The results of evaluating the use of vegetable additives in bread production

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Abstract. The results of research on the influence of potato, carrot, and pumpkin additives in the dough in the production of bakery products are presented. It has been found out that the vegetable components introduced into bread making have a positive effect on the quality of finished products, improving their organoleptic and nutritional properties. It has been discovered that the addition of vegetable purees in an amount of 5 to 25 % significantly improves the quality of raw gluten flour with reduced baking properties. The introduction of natural additives in products not only improves the quality characteristics of products, but also allows expanding the range of products for healthy eating.

1. Introduction
The analysis of the dynamics of food consumption in the Russian Federation over the past decade has shown that the share of bakery products in the structure of the diet of Russians has increased significantly and continues to increase. However, the nutritional value of traditional products produced according to the national standards does not meet the modern requirements of the science of healthy and balanced nutrition, therefore, the introduction of components that give bakery goods dietary, preventive and functional properties to their recipe will solve the problem of deficiency of necessary nutrients, as well as give finished products preset positive character [1, 2]. Expanding the range of bakery products for functional purposes, including for dietary and therapeutic nutrition, is an urgent task.

Unfortunately, despite the abundance of experimental studies devoted to the problem of creating functional bakery products, a lot of issues concerning introducing into the recipe and the influence of the introduced components on the consumer properties of the finished products have not been studied much [3].

2. Materials and methods
Bakery products are mass consumption products, in connection with this, the development of their enrichment with biologically active substances - vitamins, minerals and dietary fiber while reducing calories is relevant [4, 5].
Fruits and vegetables are an indispensable part of the human diet, as it serves as a source of the whole complex of vitamins, minerals, enzymes, fiber, easily digestible sugars, flavoring, aromatic and other biologically valuable substances. One of the valuable properties of juicy products is its ability to increase the digestibility of proteins, fats and carbohydrates [6]. In this regard, one of the promising areas in food production is the enrichment of food products with vegetable and fruit powders, purees, cereals, ground raw or boiled mass, juices, extracts [7, 8, 9]. They are used to reduce energy-intensive components in the product formulation, enrich food products with dietary fiber, and improve organoleptic quality indicators.

For long times, bakers tried to diversify the varieties of bread and improve its taste, adding various food products to the dough, for example, honey, salt, cottage cheese, eggs, fat, malt, potatoes. And these additives justified themselves to a certain extent, giving the dough certain qualities, and the finished bread a new taste or a property. There are special requirements for functional ingredients: the lack of ability to reduce the nutritional value of a food product, safety in terms of balanced nutrition and naturalness. Vegetables rich in vitamins, dietary fiber and phospholipids, macro- and microelements, proteins and amino acids satisfy these requirements [6].

The purpose of our research has been to evaluate the consumer properties of functional bread enriched with additives of local vegetable raw materials: potatoes, carrots and pumpkins.

The objects of the study were the first-class wheat baking flour and bakery products made from it without additives and with vegetable additives. The quality of raw gluten in flour was evaluated in accordance with the requirements of GOST (All Union State standard) R 27839-2013 «Wheat flour. Methods for determining the quantity and quality of gluten». The finished bakery products were evaluated by organoleptic quality indicators.

3. Results and Discussion
The primary objective of the research was to study the effect of heat treatment on the chemical composition of vegetables. The maximum preservation of biologically active substances in vegetables (carrots and pumpkins) during heat treatment in the preparation of puree, which was obtained by baking in the oven, pre-treated with a solution of citric acid, which was used in the technology for preparing puree so that β-carotene does not oxidize. It is known that β-carotene is easily oxidized in air, especially at high temperatures, as a result of which the colour of the product weakens. This method of preparing puree makes it possible to recommend it as an enrichment of bakery products with β-carotene and pectin substances.

After heat treatment, the content of basic nutrients in wheat flour of the 1st grade and vegetables changed to a varying extent. A trend of increasing in varying degrees of the share of total carbohydrates in raw materials for bread production was revealed. So, in wheat flour without any additives, this indicator reached 15%, in potatoes – 4.4%, pumpkins – 0.3% and carrots – 0.1% (Table 1). The starch content decreased from 0.3 to 15%. The proportion of fiber and ash elements remained at the same level after heat treatment.

| №  | Indicator       | Wheat flour, 1st grade | Potatoes | Carrots | Pumpkin |
|----|-----------------|------------------------|----------|---------|---------|
| 1  | Proteins        | 10.6 / 10.5            | 2.0 / 1.98| 1.3 / 1.23| 1.0 / 0.97|
| 2  | Fats            | 1.3 / 1.25             | 0.1 / 0.09| 0.1 / 0.09| -       |
| 3  | General carbohydrates | 73.2 / 88.2    | 19.7 / 24.1| 7.0 / 7.1 | 6.5 / 6.8 |
| 4  | Starch          | 67.1 / 52.1            | 18.2 / 13.8| 0.2 / 0.1 | 2.0 / 1.7 |
| 5  | Fiber           | 0.2 / 0.2              | 1.0 / 1.0 | 1.2 / 1.2 | 1.2 / 1.2 |
| 6  | Ash             | 0.7 / 0.7              | 1.1 / 1.1 | 1.0 / 1.0 | 0.6 / 0.6 |

