Impact of bakery mix ingredients on the quality and biological value of bread

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Abstract. Bread is a product of daily consumption. That is why development of functional bakery products is important. New recipes and technologies using enriching additives allow expanding the range and improve physiology of bakery products. The goal of this research was to identify the impact of bakery mix ingredients on the quality and biological value of bread. The objectives of the research: to identify technological qualities of flour and flakes, study the possibility of using flakes for bakery mixtures in bread production; assess the impact of flakes on the quality and biological value of wheat bread. The objects of the studies: mixture of 5 corns (oat, wheat, rye, barley, millet flakes). To identify the impact of flakes on the quality of wheat bread, two bread samples were made – control sample without flakes and testing sample with mixture of 5 corns. The proportion of flakes was 10% of the total mass of flour and flakes. This study used a method of complex evaluation with complex indicators of quality combinations which were supposed to consider the importance of each criterion. Every single indicator of quality was characterized by two parameters: relative ratio and weightiness. The used complex evaluation method allowed making a conclusion about the practicability of using flake products in bread production. Studies show that in case of adding mixed flakes in the amount of 10% from the total mass of flour when making wheat bread, the quality can be improved and the biological value of bread can be increase.

1. Introduction

One of the priorities of the Russian Federation state policy is to ensure food safety and develop a healthy dietary system of the citizens.

It is possible to accomplish these tasks by optimizing dietary system by adding functional food products to the diet which have the capacity to satisfy physiological needs of a human body, namely nutrients and energy.

Thus, studies and research in the field of technology in manufacturing of mass consumed food products have become very important. Bakery products must be of good quality, high nutritional value and also must have preventive rehabilitation qualities which are good for people especially in ecologically unsafe environment.

Sufficient decrease of food fiber in daily diet of the people of all social and age groups has affected their state of health. Lack of food fiber, pectin substances, wood polysaccharose in a human body
resulted in development of such illnesses as rectal cancer, saccharine diabetes of 2nd type, excessive weight, atherosclerosis, deteriorated intestinal peristalsis and subsequently cardiovascular diseases.

The optimal daily quantity of food fiber for an adult must be not less than 30 gr. The main sources of the fiber, as a rule, are fruits, vegetables, oil seeds, corn, rice, wheat and soya bran, cereal products [2, 3].

Sufficient part of food fiber gets in a human body with grain products. Bread and other bakery products (particularly made of whole grain flour) contain large amount of physiologically active ingredients – cellulose, lignin, wood polysaccharose. However, nowadays daily consumption of bread and other bakery products in Russia can provide only 15-20% of the needed amount of food fiber. [4,5]

Flake products may be considered advanced food raw materials for bread bakery. They have certain benefits compared to whole grain and cereal. For example, they do not need technological process of special preparation; besides this flake technology allows to keep all the good qualities of the original products even after their processing. [6, 7, 8].

2. Research Goals
To study the impact of bakery mix ingredients on the quality and biological value of bread.

3. Research Objective
- to identify technological qualities of flour and flakes;
- to study perspectives of using flakes as additive material to bakery mixtures in baking process
- to assess the impact of flakes as additive material on the quality and biological value of wheat bread.

4. Materials and methods
As potential ingredients for bakery mixtures were used grain flakes of 5 sorts “Uvelka” (a mixture of oat, wheat, rye, barley, millet flakes), produced in Russia TC 9294-007-53860659-06. In the research works the following raw materials were used: baking wheat flour of 1st sort the Russian State Standard 52189-2003; culinary dietary salt - the Russian State Standard 51574-2000; dry wheat gluten produced in Tol’yatti by Closed Joint-Stock Company “Doka-bio-mix” TC 9189-005-00365517-06.

