The influence of food additives on the production technology and quality indicators of bread

E A Pyanikova, A E Kovaleva and M A Zaikina
Southwest State University, 94, 50 Let Oktyabrya street, Kursk, 305040, Russia

E-mail: pyanikovaelvira@yandex.ru

Abstract. Recently, the focus has been on the introduction of raw materials with a low glycemic index into the food industry, among which buckwheat and rice flour occupy a special place. The use of apple pomace in the bread recipe improves the organoleptic and physicochemical properties of the product. It also allows you to make adjustments to the traditional technology of bread production: to reduce the fermentation process by increasing the rate of formation of acids in the dough. The duration of the technological process for the production of bread with the addition of rice flour is increased by increasing the duration of soaking apple pomace in vegetable oil for better binding capacity in the future with rice flour and reducing the moisture content of the dough. In order to adjust the chemical composition, recipes for wheat bread were developed with a partial replacement for buckwheat and rice flour (sample No. 1 and sample No. 2, respectively) and the addition of 9.43% apple pomace. The introduced components will improve the structural and mechanical properties of the dough. The use of apple pomace and flour of cereal crops (buckwheat and rice) in the food industry makes it possible to enrich the chemical composition of bread with dietary fiber, vitamins of group B, K, mineral components (magnesium, calcium, iron, phosphorus, manganese, selenium). Vitamin B2 helps to absorb iron and, together with vitamin B1, helps to maintain the level of this trace element in the blood. From the results of the analysis of the vitamins, it follows that the finished product contains vitamins B1, B2, B5, B6 and K, which can be used for preventive nutrition. The use of food additives of plant origin in the formulation of wheat bread leads to an increase in the biological value of the product and a decrease in its calorie content.

1. Introduction
Bread is the staple food for most of the population. Bread supplemented with phenolic compounds has attracted more and more scientific interest in recent years. In addition to improving antioxidants in bread, the addition of phenolic compounds also affects the physicochemical properties and quality of the dough due to various interactions with flour components. In addition, phenolic compounds can prevent the formation of carcinogens such as acrylamide during baking, thereby functioning as an anti-carcinogenic agent in food systems [1].

The aim of the study was to carry out a comparative analysis of the effect of buckwheat and rice flour on the production technology and quality indicators of wheat bread with apple pomace.

2. Materials and methods
An important source of dietary fiber, pectin, water-soluble vitamins, organic acids, tannins, essential oils, flavonoids and minerals [2-4] are apples, which account for more than a third of all fruit products...
used in the food industry. Apples, as a valuable source of vitamin C, provide up to 15% of human physiological needs [5]. The use of products derived from processed plant raw materials allows you to improve the quality of flour, adjust its baking properties, as well as enhance the functional orientation and nutritional value of finished products by adding phytopowders from apples or apple pomace. The pomace is a residual product in the production of directly squeezed juices [6, 7], which makes it possible to ensure a waste-free production cycle. The seasonality factor can be levelled by drying or freezing valuable apple raw materials, as well as the production of phytopowders.

Apple pomace is a rich source of carbohydrates, pectin, crude fiber and minerals, and as such is a good source of nutrients [8]. The value of pectin is determined by the possibility of a complex effect on the organs of the gastrointestinal tract, digestive and circulatory systems, pronounced regenerating, astringent and anti-inflammatory properties. The most important factor for choosing a source of pectin substances is the availability of raw materials. In places where apples grow or are processed, it is advisable to use apple pomace.

Meanwhile, apple pomace is a rich source of biologically active substances - vitamins C, P, E, β-carotene, triterpene compounds, B vitamins, mineral elements (after squeezing the juice, almost half of the total amount of essential mineral elements remains in the pomace), dietary fiber, including pectin substances [9]. Dietary fiber from various sources is used to replace wheat flour in baked goods.

Dietary fiber has a great influence on the technology of making bread and its quality indicators. Dietary fiber can improve the texture, sensation and shelf life of baked goods due to their water binding and gelling properties [10-12].

