimovich M.G., 2016. Gluten-associated diseases: current data. In: Issues of Children Dietology, vol. 14, pp. 42-48.
6. Kovaleva L.I., Rogova Yu.E., 2016. On the issue of enriching bread products with proteins. In: Bulletin of the Hospitality Industry. St. Petersburg State University of Economics, St. Petersburg, pp. 92-99.
7. Kucheryavenko I.M., Vershinina O.L., 2013. Rye starter with the use of pumpkin seed flour. In: Food Science and Technology, vol. 4, pp. 101-103.
8. Lapteva N.K., 2012. Assortment of bakery and flour confectionery products using rye raw materials and its role in the nutrition of a modern human. In: Achievements of Science and Technology of the Agro-Industrial Complex, vol. 6, pp. 75-78.
9. Shchekoldina T.V., Vershinina O.L., Kudinov P.I. et al., 2015. Study of the influence of protein sunflower isolate on the properties of a rye and wheat flour mixture. In: Technology and Merchandizing of Innovative Food Products, vol. 1(30), pp. 20-28.
10. Skurikhin I.M., Tutelyan VA, 1998. Guidance on the methods for analyzing the quality and safety of food products. Brandes, Medicine, Moscow, Russia, 342 p.
11. Tarasova O.A., Faizullina I.I., Gabdrakhimova I.I., 2017. Use of raw plant materials-based biologically active supplements in the production of bread from a rye and wheat flour mixture. In: Bulletin of Kazan Technological University, vol. 23, pp. 104-106.
12. Tutelian V.A., 2009. Norms of physiological needs in energy and food substances for various populations of the Russian Federation. In: Questions of Nutrition, vol. 78(1), pp. 4-16.
13. Tutelian V.A., 2012. Chemical Composition and Caloric Value of Russian Food Products: Handbook, DeLi Plus, Moscow, Russia, 284 p.