The following indicators of the baking wheat flour of 1st sort were studied:
- moisture content in flour State Standard 9404-88 – by expedited way;
- titratable acidity of flour State standard 27493-87 – by titration of a flour meal;
- gas generating ability of wheat flour using volumetric method on Yago-Ostrovsky device;
- “strength” of flour – studied ballability of flour;
- mass fraction of raw gluten State standard 27839-2013;
- quality of gluten according to State Standard 27839-2013 using IDK device and according to its elongation

The following flake indicators were studied:
- moisture content in flakes according to State Standard 26312.7-88;
- acidity of flakes according to State Standard 263126-84.
- water absorption capacity of the flakes was identified by the following method: 1gr of mixture was added to 6 ml of water and mixed with a glass stick during 1 minute and left for 30 min. Then it was centrifuged for 25 minutes 3200 rpm. The unbound water was poured into a graduated cylinder of 5 ml and the remained mixture was centrifuged for another 25 minutes. Afterwards the water was again poured into the cylinder. The amount of the bound water Yx, ml was calculated by the following formula:

\[ Y_x = Y_u - (Y_1 + Y_2) \]

Where Yu – added water, ml;
Y1, Y2 – the amount of water after 1st and 2nd centrifuging, ml.

Water absorption capacity was assessed by water adsorption A,%, calculated by the formula:

\[ A = \frac{Y_x (d/B)}{100} \]
Where \( d \) – density of water, gr/cm\(^3\),
\( B \) – product hitch, gr.

Linear dimensions of the flakes were measured by calipers.

The capacity of the flakes to bind moisture when swelling was studied the following way: flake hitch (5 gr) was put into a centrifugal tube, 20 cm\(^3\) of distilled water was added. Then thoroughly blended this mixture, waited for 10 minutes, then centrifuged it for 5 minutes at 5000 rpm. Afterwards the content was carefully poured out and the amount of moisture in the sediment was determined by drying in a drying cabinet SESH-3.

Swelling capacity \( H \), %, was calculated by the formula:

\[
H = \left( \frac{m - m_0}{m_0} \right) \times 100 ,
\]

(3)

Where \( m \) – weight of flakes after swelling, gr;
\( m_0 \) - weight of dry flakes hitch, gr.

The weight of the flakes after swelling (\( m \)) was calculated by the formula

\[
m = \frac{(100 - B) m_0}{100 - B_1} ,
\]

(4)

where \( B \) – mass fraction of moisture in the dry flakes, %;
\( B_1 \) - mass fraction of moisture in the swelled flakes, %.

To assess the quality of other raw products were used organoleptic indicators in accordance with the requirements of the regulations.

The dough was made by a straight dough method. The samples were made from wheat flour, baking yeast, culinary nutritive salt, flakes, dry wheat gluten and water. Regulatory recipe for wheat bread is shown in Table 1.

| Name of raw material          | Amount, % |
|-------------------------------|-----------|
| Wheat flour of 1\(^{st}\) sort | 100.0     |
| Culinary nutritive salt       | 1.5       |
| Pressed baking yeast          | 2.5       |
| Flakes                        | -         |
| Dry wheat gluten              | -         |
| Improver “Garantamax”         | -         |
| Water                         | calculated|

Table 1. Regulatory recipe for wheat bread.

Standard methods were used for choosing technological parameters of dough processing, handling, proofing and baking. Temperature of dough fermentation 30-32 °C, duration 150 minutes, with two punching every 60 minutes after the beginning of the fermentation. Moisture of prepared dough – 48 and 49 %. The baking was done in the laboratory stove under the temperature 220-230 °C with duration 30-40 minutes. The baked products were studied and analyzed after their cooling down.

The analysis of the baked products was carried out after 24 hours after the baking process. The following indicators were used:
- the weight of the products was measured by weighing on dial scales;
- volume – with the help of volume measurer;
- specific volume was calculated according to the results of measured volume and product weight, expressed in cm\(^3\)/100gr;
- product stability (hearth baked) was determined in relation height to diameter, expressed in mm;
- organoleptic indicators: appearance, crust color, color, crumb condition, nature of porosity, chewing characteristic, smell, taste of baked products on a 20point scale.
The total score was calculated as the score sum of all the indicators pre-multiplied by the coefficient of weightiness.