Buckwheat flour contains a significant amount of vitamins and minerals. It has the ability to improve digestion and speed up metabolic processes.

Rice flour has many beneficial properties. Vitamins of group B, which are part of rice flour, improve the functioning of the nervous system. The high protein content promotes the growth of new cells in the tissues.

Vitamin B1 (thiamine) regulates carbohydrate and amino acid metabolism, it is necessary for the normal functioning of the central and peripheral nervous system. Its insufficient intake into the human body manifests itself in disorders of the nervous and cardiovascular systems, accompanied by muscle exhaustion, mental disorders.

Vitamin B2 (riboflavin) is a part of enzymes that play an essential role in oxidation reactions in all tissues of the human body. It regulates the metabolism of carbohydrates, proteins, fats and participates in the processes of tissue respiration, growth and development of the body.

Vitamin B5 (pantothenic acid) is a water-soluble vitamin, therefore it remains in the body for a very short time and requires constant replenishment of its reserves.

Vitamin B6 (pyridoxine) activates protein metabolism, plays a significant role in the synthesis and decay of various amino acids.

These B vitamins are resistant to heat treatment. If vitamins B1 and B2 are involved in providing the body with energy, then vitamin B6 plays an important role in the creation of protein molecules. Vitamin B6 is considered one of the most digestible vitamins. It is easily absorbed by the body, and only a lack of magnesium can prevent the normal absorption of the vitamin into the human body [13].

The presence of a normal amount of vitamin B6 helps the absorption of vitamin B12, as well as various magnesium compounds in the body. Humans and other mammals cannot synthesize vitamin B6 and therefore must receive the vitamin through intestinal absorption [14].

Calcium in the form of calcium salts of phosphoric acid makes up the bulk of bone tissue. Calcium activates the activity of a number of important enzymes, participates in maintaining ionic balance in the body, affects the processes occurring in the neuromuscular and cardiovascular systems, affects growth and increases the body's resistance to infectious diseases.

Magnesium participates in enzymatic processes, as well as in the formation of bones, regulation of the work of nervous tissue, in the metabolism of carbohydrates and energy metabolism. In the human body, magnesium promotes the elimination of cholesterol, exhibits a vasodilating effect, stimulates
intestinal motility, bile secretion, and activates enzymes. With a lack of magnesium, the excitability of the neuromuscular apparatus decreases, skin defects and ulcers appear, food absorption worsens, growth is impaired with a simultaneous decrease in body temperature.

Phosphorus is an essential element in proteins, nucleic acids, and bone tissue. With a lack of phosphorus, nervousness increases, efficiency decreases, headaches and deep disorders of the whole body develop.

Iron is an essential element for the human body, as it participates in the formation of hemoglobin and some enzymes. With a lack of this element, anemia may occur.

Manganese helps to activate the enzymes necessary for the proper use by the body of biotin, vitamins B1 and C. The interaction of manganese with copper and zinc is a recognized antioxidant agent.

Selenium is a biologically active trace element that is necessary to maintain the normal functioning of the body. Selenium deficiency can cause diseases of various organs and systems, usually occurring against a background of low acidity. This is the reason for premature aging and a decrease in the life expectancy of humans and animals.

This trace mineral is a powerful immune stimulating and carcinostatic agent with a wide range of effects on our health. Regular prophylactic selenium supplementation prevents hepatitis, herpes, and even Ebola virus infections.

Selenium deficiency in the body can lead to atherosclerosis of the vessels of the heart and brain, to the development of cancer, diseases of the skin, hair and nails.

2.1. Technological process of making bread without proving

Stage 1. Preparation of raw materials
1. Preparation of traditional raw materials: sifting flour, cleaning flour from metal-magnetic impurities, moving to a container.
2. Preparation of unconventional raw materials - apple pomace.
   Defrost frozen apple pomace under normal conditions at a temperature of 22-25 ° C. Soak defrosted apple pomace in vegetable oil and warm water 1:11 at a water temperature of 28-30 ° C. Stir the mixture continuously for 2-3 minutes until smooth and stand for 15-20 minutes.

