Development of enriched grain bread

O V Evdokimova, T N Ivanova, E D Polyakova, E A Pyanikova, A E Kovaleva and E I Bykovskaya

1 Oryol State University named after I.S. Turgeneva, 29, Naugorsk highway, Oryol city, 302028, Russia
2 Southwestern State University, 94, 50 years of October Str., Kursk, 305040, Russia

E-mail: evdokimova_oxana@bk.ru

Abstract. The ratios of the flour from whole grain of buckwheat and wheat were selected to create a composite mixture of grain bread. The creation of the mixture is intended for increase its nutritional value in order to minimize certain disadvantages of the feedstock, including low biological, functional properties, high-calorie content due to the use of powders from a meal in the recipe plant materials (nettles, rose hips). The effect of various dosages of vegetable fortifiers on the viscosity of the dough, physicochemical parameters of experimental bread samples is revealed. The recipes of grain bread enriched with powders of nettle and rosehip meal are presented. The results of the assessment of organoleptic and physicochemical quality indicators of grain bread are presented. The effect of meal powders on the aroma-forming compounds of the finished product and its digestibility is established. The data for calculating the percentage of the daily requirement for certain food substances when using enriched grain bread are presented.

1. Introduction

Currently, food products are intended not only to satisfy hunger and basic nutritional needs but also to prevent nutrition-related diseases and improve consumer welfare [1].

The grain processing industry is one of the most important sectors of the food industry. The type of grain, as well as products from it, require a vast number of operations and specific processes that will allow getting a wide range of products (bread, cakes, snacks, transformed flour, gluten-free products, fortified products). Mixing and enrichment of products derived from grain lead to an increase in their nutritional value, preservation and improvement of organoleptic characteristics (texture, smell and taste) [2].

Bakery, as a socially significant branch of the economy, is vital in the nutrition structure of the population. Moreover, speaking about the nutritional value of bread, it should be noted that it has relatively low functional properties, biological value and high-calorie content. To increase the nutritional value in bakery technologies, wild-growing raw materials rich in biologically active substances [3, 4, 5, 6], which help to create healthy food products, are increasingly being used as functional ingredients [7]. In order to increase the biological characteristics of bread, in recent times, much attention has been paid to the use of non-traditional buckwheat grain in baking. Buckwheat, which contains high-level protein [8], has great potential as a functional ingredient for the food industry. Scientists have proven that the inclusion of buckwheat in bread can significantly reduce the postprandial reaction of blood glucose and insulin compared to white wheat bread [9]. Expanding the
assortment of this type of bread allows actualizing the task of developing technologies and formulations aimed at obtaining a finished product with predetermined consumer properties and increased nutritional value.

- Since buckwheat mainly contains water-soluble and salt-soluble proteins, we propose the introduction of dry gluten into the test formulation, the functional properties of which have been studied sufficiently [10]. Unconventional raw materials in a bakery not only increase the nutritional value of products but also increase the biotechnological properties of the dough, improving the quality of the finished product [11].

2. The purpose of the study
The work aims to develop bread from whole grains of buckwheat and wheat. Following the aims, the following tasks were determined:

- optimization of the amount of a composite mixture of flour from whole grains of buckwheat and wheat;
- study of the effect of the number of powders from the nettle and rosehip meal on indicators: number of drops and viscosity of the dough;
- study of the effects of the introduction of powders from nettle and rosehip meal on bread quality indicators;
- development of enriched grain bread recipes and assessment of organoleptic and physicochemical parameters of bread.

3. Materials and methods
During optimization, the composition of the composite mixture used the method of test laboratory baking (GOST 27669-88).

The specific volume of bread as per GOST 27669-88.
The humidity of crumb of bread – per GOST 21094 -75.
Porosity – according to GOST 5669-96.
The acidity of the crumb is per GOST 5670-96.

Aromatizing substances in bread were determined according to the method of L.I. Puchkova [12].
The number of powders from the nettle and rosehip meal by the method of test laboratory baking (GOST 27669-88).
The indicator “fall number” as per GOST 27676-88.

Organoleptic indicators of the bread quality were carried out by the method of scoring according to the requirements of standardization.