5. Results and discussion

Baking mixtures are one of the ways to expand assortment of baking products. These mixtures contain various products of processing agricultural raw materials. Flakes contain large amount of dietary fiber, also minerals and vitamins, that is why they are considered to be functional foods.

Dietary fiber content in cereals is 70-80% of hemicellulose, 11-20% of cellulose, 1.3-6 of lignin. Buckwheat, oatmeal, peas have the highest amount of dietary fiber. They also contain the largest amount of minerals (over 350mgr potassium and over 40 mgr. magnesium). High content of vitamin B1 in oatmeal, buckwheat, millet, it is satisfactory in other cereals. Only unground grain has high content of vitamin B2. Peas, oatmeal, buckwheat have satisfactory content of this vitamin, while millet has low content of vitamin B2.

Cereals have high amount of protein. As a rule, cereals with high amount of dietary fiber have also high amount of protein. Peas, oatmeal and buckwheat are rich in protein [9, 10, 11].

So, bakery production using baking mixtures is effective. The use of backing mixtures will allow to improve and stabilize finished product quality, expand the range of bakery products with high biological and consumer value, including kinds of cereals with therapeutic and preventive purpose and products with long period of freshness, improved product quality in processing flour with low baking characteristics.

The next stage of studies was aimed at evaluation of backing raw materials. Quality indicators of backing wheat cereal are shown in table 2.

| Name of indicator                                      | Value of indicator |
|--------------------------------------------------------|--------------------|
| Mass fraction moisture, %                              |                    |
| Titration acidity, °                                   |                    |
| Mass fraction of raw gluten, %                         | 32.0               |
| Quality of raw gluten:                                 |                    |
| - elongation, cm                                       | 11                 |
| - compressibility using IDK device (device units)      | 62                 |
| Gas generating capacity, cm³, CO₂                      | 1710               |
| D₁₈₀ of yeast free of dough ball, mm                    | 73                 |

The studied flour had short tearing of gluten. 2nd quality group according to dough ball slackness was considered as “strong”. On the whole, backing wheat flour of 1st sort met the requirements of Russian State Standard 52189-2003.

Physico-chemical and technological characteristics of 5 grain flakes “Uvelka” are shown in Table 3.

Mass fraction moisture in the flakes was under 9.5%, acidity 2.0°. Swelling factor of the studding flakes 339 %, water absorbing ability – 250 %. Length of 5 grain of the flakes of 5 grains varied from 1 to 3 mm with 2-4 mm.

| Name of indicator                                      | Value of indicator |
|--------------------------------------------------------|--------------------|
| Mass fraction moisture, %                              | 9.8                |
| Titration acidity, °                                   | 2.0                |
| Swelling factor, %                                     | 339                |
Two samples were made to identify the impact on the flakes on weed bread quality. Control sample - without flakes and testing samples with 5 grains (mixture of oat, weed, rye, barley, millet flakes). The flakes were added in the amount of 10 % of the total mass of flower and flakes. Such dosage of flakes didn’t result in significant decline of product quality [12], it can be corrected with matching technological parameters and improvers.

The mixture of flakes contains nontraditional ingredients for bread baking that is why consumer quality of finished products will decline. When making dough with flakes to form a gluten carcass of the dough, dry weed gluten was added in the amount of 8% and improver “Garantomax” – 0.3% of the flour mass which allowed getting good volume of the products.

Then the impact of the baking mixture on the quality of the finished products was evaluated. Such characteristics as stability of shape, specific volume and bread score were considered. Variance percent in the values of the testing and control samples was calculated (were used specific volume and bread score).

