Introduction of innovative technology for the production of textured products from grain raw materials

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Abstract. With the use of innovations in grain processing enterprises, the goal of increasing production efficiency, obtaining new opportunities to improve product quality and customer satisfaction is achieved. The main place in the creation of innovative technologies is occupied by a scientific idea, then research is conducted to confirm the scientific concept and testing in industrial conditions. All this will allow to effectively integrate new technologies into production processes at enterprises. As part of this direction, the scientific idea of creating products enriched with trace elements has found its embodiment in a new way of enriching grain products with trace elements. The novelty of the technical solutions concepts, the developed method for obtaining products enriched with trace elements became the basis of innovative technology for the production of enriched textured products with specified functional and technological properties. The calculation of the planned calculation of textured products enriched with microelement (Fe) obtained by innovative technology from wheat, barley and oat extrudates per 1 ton showed the efficiency of their production. The production of the developed range of bread with the using textured product is economically feasible. This confirms the high level of profitability, which is above 13 % for all types of bread. Thus, while maintaining high quality and affordable prices, the developed types of products will be competitive and bring profit to enterprises.

1. Introduction

"Repeatedly conducted various studies have shown that the majority of the population in Russia revealed violations of proper nutrition, due to both insufficient consumption of food substances and their irrational ratio" [1, 2]. Therefore, "cereals and products of their processing are an integral attribute of a full-fledged nutrition" [2, 3].

Currently, trends in the nutrition of the Russian population are aimed at improving the health of the body, eating foods with functional properties. “This market offers products that meet the physiological need for nutrition” [4]. Therefore, one of the main directions in development of the grain processing industry is the intensification of technological processes, including the impact on raw materials by various methods, leading to changes in the physical and chemical properties of plant raw materials [5, 6].

Therefore, in the grain processing industry, considerable attention is paid to the introduction of advanced methods and the most advanced equipment in order to increase the efficiency of grain use in
its processing. “The method can be considered universal in the framework of both the processing industry and the agro industrial complex as a whole” [7].

The introduction of new innovative technologies for processing grain products makes it possible to increase the period of the product presence on the market due to the appearance of new quality characteristics of the product [8].

The use of innovative technologies in the production of products from grain raw materials is studied by both Russian and foreign scientists. P. D. Polandova, S. D. Shestakov, T. P. Volokhova, V. N. Khmelev, T. V. Shlenskaya, O. N. Krasulya, B. A. Krasulya, V. I. Bogush, Ya. A. Artemova, L. Wangl worked on the problem of introducing innovative technologies into the food industry. Such authors as Zakshevsky V. G. and Bogomolov A.V. in their work [9] consider “the use of new ingredients (of plant origin) in the technology of grain processing in order to improve the quality of flour and bread. The main goal of implementing an innovative solution is to correct the shortcomings of the raw material (grain) and give the final product the desired consumer properties (increased nutritional and biological value)”.

To a greater extent, foreign scientists consider the process of extrusion of various products, while the authors studying this topic are Abeykoon, Chamil & Kelly, Adrian L. & Brown, Elaine C. & Vera-Sorroche, and others [10].

Ferrum deficiency is the most common nutritional disorder, so, today about 1 billion people on earth suffer from ferrum deficiency anemia. It is believed that ferrum deficiency is present in about 1 billion more people, but without signs of anemia [11].

The literature indicates some achievements in the production of ferrum-enriched products. Thus, a number of sources say that people who ate ferrum-rich foods such as flour, rice, corn, salt, sauces, and milk had an improvement in the body's supply of this element [12].

Despite the presence of research on the introduction of innovative technologies in grain processing by Russian and foreign authors, the use of textured products from grain raw materials in the industrial sector is poorly reflected, which causes the relevance of studying this issue.

2. Research methods

In innovative technologies, changes in processing facilities, processes, and organization methods can be radical or gradual, and both ways of change are acceptable for grain processing. With the use of innovations in grain processing enterprises, the goal of increasing production efficiency, obtaining new opportunities to improve product quality and customer satisfaction is achieved [13].

The first place in the creation of innovative technologies is a scientific idea, then research is conducted to confirm the scientific concept and testing in industrial conditions. An important stage of innovation is testing the technology and, considering the results obtained, making final changes to the technological process and creating regulatory and technical documentation. All this will allow to effectively integrate new technologies into the production processes of the enterprise. The most successful innovative technological solutions become typical for the grain processing industry until more advanced technological techniques and technologies appear on the market.

One example in the grain processing industry in the production of flour and cereals is the use of technology that uses ultrasound-treated water to cool the grain, it reduces the preparation of raw materials for processing by almost 3 times. In addition to the acceleration of technological operations, there is also a positive effect on the finished product, for example, bread produced using such flour remains fresh for 72 hours [14, 15, 16].

