Innovative technologies of using promising phyto-fortificants in bakery products of high nutritional value

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Abstract. The studies in the field of designing recipe compositions and technologies for new kinds of bakery products, including those enriched with physiologically functional ingredients, are now very relevant and promising, since they allow organizing nutrition on a scientific and hygienic basis, and focusing on the health aspect is one of the most powerful factors of bakery products liquidity. The aim of the study was an experimental substantiation for the use of grain ingredients, medicinal plant raw materials, carotene-containing raw materials and a food protein additive based on grain flour enriched with the mycelium of white button mushroom (\textit{Agaricus bisporus}) in the production of functional bread. A systematic analysis of the bakery production technology of products enriched with promising phyto-fortificants serves as the methodological basis of the study. According to the selected methodology, the problem of selecting and justifying the use of phyto-fortificants in the recipe of bakery products, as well as improving the prescriptions of bakery products using promising phyto-fortificants, was solved. It has been found that applying of phyto-fortificants has a positive effect on the dough maturation processes.

1. Introduction

The health of the individual and the nation as a whole is largely determined by the diet of nutrition. Optimal nutrition is a key factor in the active working capacity, life expectancy and preservation of the nation’s gene pool. At present, in all developed countries of the world, healthy nutrition has been elevated to the rank of State policy. Thus, "State policy foundations in healthy nutrition of Russian Federation population for period up to 2020" define as a priority the production increase of food products enriched with nutrients for mass consumption [1].

Organizing nutrition of the population on a scientific and hygienic basis is carried out in the following directions: quality improvement, biological value and taste advantages of food products, assortment improvement, introducing new effective methods of product manufacturing taking into account rational use of raw materials, developing combined food products of functional purposes.

Given the historically large share of the grain group in the consumer basket of the Russian Federation population, research in the field of prescription compositions design and technologies of bakery new types of products, including enriched with physiologically functional ingredients, is essential.

The volume of bakery production in the Russian Federation territory for 2015 to 2017, according to Rosstat (Russian Federal State Statistics Service) and Tebiz grup marketing company, was at the level of about 6 million tons. Sales volume of products according to the results of 2017 amounted to 715.14 billion rubles. Production capacity of Russian bakery production enterprises was estimated at 10.1
million tons. On average, in Russia in December 2017, production prices of the "Bakery products from wheat flour" category amounted to 44.8 rubles/kg.

Today, the share of enriched bakery products, positioned in the price segments "medium-plus" and "premium," does not exceed 3 to 5% of the total volume of the domestic bakery market. Companies focused on the production of social varieties of bread tend to allocate enriched bakery products to a special series with the status of healthy food products. Manufacturers whose product is designed for consumers with purchasing power "medium" and "above average", have this product promoted as elite product with original taste. Bakeries at supermarkets consider such bakery products as a kind of business card of their point of sale, an indicator of its prestige and wealth of assortment, and that is playing big part for today’s consumers favoring of having an opportunity to choose.

The term "functional nutrition" currently means not only proper organizing of the products consumption, their right balance, but also use in diets of the new generation food products, which have the specified properties and are intended to have a mobilizing effect on the own mechanisms and reserves of the organism regulating its vital activity, as well as to improve functioning of its specific systems and organs [2].

An application of promising plant-origin enriching agents contributes to improvement of organoleptic and physical and chemical parameters of bakery products, enhancement of their nutritive value, intensifying technological process of bread preparation [3, 4, 5, 6, 7, 8], reduced intensity of bread staling processes during storage [9, 10].

There has been defined a possibility of using medicinal and spicy-aromatic plants in bread production. The problem of increasing the biological value of bakery products is relevant and can be solved by adding supplemental kinds of protein-containing additives. Currently, leguminous crops are widely used in solving this problem [11]. The use of iodine-containing additives in the bakery production is an effective method of controlling iodine deficiency. Opportunities for using fruit phyto-additives in bread production have been revealed.