The results of identifying the quality indicators of the finished bread products are shown in table 4.

| Bread samples       | Dough moisture 48% | Dough moisture 49% |
|---------------------|--------------------|--------------------|
|                     | Bread score        | Specific volume    | Bread score        | Specific volume    |
|                     | score              | stability of shape (H:D) | score              | stability of shape (H:D) |
|                     | ∆, % of control samples | cm³/100г | ∆, % of control samples | cm³/100г |
| Control             | 19.1               | 0.35               | 18.3               | 0.39               |
| Grain flakes        | 20.0               | 0.42               | 18.8               | 0.32               |
| «Uvelka»            |                    |                    |                    |                    |

Table 4. Testing data of the quality indicators of finished bread products.

It is clear from table 4 that the sample with flakes had lower specific volume than the control sample. For example, the sample with 5 grain flakes (dough moisture 49%) had specific volume 50.7% lower than the control 1. With dough moisture 49% the value of specific volume of the control sample was higher than with dough moisture of 49%.

With dough moisture of 48.0%, the sample had higher bread score than the sample with dough moisture of 49.0%.

The testing samples had slightly humpy crust which is related to the presence of flakes on its surface. The samples with flakes had single floury flake inclusions in the crumb of the bread due to not complete swelling of the flakes.

With dough moisture of 49%, the control sample had the highest value of shape stability, which was 0.39. The testing samples with 5 grain flakes with dough moisture of 39% had the highest value of shape stability of 0.42% compared to the control sample and the sample with flakes (dough moisture of 49%) which is related to the strengthening impact of these flakes on the dough.

The results of the table show that the bread score of the samples with 5 grain flakes was higher or equal to the bread score of the control sample.
The implemented assessment of the quality of the 5 grain flakes doesn’t allow to make a definite conclusion about the benefits of using them. That is why it was decided to use the integrated assessment method. There are various methods of calculating the integrated summarized indicator [13]. The integrated indicators of totality of qualities are used in the integrated assessment of the quality level. They are supposed to consider the value of each quality characteristic. Each single indicator of quality is characterized by two parameters: relative indicators and weightiness.

This method is based on the model of the integrated assessment described in [13].

This model includes the following integrated indicators: organoleptic, physical-chemical indicator, dietary value (satisfaction of body needs in nutrients and energy), usefulness (presents of physiological functional and ingredients) and price (economic indicators). The group of organoleptic indicators includes such indicators as appearance, coloring of crust, color of crumb, nature of porosity, physical-chemical qualities of crumb, smell, taste, biting-down capacity. These organoleptic indicators were taken from 20-point assessment scale for bakery products, made of bakery mixtures [12]. The coefficients of weightiness of the organoleptic indicators were converted to make their sum equal 1 (each of them divided by 4)

Flakes enrich bakery products that is why such integrated indicator as dietary value (satisfaction of human body needs in nutrients and energy) was included in this model. This indicator is comprised of the following relative indicators of dietary value: protein, fat, carbohydrates and calories. The coefficients of weightiness of single indicators in this integrated characteristic were taken equitable – 0.25. The integrated indicator of physicochemical characteristics included specific volume and shape stability which were applied to all the samples of the bakery products.

The indicator of usefulness (presence of functional ingredients) considered the amount of vitamins, minerals, food (alimentary) fibers and biological value of protein. The weightiness coefficients of these indicators are equal – 0.25. Also the vitamin content was evaluated — В₁, В₂, PP, E, minerals – K, Ca, Mg, P, Fe, irreplaceable amino acids and food fiber. The coefficients of weightiness in the listed above vitamins are 0.23 for В₁ and В₂, 0.24 for PP, for E – 0.30. For the minerals the coefficients were accepted equal for each – 0.2. The following amino acids were included:
- valine (amino isovaleric acid), coefficient of weightiness 0.11;
- isoleucine, coefficient of weightiness 0.11;
- leucine, coefficient of weightiness 0.11;
- lysine, coefficient of weightiness 0.15;
- methionine + cysteine, coefficient of weightiness 0.20;
- threonine, coefficient of weightiness 0.11;
- tryptophan, coefficient of weightiness 0.11;
- phenylalanine+tyrosine, coefficient of weightiness 0.10.