The quality of the developed bread samples was evaluated after 24, 36 and 72 hours.

4. Discussion of the results
It is shown that in bread made from flour with a ratio of flour from whole grain of buckwheat and wheat 50:50, the porosity and specific volume exceed other bread samples. According to the physicochemical quality indicator, a bread made from a mixture of buckwheat flour and wheat in a ratio of 40:60 had the best indicators, and according to organoleptic indicators. The best sample was with a ratio of a mixture of flour 40:60. The data obtained from laboratory test baking are presented in Table 1.

For the enrichment of grain bread, powders of dried nettle and rosehip meal were used as sources of biologically active substances and fibre.

With the addition of 1% nettle powder, the starch content decreased. This result is confirmed by a decrease in the “drop number” by 4.5%, with 3% nettle powder – 8.7%, and with 5% nettle defect – by 12.3%. The indicator “number of falls” with an increase in the dosage of rosehip powder decreases slightly (1.7 – 3.9%), it reveals that the addition of the additive does not significantly affect the activity of amylolytic enzymes of flour.
Table 1. Quality indicators of bread from a mixture of buckwheat flour and wheat

| The ratio of whole-grain flour buckwheat and wheat in the composite mixture | The moisture content of the bread, % | Acidity, deg. | Porosity, % | Specific volume of bread, cm³/g |
|---|---|---|---|---|
| 50:50 | 48.6 | 3.1 | 56.33 | 2.12 |
| 60:40 | 48.6 | 3.3 | 52.89 | 1.91 |
| 70:30 | 49.1 | 3.3 | 48.97 | 1.67 |
| 80:20 | 49.2 | 3.4 | 42.60 | 1.34 |

The effect of powders from a meal of vegetable raw materials on the quality indicators of dough and bread is investigated. When endlessly preparing the dough, the necessary amount of raw materials (flour, water, yeast, salt, SEC, powders from a meal) was calculated with the subsequent kneading of the dough.

The results of studies of the effect of nettle meal powder on the viscosity index of the dough showed that with increasing dosage, the viscosity of the dough increases by 25.3%, 39.2%, 42.6%, respectively, compared with the test sample (Figure 1a).

The results of studies of the effect of powder from rosehip meal on the viscosity index of the test showed that when 1%, 3%, 5% of rosehip powder is added, the viscosity of the test increases 8.2%, 9.7%, 24.7%, respectively, therefore, in comparison with the test sample, the strength characteristics of the test increase (Figure 1b).

![Figure 1a](image1a.png) ![Figure 1b](image1b.png)

**Figure 1.** The effect of the number of powders from the meal of vegetable raw materials on the viscosity of the test: a) rosehips; b) nettle

The introduction of powders from nettle and rosehip meal into the bread recipe leads to a change in the physicochemical properties of the bread crumb. The research results are presented in Table 2.

The acidity of bread with the addition of plant materials decreased slightly, compared with the test. In control and products with the addition of 1% nettle powder to the mass of flour, the acidity is the same. With the introduction of 3% and 5% nettle powder, the acidity decreased by 0.2 and 0.4 degrees. Based on the data obtained, it can be concluded that with the addition of 1%, 3%, 5% of powder from nettle meal, the specific volume slightly decreases. Nettle contains a significant amount of dietary fibre, cellulose, which reduces the unit volume. When 1%, 3%, 5% of rosehip meal powder is added, the specific volume indicator increases by 6.9%, 7.2%, 2.2%, as compared to the test sample. At the same time, bread with the addition of 3% of rosehip is the best sample. The increased content of ascorbic acid explains the increase in the specific volume of bread crumb in the powder of rosehip.
meal. Ascorbic acid, being a reducing agent, turns into dehydroascorbic acid in the test, acting as an oxidizing agent.