2. Purpose of this research
Experimental substantiation of applying grain components, medicinal vegetable raw materials, carotene-containing raw materials and food protein additive based on grain flour enriched with mycelium of white button mushroom in production of functional purpose bread. The research objectives included: 1) determine quality of bread from prime grade wheat flour using medicinal vegetable raw materials, grain components, carotene-containing raw materials and a food protein additive based on grain flour enriched with mycelium of white button mushroom depending on its organoleptic, physical and chemical parameters; 2) determine optimal dosage of grain components, medicinal vegetable raw materials, carotene-containing raw materials and food protein additive based on grain flour enriched with mycelium of white button mushroom while producing bread from prime grade wheat flour; 3) optimize recipe components of bread of preventive purpose with applying unconventional plant raw materials. The research objects were bakery products of increased nutritive value with the use of promising phyto-fortificants, their technology and composition. The subject of the research is the effect of applying phyto-fortificants on the quality and nutritional value of bakery final products.

The development of bakery prescriptions with the use of promising phyto-fortificants is of great theoretical and practical interest and creates prerequisites to expand an assortment, improve the quality, increase the nutritive and biological value of the final products.

3. Research materials and methods
In the experiments, straight dough method was used for dough preparing. The research used prime grade wheat flour, which met the requirements of the Russian standard "Wheat flour. General Specifications". Bread within the experiment variants was produced using the method of trial laboratory baking in accordance with the Russian standard "Bakery wheat flour. Method of trial laboratory baking of bread" followed by its evaluation by quality indicators according to generally accepted methods. Bakery products were enriched in the following directions: imparting therapeutic and preventive value when
using milled parts of wild medicinal herbs, increasing physiological value when using carotene-containing grain and vegetable raw materials, and increasing biological value when using a food protein additive based on grain flour enriched with mycelium of white button mushroom. Introducing to the bread composition the components that give them therapeutic and prophylactic properties, allows us to solve the problem of prevention and treatment of various diseases associated with a deficiency of certain substances. The use of wild medicinal herbs favorably affects the consumer properties of bread and gives it a functional focus. Promising raw materials for the production of functional products, including bread, are medicinal herbs: chicory and thyme. Flour from chicory root is a unique ingredient obtained by grinding dried chicory roots, has therapeutic and prophylactic properties. One of the features of this flour is the ability to combine high concentration of inulin (up to 60%), protein substances, sugar: levulose (10-20%), fructose (4.5-9.5%), pectin, lipids, choline, glycoside - intibin (0.2%), as well as chicory, chlorogenic, apple, citric and tartaric acid. Chicory contains 33 mineral elements, vitamins A, E, PP and group B. This aggregate gives chicory flour the original functional properties that are much wider than those of conventional flour. The thyme has a tangible antiseptic and immunostimulatory action. Herein was studied the effect of introducing the chicory root powder and thyme on the quality of wheat bread. Chicory root powder and thyme were added at dough kneading in dry form in amount of 1, 2, 3, 4 and 5% of flour weight. In plant composition the carotenes play the role of defenders, and this protection is perfect - they prevent free radicals from destroying the structure of cells. Once in the human body, carotenes begin to protect him too: if it weren’t for the carotenes, the cells of our body could die in a few minutes - although we certainly never think about that. As an antioxidant, carotene does a lot: in addition to protecting us from free radicals, it also increases stress resistance, helps the body adapt faster in unusual and difficult conditions, eases the effects of radiation, electromagnetic and chemical contaminants, strengthens immunity and increases the body’s ability to resist infections. Carotene and carotenoids are thermally stable, which makes it possible to use carotene containing raw materials in bread production as raw materials. The test scheme included ten options: without the use of carotene-containing raw materials (control variant) and with the use of pumpkin puree, carrots and tomatoes in an amount of 1, 3 and 5% of the mass of flour. The following carotene-containing grain additives were used: millet flour, millet flour subjected to hydrothermal steaming, and millet malt flour. They were added in the amount of 1, 3 and 5% by weight of the composite mixture. Creating industrial technologies for the production of concentrated protein products from plant raw materials is one of the main directions of increasing food resources, increasing their nutritional and biological value and improving the quality of nutrition of the population. Experiment on studying consumer properties of bread from prime grade wheat flour with applying a food protein additive based on flour enriched with mycelium of white button mushroom have included six versions: without applying a protein additive (control version) and with applying a food protein additive based on flour from soft wheat grain, oats, barley, millet and buckwheat enriched with mycelium of white button mushroom. The amount of additive input was 3% by weight of the composite mixture. All the tests described in the paper were performed in 3 to 4-fold repetition, with analytical definitions for each sample performed in at least three repeats. The tables show data from typical experiments, with each value consisting the average of three or more definitions. Herein only those results that have been reproduced in each experiment are discussed. Deviations in each case did not exceed 1 to 3%.