The coefficients of weightiness were accepted according to their importance. For organoleptic indicators it was 0.25, for physicochemical – 0.12, for food value – 0.23.

In this research we implemented the integrated assessment of wheat bread with suggested general integrated indicator. The sample with flakes was the testing sample. The control one was the 1st sort wheat sample.

To calculate the relative indicators of bakery product quality for studied bread samples, we first calculated the relative value of product quality indicators by the formulas:

\[ q_i = \frac{P_i}{P_k}, \]  \hspace{1cm} (5)

or

\[ q_i = \frac{P_k}{P_i}, \]  \hspace{1cm} (6)

where \( P_i \) – value of i quality indicator of the evaluated (testing) sample;

\( P_k \) – value of i quality indicator of the control sample.
Formulas (5) or (6) showed the increase of the relative indicator which was correspondent to the quality improvement of the evaluated criterion. The quality indicators of the testing samples of wheat bread and control samples with coefficients of weightiness are shown in table 5.

Table 5. Characteristics of numeric expressions of quality of wheat bread with 5 grain flakes Uvelka”.

| Indicators                               | Control | Bread with flakes | Relative quality indicator | Cor. weightiness | Integrated indicator with weightiness | Coefficient |
|------------------------------------------|---------|-------------------|----------------------------|------------------|----------------------------------------|-------------|
| **Organoleptic indicators**              |         |                   |                            |                  |                                        |             |
| Appearance                               | 5.00    | 5.00              | 1.00                       | 0.12             | 0.12                                   |             |
| Coloring of crust                        | 5.00    | 5.00              | 1.00                       | 0.08             | 0.08                                   |             |
| Nature of porosity                       | 5.00    | 5.00              | 1.00                       | 0.12             | 0.12                                   |             |
| Color of crumb                           | 4.00    | 5.00              | 1.25                       | 0.05             | 0.06                                   |             |
| Physicochemical qualities of crumb       | 5.00    | 5.00              | 1.00                       | 0.13             | 0.13                                   |             |
| Smell                                    | 4.00    | 5.00              | 1.25                       | 0.20             | 0.25                                   |             |
| Taste                                    | 5.00    | 5.00              | 1.00                       | 0.20             | 0.20                                   |             |
| Biting down capacity                     | 4.00    | 5.00              | 1.25                       | 0.10             | 0.13                                   |             |
| **Total**                                |         |                   |                            |                  |                                        | 1.09        |
| **Physicochemical indicators**           |         |                   |                            |                  |                                        |             |
| Specific volume                          | 289.00  | 324.00            | 1.12                       | 0.50             | 0.56                                   |             |
| Shape stability                          | 0.48    | 0.52              | 1.08                       | 0.50             | 0.54                                   |             |
| **Total**                                |         |                   |                            |                  |                                        | 1.10        |
| **Dietary value in:**                    |         |                   |                            |                  |                                        |             |
| protein                                  | 8.04    | 11.60             | 1.44                       | 0.25             | 0.36                                   |             |
| fat                                      | 51.01   | 44.83             | 0.88                       | 0.25             | 0.22                                   |             |
| carbohydrates                            | 1.01    | 1.43              | 1.42                       | 0.25             | 0.36                                   |             |
| caloricity                               | 248.13  | 234.72            | 1.06                       | 0.25             | 0.26                                   |             |
| **Total**                                |         |                   |                            |                  |                                        | 1.20        |
| **Usefulness:**                          |         |                   |                            |                  |                                        |             |
| Vitamins:                                |         |                   |                            |                  |                                        |             |
| B1                                       | 0.19    | 0.22              | 1.11                       | 0.23             | 0.26                                   |             |
| B2                                       | 0.07    | 0.08              | 1.07                       | 0.23             | 0.25                                   |             |
| PP                                       | 1.82    | 1.69              | 0.92                       | 0.24             | 0.22                                   |             |
| E                                        | 2.25    | 4.20              | 1.87                       | 0.30             | 0.56                                   |             |
| **Total**                                |         |                   |                            |                  |                                        | 1.29        |
| Total with the coefficient of weightiness|         |                   |                            |                  |                                        | 0.25        |
| **Mineral substances:**                  |         |                   |                            |                  |                                        |             |
| K                                        | 131.46  | 174.99            | 1.33                       | 0.20             | 0.27                                   |             |
| Ca                                       | 28.18   | 113.13            | 4.01                       | 0.20             | 0.80                                   |             |
| Mg                                       | 33.06   | 64.72             | 1.96                       | 0.20             | 0.39                                   |             |
| P                                        | 86.90   | 132.47            | 1.52                       | 0.20             | 0.30                                   |             |
| Fe                                       | 2.12    | 3.31              | 1.56                       | 0.20             | 0.31                                   |             |
| **Total**                                |         |                   |                            |                  |                                        | 1.77        |
| Total with the coefficient of weightiness|         |                   |                            |                  |                                        | 0.25        |
| **Amino acid content:**                  |         |                   |                            |                  |                                        |             |
| valine                                   | 375.92  | 507.31            | 1.35                       | 0.11             | 0.11                                   |             |
| Isoleucine                               | 390.66  | 518.84            | 1.33                       | 0.11             | 0.11                                   |             |
| Leucine                                  | 599.26  | 836.53            | 1.40                       | 0.11             | 0.32                                   |             |
| Lysine                                   | 195.33  | 270.00            | 1.38                       | 0.15             | 0.25                                   |             |
The results shown in the table make it clear that the evaluated indicators of the sample with the additive flakes are higher than those of the control sample.