Stage 2. Preparation of the dough
Simultaneous adding of the components of the recipe (flour, salt, yeast, prepared mixture), kneading the dough at high speed for 5 minutes, fermenting the dough for 5-7 minutes, dough temperature up to 29-31 ° C, kneading the dough, after which the fermentation process lasts 8 minutes.

Stage 3. Cutting the dough
Cutting the dough into pieces of a given weight of 0.2 kg each, shaping (rounding off the pieces of dough), proofing the dough pieces in a special chamber for 20 minutes at a temperature of 34–35 ° C.

Stage 4. Baking
Bread baking at 195–205 ° C for 20 minutes.

Stage 5. Final
Cooling at room temperature, packaging, storage, transportation.

The reduction of the fermentation process in the bread production technology has been established experimentally and is associated with the introduction of apple pomace into the recipe. Apple pomace has an effect on acidity during fermentation. In this regard, in order to prevent an increase in acidity in the dough and the finished product, the duration of fermentation of the dough from standard modes is reduced by 1 hour and 45 minutes.

3. Results and discussion
The content of all components in bread samples with the addition of freshly frozen apple pomace, rice and buckwheat flour was determined experimentally. In the course of research when baking pilot batches of samples by organoleptic and physicochemical indicators, the optimal ratios of the components were established, which are presented in table 1.
Table 1. Bread recipe.

| Raw material composition | Controlsample | Sample No.1 | Sample No.2 |
|--------------------------|---------------|-------------|-------------|
| High-grade baking wheat flour, % | 55.08 | 44.03 | 44.03 |
| Buckwheat flour, % | - | 6.28 | - |
| Riceflour, % | - | - | 6.28 |
| Pressedyeast, % | 1.89 | 1.73 | 1.73 |
| Drinkingwater, % | 37.87 | 34.6 | 34.6 |
| Vegetableoil, % | 3.44 | 3.14 | 3.14 |
| Applepomace, % | - | 9.43 | 9.43 |
| Tablesalt, % | 0.86 | 0.79 | 2.5 |
| Sugar, % | 0.86 | - | - |

For the organoleptic assessment, a scale was developed to assess the quality of bread, in which each indicator assigned the maximum number of points - 5, the total amount of points was 40 points [16].

Evaluation of the quality indicators of baked bread samples was carried out using expert and organoleptic methods. The expert method is based on the fact that each of the 5 experts participating in the survey assigns a certain point to each of the criteria. The tasters, using their senses, assessed the quality of the organoleptic characteristics of the developed bread samples using recycled apple raw materials and adding rice and buckwheat flour. The obtained results were calculated and based on these results a test report was drawn up. The average values of organoleptic indicators of the quality of bread samples are shown in figure 1.

![Figure 1. Sensory evaluation of bakery products samples.](image_url)

According to the results of the study of the organoleptic indicators of the quality of the developed samples of bread (figure 1), it can be seen that they are superior to the control sample. The best was the sample with the addition of rice flour (sample No. 2), which scored 39.1 points out of 40. The sample of bread with the addition of buckwheat flour (sample No. 1) yielded 0.9 points and scored 38.2 points in all indicators.

According to the "shape" indicator, sample No. 1 scored 4.6 points, sample No. 2 - 4.8 points, which meets the requirements of GOST: the shape is round, not vague, without imprints.

Sample No.1 had a light brown color with an even distribution of plant-based additives (it scored 4.6 points); for sample 2 - light brown; the crumb is white with a slight greyish tinge.

According to the indicators "baked" and "mixture", both samples received 5 points each. The crumb is baked, not wet to the touch; elastic, after light pressure with fingers, it took its original shape. Lumps and traces of impurities were not observed in the samples.

According to the "porosity" indicator, sample No. 1 scored 4.6 points: the porosity is developed, without voids and compaction, uniform, but the pores are larger than that of the control sample. Sample No. 2 has well-developed porosity, without voids and compaction, and is uniform.