4. Results of research
Before laboratory tests, we examined the quality parameters of raw materials: prime grade wheat flour, composite mixtures and protein additives, which characterize their suitability for bakery. Prime grade wheat flour had a taste characteristic of the product, a white color with a cream tint and a smell characteristic of wheat bakery flour (Table 1). Prime grade bakery wheat flour was used in the experiment.
Table 1. Organoleptic and physicochemical quality parameters of bakery wheat flour taken for research.

| Name of parameter | As required by Russian standard | Actual meaning |
|-------------------|---------------------------------|----------------|
| Taste             | Peculiar to wheat flour, without extraneous flavors, not sour, not bitter | Peculiar to wheat flour, without extraneous flavors, not sour, not bitter |
| Color             | White or white with cream tint Inherent to wheat flour, without extraneous odors, not musty, not moldy | White with cream tint |
| Smell             | Inherent to wheat flour, without extraneous odors, not musty, not moldy | Inherent to wheat flour, without extraneous odors |
| Moisture content, % | Not more 15.0 | 11.3 |
| Mineral impurities | When chewing flour should not feel the crunch | When chewing flour crunch was not felt |
| Pest infestation  | Not allowed | Not found |
| Pest contamination| Not allowed | Not found |
| Mass fraction of ash, % | Not more than 0.55 | 0.50 |
| Mass fraction of crude gluten, % | Not less than 28.0 | 34.5 |
| Gluten quality, points GSG | - | 82.0 |
| Gluten quality group | Not lower 2-nd (II) | 2-nd (II) |
| Fall number, s | Not less than 185 | 346 |
| Acidity, degrees | - | 2.2 |

According to the organoleptic and physico-chemical quality parameters, premium-grade wheat flour met the requirements of Russian State Standard GOST R 52189-2003 “Wheat flour. General specifications.”

The properties of the main raw material changed depending on the type of additional raw material and its fraction in the composition of the composite mixture (table. 2).

Table 2. Physico-chemical quality parameters of flour and composite mixtures.

| Additional raw material fraction*, % | Flour moisture, % | Gluten content, % | Gluten quality, points GSG / group | WAC of flour, % | Flour acidity, degrees | Fall number, s |
|------------------------------------|------------------|-------------------|------------------------------------|----------------|------------------------|---------------|
| Requirements of Russian standard “Wheat flour. General specifications” | not more than 15 | not less than 28 | not lower than 2-nd (II) group (II) | n/a | not higher than 3 | not less than 185 |
| Premium-grade wheat flour | 0 | 11.3 | 34.5 | 82/II | 60 | 2.2 | 360 |
| Composite mix of premium wheat flour and millet flour | 1 | 11.3 | 34.4 | 82/II | 60 | 2.2 | 346 |
| 3 | 11.3 | 34.1 | 82/II | 60 | 2.2 | 343 |
| 5 | 11.4 | 33.6 | 82/II | 58 | 2.2 | 344 |
| Composite mixture of premium wheat flour and millet flour subjected to hydrothermal treatment | 1 | 11.3 | 34.2 | 82/II | 60 | 2.2 | 336 |
| 3 | 11.5 | 33.9 | 82/II | 60 | 2.2 | 331 |
| 5 | 11.5 | 33.5 | 82/II | 56 | 2.2 | 336 |
When using additional raw materials in the studied application rates, there was no significant change in the moisture content of the composite mixture compared to flour, which is due to the similar moisture content of the components and the low dosage of additional raw materials. A decrease in the mass fraction of crude gluten by 0.1 ... 0.9% was proportional to an increase of additional component fraction that does not contain gluten fraction proteins. At the same time, the quality of gluten has been maintained at a constant level. A significant decrease in the fall number was noted in the options using the malt flour. This trend is understandable and is due to an increase in the amount of α-amylase introduced with flour from germinated grain (malt).

The studied food protein additives based on a mixture of grain mycelium were a homogeneous dry powder, without impurities, insoluble in water. The color of food protein additives corresponded to the color of the grain used. Nutritional supplements obtained on the basis of flour from soft wheat and millet grains enriched with mycelium of white button mushroom were light brown, and on the basis of buckwheat - dark brown. Food additives obtained on the basis of flour from oats and barley grains enriched with mycelium of white button mushroom acquired a light-yellow color. The smell of the studied food protein additives was typical for this type of raw material, not musty not moldy. The taste of additives was typical for this type of raw material, mealy, without extraneous flavors, not sour, not bitter.