Table 2. Physicochemical quality indicators of bread with powders from rosehip and nettle meal

| Name of indicators | Control | Nettle powder dosage, % | Rosehip powder dosage, % |
|--------------------|---------|-------------------------|---------------------------|
|                    |         | 1% 3% 5%                | 1% 3% 5%                  |
| The moisture content of the bread, % | 47.19 46.61 44.79 | 42.02 | 45.89 44.48 43.01 |
| Acidity, deg.      | 3.19    | 2.62 2.81 2.88 | 2.59 2.89 2.98 |
| Specific volume of bread, cm³/g | 2.01 1.97 1.72 | 1.68 | 2.32 2.61 2.72 |
| Porosity, %        | 57.03   | 57.06 58.01 57.02 | 57.11 58.54 56.03 |

With the addition of 1%, 3%, 5% of nettle meal powder, the porosity of bread crumb, compared with the test sample, decreases by 1.4%, 11.8%, 21.6%, respectively. That is explained by nettles having a content of 23.6% more dietary fibre, having greater mechanical strength, being insoluble in water and not absorbed by the body. With the addition of 1%, 3%, 5% powder of rosehip meal, the porosity index increases by 2.8%, 2.7%, 0.1%, respectively.

With an increase in the dosage of powders, there is a decrease in the organoleptic and physicochemical indicators of the bread quality. The optimal dosage of powders from nettle and rosehip meal is 3%. Table 3 shows the recipes of grain bread enriched with a nettle meal (sample № 1) and with a rosehip meal (sample № 2).

Table 3. Formulations of enriched grain bread, kg per 100 kg of flour

| Name of raw materials | Control sample | Sample № 1 | Sample № 2 |
|-----------------------|----------------|------------|------------|
| Flour from the buckwheat | 50.00 | 40.00 | 40.00 |
| Flour from grain of wheat | 50.00 | 60.00 | 60.00 |
| Pressed yeast | 1.10 | 1.10 | 1.10 |
| Salt | 1.20 | 1.20 | 1.20 |
| Dry wheat gluten | 4.00 | 3.50 | 3.50 |
| Nettle meal powder | - | 3.00 | - |
| The powder from the wild rose meal | - | - | 3.00 |
| Water | on calculation | on calculation | on calculation |

5. Discussion of the results

According to the results of the test baking in laboratory conditions, it can be concluded that the use of nettle and rosehip powder in the formulation reduced the fermentation process by 15 and 25 minutes, respectively. This result can be explained by the presence of vitamin C and minerals that can intensify the fermentation process.

The consumer properties of enriched grain bread are investigated. When conducting an organoleptic assessment, the following indicators were taken into account: the surface condition of the peel, the colour of the peel, the nature of porosity, the colour of the crumb, taste and aroma, and mastication.

Each of the indicators was evaluated in points on a 5-point scale, taking into account the weight coefficient. The results of the tasting test are presented in Table 4. As can be seen from the data presented in the table, a bread sample with 3% powder from rosehip meal has the highest average score. In terms of “crust condition,” “porosity,” “aroma” and “taste,” bread sample No. 1 scored the
highest result relative to the test. A similar result was observed in the analysis of organoleptic quality indicators at the end of 36 and 72 hours of storage [13].

An analysis of the results of physicochemical indicators of the quality of enriched bread allowed establishing that the indicators of porosity and specific volume of bread are higher, compared with the test. The highest porosity had bread with the addition of powder from rosehip meal. In the formulations of which powders from nettles and rosehip were introduced, the moisture content of the bread was lower compared to the test. The introduction of herbal supplements slightly reduces the acidity of bread, especially in bread with nettle meal powder.

| Name of indicators                  | Control sample | Score | Sample №1 | Sample №2 |
|------------------------------------|---------------|-------|------------|------------|
| Condition of the crust surface     | 4.1±0.2       | 4.4±0.3 | 4.8±0.3    |
| Color of the crust                 | 4.6±0.1       | 4.2±0.4 | 4.8±0.1    |
| The nature of porosity             | 4.2±0.3       | 4.3±0.1 | 4.7±0.2    |
| The crumb color                    | 4.3±0.2       | 4.2±0.3 | 4.9±0.2    |
| The elasticity of the crumb        | 4.0±0.4       | 4.0±0.4 | 4.9±0.1    |
| The aroma of bread                 | 4.0±0.1       | 4.2±0.3 | 4.8±0.3    |
| Taste of bread                     | 4.2±0.2       | 4.5±0.1 | 4.9±0.4    |
| Chewability                        | 4.0±0.3       | 4.0±0.3 | 4.7±0.1    |
| Sum of points                      | 33.4          | 33.8   | 38.5       |
| Average score                      | 4.18          | 4.22   | 4.81       |

During storage in the test and in samples of bread with vegetable additives, humidity decreases, which is explained by the evaporation of moisture and a certain amount of volatile substances.