In the sample of bread No. 1, the taste and smell received 4.8 points each: they were characteristic of this type of product, without any strange taste and smell. Sample No. 2 has a slightly sweet taste.
characteristic of this type of product. For this indicator, the sample scored 5 points. The smell of this sample scored 4.9 points: it is characteristic of the introduced flavouring additives, without strangeodours.

The resulting finished bread with a amount of rice flour of 12.5% had a good appearance (crumb colour), elasticity, surface without cracks and tears. With an increase in the amount of rice flour in the recipe, a deterioration in the rheological properties and elasticity of bread was observed.

Physicochemical indicators of product quality characterize the quality of technological processes [17], therefore, their determination is an integral part of assessing the quality of finished products.

For the developed bread samples, a physicochemical quality assessment was carried out for compliance with GOST 31805-2018. In a comparative analysis of the obtained results of the test samples in terms of moisture, acidity and porosity, all values are within acceptable limits and meet the requirements. Humidity for the control sample is 25.57%, for sample No. 1 - 25.98% and for sample No. 2 - 43.6%. The acidity of the crumb is within the normal range and was: for the control sample - 3.2 degrees, for sample No. 1 - 3.3 deg. and sample No. 2 - 3.4 deg. The porosity was 69.25% for the control sample, 73.3% for sample No. 1 and 73.3% for sample No. 2. But it should be noted that when comparing sample No. 1 with sample No. 2, there are significant deviations in humidity of 25.98% and 43.6%, respectively. This is due to the fact that rice flour does not have a water-holding capacity, which affects the moisture content of the bread crumb.

Bread with the addition of freshly frozen apple pomace and the replacement of part of the wheat flour with rice or buckwheat in terms of organoleptic and physicochemical indicators corresponded to the indicators of GOST 31805-2018. And among themselves the samples of bread did not differ significantly.

The results of determination of energy and nutrients in the studied samples of bread are presented in Table 2.

| Nutrient            | Daily rate | Content in the control sample | Content in sample No. 1 | Content in sample No. 2 |
|---------------------|------------|-------------------------------|-------------------------|-------------------------|
| Calorie content (kcal) | 1328       | 241.0                         | 221.0                   | 219.0                   |
| Proteins (g)        | 80         | 6.7                           | 6.3                     | 5.7                     |
| Fat (g)             | 58         | 4.7                           | 4.3                     | 4.3                     |
| Carbohydrates (g)   | 121        | 42.9                          | 39.3                    | 39.2                    |

The nutritional value of the developed bread samples was characterized by the degree of balance of the main nutrients, the content of vitamins and minerals. The theory of adequate nutrition does not only provide for the presence of complete proteins and fats in foods. It is necessary that all nutrients, including minerals and vitamins, enter the body at the same time and in optimal proportions.

The results of the study (Table 2) showed that the developed types of bread (wheat-buckwheat and wheat-rice) include all the necessary nutritional components. As can be seen from the research results, they contain in 100 g: from 7.1% to 7.9% protein, 7.4% fat, from 32 to 33% digestible carbohydrates and 11.0% fiber. The bread contains vitamins B1, B2, B5, B6, vitamin K, which are transferred from the main and additional raw materials. Nutrients are in a state that allows them to be easily absorbed.

When comparing the chemical composition of the control and developed samples of bread, it was found that the proposed samples contain a greater amount of minerals, vitamins and fiber. This is due to the introduction of raw materials richer in these substances into the recipe (various types of flour from cereals, apple pomace).