Physico-chemical and functional-technological parameters of the quality of food protein supplements obtained on the basis of flour from grain enriched with mycelium of white button mushroom are shown in table 3.

| Table 3. Physico-chemical and functional-technological quality parameters of food protein supplements based on flour from grain enriched with mycelium of white button mushroom. |
|---|---|---|---|---|
| **Food protein additives** | **Moisture content, %** | **Acidity, degrees** | **Water absorption capacity, %** | **Fat-binding capacity, %** |
| Based on flour from soft wheat grain enriched with mycelium of white button mushroom | 8.05 | 2.8 | 800 | 200 |
| Based on flour from oat grain enriched with mycelium of white button mushroom | 8.92 | 2.7 | 800 | 200 |
| Based on flour from barley grain enriched with mycelium of white button mushroom | 8.77 | 2.7 | 800 | 200 |
| Based on flour from millet grain enriched with mycelium of white button mushroom | 8.52 | 2.6 | 750 | 190 |
| Based on flour from buckwheat grain enriched with mycelium of white button mushroom | 8.50 | 2.7 | 750 | 190 |
Mass fraction of moisture in food protein supplements obtained on the basis of grain enriched with mycelium of white button mushroom according to the options of the experiment was 8.05 ... 8.92%. Active acidity, depending on the raw materials used, was practically unchanged and was at the level of 2.6 ... 2.8 degrees. The highest meaning of this indicator was noted in food protein supplements obtained on the basis of soft wheat flour enriched with mycelium of white button mushroom, and amounted to 2.8 degrees. Moisture-binding capacity amounted to 750 ... 800%; fat-binding capacity - 190 ... 200%, respectively. Thus, the effective proportion of water and food protein supplements for their hydration will consist 1: 7.5 ... 1: 8. The chemical composition of food protein supplements is shown in table 4.

**Table 4.** Chemical composition of food protein supplements based on flour from grain enriched with mycelium of white button mushroom.

| Food protein additives                                      | Dry matter, % | Crude protein, % | Crude fiber, % | Raw fat, % | Raw ash, % | NFE, % |
|------------------------------------------------------------|---------------|------------------|----------------|------------|------------|--------|
| Based on flour from soft wheat grain enriched with mycelium of white button mushroom | 91.95         | 16.08            | 3.25           | 3.92       | 3.78       | 64.92  |
| Based on flour from oat grain enriched with mycelium of white button mushroom | 91.08         | 15.21            | 7.84           | 4.81       | 3.14       | 60.08  |
| Based on flour from barley grain enriched with mycelium of white button mushroom | 89.23         | 15.95            | 2.43           | 2.98       | 2.77       | 65.10  |
| Based on flour from millet grain enriched with mycelium of white button mushroom | 91.48         | 10.79            | 6.49           | 3.63       | 4.45       | 66.12  |
| Based on flour from buckwheat grain enriched with mycelium of white button mushroom | 91.50         | 12.40            | 6.82           | 3.80       | 4.20       | 65.50  |

The mass fraction of dry matter in the experimental options was 89.23 ... 91.95%. The mass fraction of protein in the studied food protein supplements varied at the level of 10.79 ... 16.08% and depended on the raw materials used. The content of the mass fraction of crude fiber, raw fat and ash also varied according to the options of the experiment depending on the type and number of components included in the composition of the studied food protein supplements.

Evaluation of the bread quality was conducted according to organoleptic parameters, providing for the assessment of the appearance of products by shape, surface condition and color of the crust, as well as by parameters characterizing the state of the crumb: color, porosity, elasticity. The taste and smell of bread were determined. Based on the results of the quality examination, the average baking score was determined.

The results of the organoleptic evaluation of bread using wild-growing medicinal herbs showed that when a powder of chicory root and thyme herb is introduced into the composition, it is possible without deterioration in quality and is determined by the standard of their application (Table 5).

In particular, in bread using chicory root flour in an amount of up to 3% of the flour mass, the crust remains well convex, with an even brown surface, the crumb is characterized by uniform porosity and elasticity, although it acquires a weak grayish tint, the bread taste is inherent.

An increase in the mass fraction of chicory root flour in the recipe leads to a decrease in the convexity of the crust, its color becomes lighter, the surface is uneven, with cracks, the crumb porosity also becomes uneven, and with a 5% option it is even dense, the crumb is gray, wrinkled, the taste of bread is fresh, there is a taste of bitterness.