6. Conclusions
So, the applied integrated assessment method allowed making the conclusion about the advisability of using flaky products in bread production. It was identified that adding flake mixtures when making wheat bread in proportion 10% of the total flour mass allows improving the quality and biological value of bread.

References
[1] Egusheva E 2018 Achievements of Science and Technology APK 32 12 pp 90-93
[2] Kalmyikova E, Kalmyikova O 2016 Rational Diet, Food Additives and Biostimulators 1 pp 65-70 http://www.journal-nutrition.ru/ru/article/view?id=35717
[3] Melnikov E, Ponkratov G, Izosimov V, Orekhova E 2009 Bread Products 3 pp 48-50
[4] Chernyiishova V, Labutina N, Belyavskay I, Bogatiyreva T, Yudina T 2016 Food Processing Industry 5 pp 66-69
[5] Merenkova S, Gmachinskaya E 2016 Bulletin of Altai State Agriculture University 10 144 pp 135-142
[6] Kolmakov U, Zelova L, Pakhotina I 2015 Bulletin of Altai State Agriculture University 4 126 pp 133-136
[7] Alekhins N 2018 Bread Products 10 pp 50-52
[8] Plekhanova L 2014 Achievements of Science and Technology APK 6 pp 65-66
[9] Chebotareva E,Yanova M, Muchkina E 2015 Bulletin of KrasSAU 11 pp 125-130
[10] Alimkulov Z, Zhiyenbayeva S, Baygazieva G, Rustemova A, Batyrbayeva N, Bayisbayeva M 2018 International Journal of Engineering and Technology (UAE) 7 2 pp 136-139
[11] Nakamura S, Suzuki K, Ohtsubo K 2009 J. FoodSci. 74 3 pp 121-130
[12] Korotkova O 2011 Technology Development and Commodity Assessment of Bakery Mixes and Based on them Products Phd dissertation (Kemerovo: Technological Institute of food Industry) p 156
[13] Renzyaeva T, Merman A, Sharfunova I 2010 Technic and Technology of Food Processing 3 pp 91-95