Thus, herbal supplements slow down the transition of starch polysaccharides from a soluble state to an insoluble state due to the aggregation of molecules. This fact is probably because herbal supplements contain physiologically functional food ingredients. In particular, such ingredients are tannins, polyphenolic compounds that can interact with protein substances that prevent them from moisture.

There was an analysis of organoleptic and physicochemical indicators of enriched bread quality. Based on the results, it was found that herbal supplements containing functional food ingredients contribute to better shelf life of bread. The consumer properties of bread include flavour and digestibility.

The content of aroma-forming compounds (aldehydes) was determined by 0.1n iodine solution (conventionally expressed in ml). The results of studies of aroma-forming compounds are presented in Table 5.

| Bread with vegetable additives | The content of aldehydes, conventionally expressed in ml of 0.1 n iodine solution |
|-------------------------------|-----------------------------------------------|
|                               | Freshly baked bread | After 72 hours of storage |
| Control sample                | 12.28              | 10.12               |
| Sample №1                     | 18.28              | 17.12               |
| Sample №2                     | 15.15              | 13.14               |

The results of the study showed that with the introduction of herbal additives, the content of aromatic substances in the bread samples increases.
Under the action of the digestive enzyme pepsin, an indicator of hydrolysis of protein, crumbs of cereal bread was studied. At the end of 24 hours after baking grain bread, the digestibility of proteins was determined by the Anson method. The hydrolysis indices were monitored after 30, 60, 90 min. Data on the results of the study of the optical density of hydrolysates are presented in Table 6.

| Sample № | Optical density, unit of the device |
|---------|-------------------------------------|
| 0.025   | 0.0491  | 0.0499  |
| 0.015   | 0.0362  | 0.0373  |
| 0.014   | 0.0241  | 0.0232  |

Table 6. The optical density of bread hydrolysates with herbal additives

An analysis of the results showed that hydrolysis of protein substances by digestive enzymes took place after 30 minutes in the crumb of bread samples with vegetable additives, therefore, more intensively than in the test bread sample.

The percentage of satisfaction with the daily intake in functional food ingredients and energy was calculated for men and women over 60 years of age. In the calculation, the results of our studies of the content of functional food ingredients in the meal of plant materials were used (Figure 2).

Figure 2. Percentage of satisfaction of the daily needs of older people in the FPI when consuming 250 g of enriched grain bread

The use of 250 g of grain-fortified bread by older people contributes to meeting the daily need of copper and phosphorus by more than 45%, zinc by 19.2%, magnesium by 29.2% when using meal of rose hips and by 29.4% when using meal of nettle. 250 g of cereal-enriched nettle meal cereal bread will provide 55% of the body's vitamin C in vitamin K, and 21.7% of vitamin C-enriched rosehip bread cereal bread [14].

6. Conclusion

1. The optimal ratio of the composite mixture of flour from whole grains of buckwheat and wheat, which was 40:60, was established.
2. The introduction of powders of nettle and rosehip in the amount of 1, 3 and 5% does not significantly affect the activity of amylolytic enzymes. With an increase in the dosage of the meal, the viscosity of the dough increases, the greatest increase is established when adding powders from the nettle meal.
3. As a result of evaluating the quality indicators of experimental bread samples, it was found that the introduction of powders from meal increases the content of aromatizing compounds and the digestibility of proteins.

4. A formulation of enriched grain bread was developed. Organoleptic and physicochemical studies showed that bread with the introduction of 3% powdered meal has the highest values. The introduction of the raw vegetable meal increases the functional properties of grain bread due to the content of phosphorus, copper, magnesium and zinc. Besides, bread with nettle meal can satisfy more than half the daily norm in vitamin K, and with rosehip meal more than 20% in vitamin C.

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