Bread made from wheat flour of the highest-grade using flour from thyme grass already in an amount of more than 1% by weight of the flour deteriorated the crust, it became bumpy, cracked, the porosity of the crumb became uneven, although it remained finely porous.
**Table 5.** Organoleptic and physico-chemical quality parameters of bread from highest grade wheat flour using powder from chicory root and thyme herbs.

| Experimental options                                      | Average baking score, points | Bread volume, cm³/100 g flour | Porosity of crumb, % | Humidity of crumb, % | Crumb acidity, degrees |
|-----------------------------------------------------------|------------------------------|-----------------------------|----------------------|----------------------|------------------------|
| Reference                                                 | 5.0                          | 290                         | 81.0                 | 41.4                 | 2.0                    |
| Bread with 1% chicory root powder                         | 4.9                          | 240                         | 63.0                 | 42.5                 | 2.8                    |
| Bread with 2% chicory root powder                         | 4.7                          | 240                         | 63.5                 | 42.5                 | 2.9                    |
| Bread with 3% chicory root powder                         | 4.7                          | 250                         | 65.0                 | 42.7                 | 3.0                    |
| Bread with 4% chicory root powder                         | 3.3                          | 235                         | 64.5                 | 42.9                 | 3.0                    |
| Bread with 5% chicory root powder                         | 2.7                          | 235                         | 62.5                 | 43.0                 | 3.1                    |
| Bread with 1% Thyme Herb Powder                           | 4.7                          | 240                         | 63.3                 | 42.5                 | 2.8                    |
| Bread with 2% Thyme Herb Powder                           | 4.4                          | 240                         | 64.0                 | 42.6                 | 2.8                    |
| Bread with 3% Thyme Herb Powder                           | 3.4                          | 250                         | 63.0                 | 42.7                 | 2.9                    |
| Bread with 4% Thyme Herb Powder                           | 2.7                          | 225                         | 62.0                 | 42.9                 | 3.0                    |
| Bread with 5% Thyme Herb Powder                           | 2.5                          | 220                         | 60.5                 | 42.9                 | 3.1                    |
| Russian standard requirements                             | Not standardized             | Not standardized            | Not less than 75%    | Not more than 44%    | Not more than 3.0 deg  |

Note that the crumb remained elastic and began to jam only on options with a maximum amount of flour from thyme grass. The taste of bread, although it acquired an unusual taste, remains pleasant, not worsening the overall impression of the taste. The use of different types of carotene-containing raw materials also had an uneven effect on the quality parameters of bread. So, bread made from premium wheat flour without the use of carotene-containing raw materials had a smooth surface corresponding to the type of product. The crust form was corresponding to the bread one, slightly convex, light brown with a ruddy tint.

Introducing the carrot puree into the composition has contributed a notable yellow hue of the peel, which visually enhanced the blush and increased the attractiveness of the product. At the same time, it should be noted that the surface of the peel was with tangible roughness. When using both carrot and tomato purees, there was a tendency of improving the products appearance as their applying dose increase from 1 to 5%. In the production of bread using pumpkin puree, the formation of a crust with a smoother surface was noted in comparison with other experiment options.

Despite the attractiveness of the appearance of bread using pumpkin puree, the crumb of bread in these experimental options was characterized by dense, uneven, thick-walled porosity, which significantly reduced the scores obtained when evaluating the porosity and elasticity of the crumb. The taste of bread was fresh. When using carrot puree, porosity was quite developed, and the crumb was elastic (Table 6).
Table 6. Quality parameters of bread using carotene-containing raw materials.

| Experimental options                                      | Porosity of crumb, % | Crumb humidity, % | Crumb acidity, deg | Average baking score, points |
|-----------------------------------------------------------|----------------------|-------------------|--------------------|-----------------------------|
| Control 100% of flour                                     | 74.1                 | 40.6              | 1.7                | 4.5                         |
| Premium wheat flour 100% + carrot puree 1% by weight of flour | 73.4                 | 41.7              | 1.7                | 4.4                         |
| Premium wheat flour 100% + carrot puree 3% by weight of flour | 74.0                 | 42.0              | 1.7                | 4.4                         |
| Premium wheat flour 100% + carrot puree 5% by weight of flour | 75.1                 | 43.4              | 1.6                | 4.6                         |
| Premium wheat flour 100% + tomato puree 1% by weight of flour | 74.0                 | 41.6              | 1.8                | 4.5                         |
| Premium wheat flour 100% + tomato puree 3% by weight of flour | 73.8                 | 42.1              | 1.8                | 4.6                         |
| Premium wheat flour 100% + tomato puree 5% by weight of flour | 75.7                 | 42.9              | 1.9                | 4.7                         |
| Russian standard requirements                             | Not less than 75%    | Not more than 44% | Not more than 3.0 deg | Not standardized |