Table 1. The content of basic food substances before and after heat treatment, %
In addition, the effects of introducing the type of vegetables (raw, dried, boiled and baked) on the organoleptic quality indicators of bakery products: the surface of the crust, the state of the crumb of the finished product were studied. 10 samples of products were baked: the bread made from the flour of the 1st grade according to a unified recipe (a control sample), 3 types of bread with the addition of pumpkins, potatoes and carrots, respectively, in raw (crushed with a grater), dry (flakes of dried vegetables) form and mashed vegetables.

The studies have shown that adding puree to the dough leads to an improvement in organoleptic characteristics, namely: the colour of the products is uniform over the entire surface; the carrot and pumpkin ones are of pronounced yellow-orange, the potato one is of golden brown. The porosity is fine bubble, thin-walled, uniform. The crumb is elastic; the shape of the finished product is smoother and more even. The products had higher organoleptic characteristics compared to other options.

The comparative data on the addition of vegetables in raw and dried form (the colour is not uniform, vegetable flakes are visible, less elastic crumb, porosity is uneven due to inclusions, the surface of the peel is rough) show that better products can be obtained by adding puree made from boiled or baked vegetables.

The effects of plant-based additives on the baking properties of first-grade wheat flour and the quality of finished products have also been examined in our studies.

One of the research objectives was to study the effect of the concentrations of added vegetable puree on the baking properties of flour and the structural and mechanical properties of the dough. It is known that vegetables contain a fairly high content of carbohydrates; therefore, the effect of additives on the gas-forming ability of wheat flour was under study. As options, we took the share of additives in the dough 5%, 10%, 15%, 20% and 25% of different types of vegetable puree.

As a control variant, a sample without any additives was adopted. It was found that the gas-forming ability of first-grade wheat flour without the addition of vegetable puree to it amounted to 1300 cm$^3$ of CO$_2$ (Figure 1). When applying different amounts of vegetable puree, there was a tendency to increase this indicator to 1600 cm$^3$ of CO$_2$ in comparison with the control sample. At the same time, the gas-forming ability at a certain concentration of additives was slightly higher than that obtained using mashed potatoes.

![Figure 1. The influence of the proportion of additives of vegetable puree on the gas-forming ability of flour](image)

The further studies were related to determining the effect of vegetable puree additives on the «strength» of flour. This indicator is associated with determining the quality of raw gluten by its elasticity using the IDK (Gluten Deformation Index) device.

It has been established that vegetable puree additives have a strengthening effect on the raw gluten of the first-grade flour.
Figure 2. The effect of vegetable additives on the elasticity of raw gluten flour at a dosage of 15% by weight

In the 1st flour sample with an initial gluten quality of 95 units of the IDK (Gluten Deformation Index) device (group II, satisfactory weak), a change in elasticity from 75 to 80 units occurred with the addition of puree. The greatest strengthening effect was exerted by the addition of pumpkin puree to the dough. When evaluating the elasticity of gluten of the first grade wheat flour with unsatisfactory weak gluten (110 units of the IDK (Gluten Deformation Index) device), the same pattern was noted: strengthening raw gluten and reducing the elasticity to 85-92 units of IDK (Gluten Deformation Index) when introducing pureed vegetable additives into the dough.

Additives of vegetable purees in an amount of 15% by weight of flour provide high structural and mechanical properties of the dough. With a further increase in dosages up to 25%, there is practically no change in the elasticity of raw gluten. Strengthening gluten with the introduction of vegetables puree leads to the formation of complex compounds of flour proteins with carbohydrate additives (glycoproteins), which contribute to the emergence of additional bonds in the tertiary and quaternary structures of oligomeric proteins due to carbohydrate bridges, which give elasticity to the structures of protein molecules.

The high efficiency of strengthening gluten flour with the addition of pumpkin puree in comparison with potato and carrot ones is due to the higher content of mono-and disaccharides involved in the formation of glycoproteins.

4. Conclusion

Based on the conducted research, it has been found out that additives of mashed potatoes, carrot and pumpkin purees into the dough contribute to the production of bakery products with high organoleptic characteristics and nutritional value. They make it possible to increase the content of vitamins, minerals and dietary fiber in products, which is important in the production of functional products. In addition, vegetable components, acting as natural and affordable improvers, help to improve the quality of flour with weak gluten, which makes it possible to use the raw materials of the baking industry rationally.

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