The chemical composition of new types of bread determines their calorific content from 219.0 to 221.0 kcal per 100 g. This is approximately 17.0% of the daily human need for energy substances in food.
Dietary fiber (g) 20 2.0 10.0 2.1 11.0 2.1 11
Vitamin B1, thiamine (mg) 1.5 0.093 6.2 0.098 6.5 0.085 5.7
Vitamin B2, riboflavin (mg) 1.8 0.035 1.9 0.042 2.3 0.032 1.8
Vitamin B5, pantothenic (mg) 5 0.247 4.9 0.237 4.7 0.264 5.3
Vitamin B6, pyridoxine (mg) 2 0.093 4.7 0.079 4.0 0.107 5.4
Vitamin K, phylloquinone (mcg) 120 0.4 0.3 0.8 0.7 0.3 0.3
Calcium, Ca (mg) 1000 16.45 1.6 16.94 1.7 14.49 1.4
Magnesium, Mg (mg) 400 11.3 2.8 12.7 3.2 11.72 2.9
Phosphorus, P (mg) 800 61.3 7.7 67.5 8.4 56.4 7
Iron, Fe (mg) 18 0.824 4.6 0.954 5.3 0.693 3.9
Manganese, Mn (mg) 2 0.4251 21 0.3731 19 0.4497 23
Selenium, Se (mcg) 55 3.049 5.5 2.763 5 3.438 6.3

The mineral composition of sample No. 1 using buckwheat flour is characterized by a high content: magnesium (3.2%), iron (5.3%), phosphorus (8.4%), calcium (1.7%). Compared with the control sample and the wheat and rice bread, it contains small amounts of manganese and selenium. Also in the sample No. 1, in comparison with the sample No. 2 and the control, contains more vitamin B1 and vitamin B2. This is due to the high content of thiamine in buckwheat flour and apple pomace.

Sample No. 2 contained 5.3 mg of this vitamin, which is more than the recommended daily allowance. This increase is due to the use of rice flour, which is rich in pantothenic acid, in the bread recipe.

The analyzed bread samples contain a significant amount of vitamin B6 2-2.5 times higher than the daily norm.

When buckwheat flour is added to the recipe in sample No. 1, there is an increase in vitamin K (phylloquinone) in comparison with other samples by 0.4 μg.

The decrease in the calcium content in sample No. 2 is primarily due to the fact that the introduced rice flour contains a smaller amount of this element.

The magnesium content in the developed bread samples, in comparison with the control sample, increased by 1.4% in sample No. 1. The content of phosphorus and iron in sample No. 1 also increases. This is due to the content of this microelement in buckwheat flour and apple pomace.

Mineral substances found in 100 g of developed bread samples cover human needs as follows: in calcium - from 1.4 to 1.7%, in phosphorus - from 8.4 to 7.0%, in magnesium - from 2.9 up to 3.2%, in iron - from 3.9 to 5.3%, manganese - from 19.0 to 23.0%, and in selenium - from 5.0 to 6.3%.

One of the most important factors in the digestibility of bread with the use of apple pomace, buckwheat and rice flour are porosity, excellent taste, aroma and appearance of the product. The
presence of numerous macro- and micropores creates a very large total surface of contact between bread and digestive juices.

4. Conclusions
In the course of the study on the development of recipes for bakery products with the addition of apple raw materials and replacing part of the wheat flour with rice and buckwheat, the following conclusions were made:

- Soaking apple pomace in vegetable oil before making the dough allows you to get bread with developed porosity and good volume. Moisture loss is slower. Therefore, after 72 hours the bread remains fresh and does not stale.
- The duration of the technological process for the production of bread with the addition of rice flour is increased by increasing the duration of soaking apple pomace in vegetable oil for better binding capacity in the future with rice flour and reducing the moisture content of the dough.
- The use of rice flour in the amount of 12.5% increases the autolytic activity of wheat flour. To obtain bread of satisfactory quality with rice flour, it is necessary to use special acidifying natural additives. Fresh-frozen apple pomace was used as an acidifying component in the recipe.
- Finished bread with the addition of rice and buckwheat flour had a good appearance (crumb colour), elasticity, surface without cracks and tears. According to the indicators "moisture", " acidity" and "porosity", these samples meet the requirements of regulatory documents.
- The introduction of apple pomace, flour from cereal raw materials, the calorie content of the developed breads decreased, which was 221.0 kcal for sample No. 1, and 219.0 kcal for sample No. 2.
- The percentage of satisfaction of the daily requirement for the content of fibre, vitamins, macro- and microelements showed that the developed types of bread exceed the values of the control sample of bread.
- The proposed recipes allow expanding the range of wheat bakery products.

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