The most uniform fine, tracery thin-walled porosity and the best values in terms of physicochemical quality parameters there were the options characterized with applying mashed tomato and carrot puree as a carotene-containing raw material, with its content in the amount of 5% by weight of flour. As a result, these options had the highest average baking score. It was in the range of 4.6 to 4.7 points.

As the source of provitamin A, as well as irreplaceable and replaceable amino acids in bread baking, there can also be considered the millet grain. By the content of these substances, the grain of millet significantly exceeds the similar indicators for wheat flour. This fact allows us to consider their use in bread production not only as a source of increasing the nutritional value of bread, but also as a factor contributing to the activation of baker's yeast at the dough process.

When studying the effect of additives based on millet grain on the activity of baker's yeast and the quality of the dough, it was noted that their use helps to increase the lifting force of yeast. The increase in dough acidity in given options also indicates the activation of yeast when using additives based on millet grain (table. 7).

Table 7. Activity of baker's yeast with use of additives based on millet grain.

| Experiment options                     | Lifting force of yeast, min | Dough acidity, degree |
|----------------------------------------|-----------------------------|-----------------------|
| Premium wheat flour 100%               | 9.2                         | 2.2                   |
| 99% wheat flour + 1% millet flour      | 7.5                         | 2.5                   |
| 97% wheat flour + 3% millet flour      | 7.0                         | 2.6                   |
| 95% wheat flour + 5% millet flour      | 6.0                         | 2.6                   |
| 99% wheat flour + 1% steamed millet flour | 6.0                  | 2.5                   |
| 97% wheat flour + 3% steamed millet flour | 6.7                  | 2.7                   |
| 95% wheat flour + 5% steamed millet flour | 7.1                  | 2.7                   |
| 99% wheat flour + 1% millet malt flour | 6.9                         | 2.6                   |
The results of the test laboratory baking showed the bread produced using additives based on millet grain in an amount of not more than 3% by weight of the composite mixture was characterized by the best appearance. Samples of bread on these options were distinguishable by more even and convex crust. The crust color was brown with a more conspicuous ruddy tint. The color of the crumb when using additives based on millet grain was white with a yellowish tinge, the crumb was soft, elastic, and after pressing it easily restored the structure. The crumb porosity when using additives based on millet grain was finer, thin-walled and more uniform. This was especially noticeable in options using flour from millet grain, subjected to heat treatment. The best average baking score, at the level of 4.8 points, was received by bread using flour from steamed millet grain, introduced in the amount of 3% by weight of the composite mixture (Table 8).

The results of the assessment of the bread quality physical and chemical parameters indicate that when using additives based on millet grain, the porosity of bread increases by 2 to 6%. The highest values of porosity, at the level of 80.0 to 82.0%, were obtained on the options using additives based on millet grain in the amount of 3% by weight of the composite mixture. Moreover, the maximum value of porosity was 82.0% when using flour from steamed millet grain.

**Table 8.** Physical and chemical quality indicators of bread from wheat flour and composite mixtures.

| Experiment option                  | Average baking score, points | Crumb porosity, % | Crumb humidity, % | Crumb acidity, degree |
|-----------------------------------|------------------------------|-------------------|-------------------|----------------------|
| Premium wheat flour 100%          | 4.1                          | 74.0              | 41.6              | 2.0                  |
| 99% wheat flour + 1% millet flour | 4.6                          | 76.8              | 43.6              | 2.0                  |
| 97% wheat flour + 3% millet flour | 4.7                          | 81.5              | 43.4              | 2.1                  |
| 95% wheat flour + 5% millet flour | 3.7                          | 74.0              | 44.0              | 2.0                  |
| 99% wheat flour + 1% steamed millet flour | 4.6                      | 75.0              | 42.2              | 2.0                  |
| 97% wheat flour + 3% steamed millet flour | 4.8                      | 82.0              | 43.0              | 2.2                  |
| 95% wheat flour + 5% steamed millet flour | 3.7                      | 74.5              | 43.6              | 2.1                  |
| 99% wheat flour + 1% millet flour | 4.1                          | 74.1              | 42.0              | 2.0                  |
| 97% wheat flour + 3% millet flour | 4.5                          | 80.0              | 44.1              | 2.1                  |
| 95% wheat flour + 5% millet flour | 3.9                          | 77.0              | 43.5              | 2.1                  |
| Russian standard requirements     | Not standardized             | Not less than 75  | Not more than 44  | Not more than 3.0    |

The crumb humidity of bread testing samples did not increase significantly compared to the control option, but its values increased as the percentage of millet-based additives in the composition of the composite mixture increased. The crumb acidity varied from 2.0 to 2.2 degrees, the optimum acidity was 2.2 degrees obtained in the variant using flour from steamed millet grain in an amount of 3% by weight of the composite mixture.

The appearance of the bread of premium grade wheat flour with the use of dietary protein supplements on the basis of a flour from the grain-enriched mycelium of white button mushroom, depending on the kind of used additives according to experimental options also differed.

The crust form of bread from wheat flour of the highest grade by the use of additives of a grain of wheat, barley, oats and millet was convex (5 points), and crust form of bread using flour from buckwheat grain enriched with mycelium of white button mushroom was weakly convex (3 points). The surface of the crust of bread from wheat flour of the highest grade was smooth, except for bread produced with the addition of flour from buckwheat grain enriched with mycelium of white button mushroom. The surface of this product was cracked (2 points). Crust color, according to the experimental options depending on the use of protein additive the appearance varied from light brown (4 points) to brown with a ruddy tint (of 5 points).

The use of food protein additives had a significant impact on the characteristics of the crumb of bread from wheat flour. The color of the bread crumb on the experimental options have changed depending...
on the type of additive. Thus, bread baked from wheat flour of the highest grade had a white crumb color (5 points). Bread from wheat flour baking with the addition of flour from wheat, barley, oats and millet had a white with a yellowish tinge of crumb color (5 points).

Bread from wheat flour of the highest grade with the addition of soft wheat, barley and millet had a fine, openwork, uniform, thin-walled crumb structure (5 points). And the use of additives from grain oats and buckwheat resulted in the formation of small, thin-walled, uneven crumb structure (4 points).

The elasticity of the crumb of bread from wheat flour and bread baked with the addition of flour from soft wheat, barley, oats and millet enriched with mycelium of white button mushroom was tender, silky, when you press your finger easily restores the original structure (5 points). The final product of wheat flour baking with the addition of flour from buckwheat grain enriched with mycelium of white button mushroom had a soft tender crumb (4 points).

The taste of bread from wheat flour baking with the addition of a food additive was normal, peculiar to this type of bread with a taste of the tested component.

The average Baker's assessment of the quality of bread from wheat flour was 4.9 points. The highest average score characterized the bread baked from wheat flour with the addition of flour from soft wheat grain and millet enriched with mycelium of white button mushroom – 5.0 points, respectively. The lowest number of points was noted in the product produced with the addition of a dietary protein supplement from buckwheat grain (3.1 points).

The porosity of bread from wheat flour baking without the use of food protein additives was 74.1%, the porosity of bread from wheat flour baking with the use of additives based on flour from grain enriched with mycelium of white button mushroom increased by 0.4 to 4.6%. The acidity of bread from wheat flour baking was within the norm and consisted 2.4 ... 3 degrees on the experimental option (table. 9).

Table 9. Physical and chemical quality parameters of bread from highest grade wheat flour with application of food protein additive on basis of flour from grain enriched with mycelium of white button mushroom.

| Experimental options                                                                 | Crumb porosity, % | Crumb humidity, % | Crumb acidity, Deg |
|-------------------------------------------------------------------------------------|-------------------|-------------------|-------------------|
| Premium wheat flour 100% (control)                                                 | 74.1              | 30.66             | 2.4               |
| Premium wheat flour 97% + dietary protein supplement based on wheat soft flour     | 78.6              | 30.03             | 3.0               |
| enriched with mycelium of white button mushroom 3%                                  |                   |                   |                   |
| Premium wheat flour 97% + food protein supplement based on oat grain flour          | 75.2              | 31.19             | 2.8               |
| enriched with mycelium of white button mushroom 3%                                  |                   |                   |                   |
| Premium wheat flour 97% + food protein supplement based on flour from barley grain | 75.9              | 32.00             | 2.8               |
| enriched with mycelium of white button mushroom 3%                                  |                   |                   |                   |
| Premium wheat flour 97% + food protein supplement based on millet flour             | 78.5              | 32.07             | 2.6               |
| enriched with mycelium of white button mushroom 3%                                  |                   |                   |                   |
| Premium wheat flour 97% + food protein supplement based on buckwheat flour         | 74.5              | 30.21             | 2.8               |
| enriched with mycelium of white button mushroom 3%                                  |                   |                   |                   |
| Russian standard requirements                                                      | Not less than 75% | Not more than 44% | Not more than 3.0 degrees |

The mass fraction of crude protein in bread in the verifying option was 17.51%, and according to the experimental options with the use of a protein supplement, it was in the range 18.14 to 18.50% with the maximum meaning for the option of using the protein supplement based on soft wheat.
5. Discussion of results

Currently, the domestic market of bakery products is quite diverse both in terms of assortment and pricing policy of each of the producers. But, if earlier consumers preferred mostly attractive appearance of the product and its taste, today it is its healthy properties. The trend of a "healthy" lifestyle opens up broad prospects for the development of the range of bakery products. Different needs and capabilities of the consumer dictate the conditions for each individual manufacturer. Ultimately, all types of positioning are reduced to focusing on the health aspect as one of the most powerful liquidity factors for bakery products with added value today. Studies have shown the introduction of phyto-enrichment agents has a positive effect on the dough maturation processes, which is explained by the high content of mono- and disaccharides, organic acids and minerals in additives. This aspect is especially interesting in the light of that many bakeries of medium, and especially low power, often use a straight dough procedure for preparing dough to reduce the duration of the production cycle. At the same time, the duration of the fermentation process is significantly reduced, and it is at this stage in the dough there is taking place an accumulation of substances that determine the aroma of bread and substances that affect the intensity of staling processes. Activation of baker's yeast using bread phyto-fortificants will partially solve this problem. It seems interesting to carry out further comparative studies to identify the effect of the use of phyto-enrichment agents on the quality of dough and bread when they are introduced at different stages of dough process (at the stages of preparing the dough and kneading the dough) with the sponge dough method of bread production, as well as on the intensity of the staling process of bread.

When using phyto-enrichment agents, an increase in the consumer properties of bread is achieved with their rather low dosage. The research results showed that their optimal amount, depending on the type of additional raw materials, is 1 to 3% by weight of flour. At the same time, the proposed bread products have high quality parameters, excellent palatability and increased nutritional value due to an increase in the content of protein substances, essential amino acids, dietary fiber, vitamins and mineral components. This bread can be attributed to the group of functional preventive products that contribute to improving human health and reducing the risk of disease.

The hardware and technological scheme for the production of bread using phyto-fortifiers does not require changes, and therefore new types of products can be produced at any bakery.

6. Conclusions

The use of phyto-fortificants in the production of bread is an urgent and promising direction in both scientific and industrial activities, since emphasis on the health aspect is currently one of the most powerful factors in the liquidity of bakery products.

Introducing phyto-fortificants has a positive effect on the dough maturation processes, which is explained by the high content of mono- and disaccharides, organic acids and minerals in the additives.

In the production of bread from premium wheat flour using thyme herb powder, its optimal amount is 1%, and using chicory root flour - 3% by weight of flour.

In the production of bread using carotene-containing raw materials, we suggest using mashed carrots or tomatoes in an amount of 5% by weight of flour. This will ensure the formation of products with the best consumer properties.

When using additives based on millet grain, the best effect is achieved when using flour from grain subjected to hydrothermal treatment by steaming. This ensures the activation of baker's yeast at the stage of dough process, the best appearance of bread, characteristics of the crumb and the values of physical and chemical quality parameters are improved. The optimal, according to the results of our research, is the use of additives in the amount of 3% by weight of the composite mixture.

Promising additives in bakery are protein supplements based on grain flour, enriched with mycelium of white button mushroom. The use of a food protein supplement based on flour from wheat, barley and millet enriched with mycelium of white button mushroom in the amount of 3% by weight of flour significantly improves the quality indicators of bread from wheat flour.
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