As part of this direction, the scientific idea of creating products enriched with trace elements was embodied in a new method, for which patent No. 25055078 "Method for enriching cereal products with trace elements" was obtained. The novelty of the technical solutions concepts, the developed method for obtaining products enriched with trace elements became the basis of innovative technology for the production of enriched textured products with specified functional and technological properties [17].

This technology has been tested in the laboratory, tested at a grain processing plant, and a set of regulatory and technical documentation has been developed for new products. All the activities carried
out allow to attribute the development of technology for the production of microelement-rich textured products to innovative ones.

The SanPiN 2.3.2.1078-01 [18] defines vitamins and mineral salts that are allowed for use in the production of specialized products. These include ferrum sulfate, from which working solutions were prepared for the enrichment of raw materials with a trace element Fe.

During the experiment, the following operating characteristics were used: temperature - in the range from 25 to 60 °C, where 25 °C is the natural temperature. Given that at 67.5 °C the starch chains are completely gelatinized, the maximum temperature of the experiment is 60 °C. Primary experiments have shown that with a processing time of less than 10 minutes, the concentration of trace elements does not reach the desired value, and with 30 minutes or more, the structure of raw materials is destroyed, based on the above, the processing time is determined from 10 to 30 minutes with an interval of 5 minutes. The ultrasound frequency of 35 and 42 kHz was selected. During the research, the calculated amount of FeSO₄ solution was poured into the reactor. Working solutions of these salts with a concentration (in terms of metals) of 65 mg/l prepared on the basis of pedestrian only water. Then, in the proportion of 1 part of the grain raw material, the working salt solution was mixed and the mixture was subjected to ultrasonic treatment. The flow rate of the working fluid was 2.4 m³ per 1 ton of raw materials. After processing with ultrasound, the working solution was drained, the raw material was dried to 15% humidity, sent to extrusion, then the resulting extrudate was milled to a flour fraction. The resulting textured product was used for the production of bread. In bread recipes wheat flour was replaced with textured product from extruded grain raw materials in the amount of 25%.

3. Results

In recent years, innovative technologies in the grain processing industry have been widely used, this is due to an increase in consumer demand for new types of products that are characterized by high quality, nutritional value, have a functional orientation, and have a favorable impact on human health. As a rule, the development of new technologies that differ in production efficiency, which allows to optimize prices for products. “So, the same search solution can be given by different technologies, different types of goods” [19].

The raw material for the production of textured products is extruded wheat grain, cereals from barley, oats, the use of which solves one of the problems of increasing the efficiency of using the raw material base of the region, reduces the cost and improves the quality of products.

When developing innovative technologies for the production of bread of increased nutritional value using textured products from grain extrudates of main cereals, the optimal ratio of prescription components was established, including the replacement of wheat flour with textured product obtained from the grain extrudate of main cereals by 25%.

Table 1 shows the computation of the planned calculation for textured products enriched with microelement (Fe) obtained by innovative technology from wheat, barley and oat extrudates per 1 ton and the efficiency of their production.

Having considered the economic efficiency indicators of different textured products, we note that the highest level of profitability is observed in the production of textured products from oat extrudates, which was 41 %, due to the lowest production cost of 1 ton.

To assess the economic efficiency of the developed range of bread, it is necessary to consider the consumption rates of raw materials and auxiliary materials per 1 ton of products, the cost of 1 kg of raw materials, as well as the cost of producing 1 ton of finished products according to the control and optimal sample [20, 21]. In table 2, we present the cost estimate for the production of bread.
Table 1. Calculation of the technology effectiveness for the production of textured products from grain raw materials enriched with microelement (Fe) and the efficiency of their production.

| Calculation article | the production of textured products from grain raw materials enriched with microelement (Fe) |
|---------------------|-------------------------------------------------------------------------------------|
|                     | from wheat extrudates per 1 ton, rub | from barley extrudates per 1 ton, rub | from oat extrudates per 1 ton, rub |
| Material costs - total including: | | | |
| - raw materials and supplies | 13219.8 | 11614.3 | 9520.9 |
| of these, the cost of water | 49.9 | 49.9 | 49.9 |
| cost of Fe powder | 65.7 | 65.7 | 65.7 |
| - heat and electricity | 2272.8 | 2355.0 | 2323.6 |
| - water supply for technological needs | 12.8 | 13.3 | 14.5 |
| Returnable waste | 143.7 | 319.1 | 394.9 |
| Depreciation | 1034.5 | 1071.9 | 1075.4 |
| The payroll with deductions on social needs | 1565.0 | 1621.6 | 1626.8 |
| Commercial and other expenses | 266.5 | 276.1 | 277.0 |
| Production cost | 16229.5 | 14903.0 | 12895.0 |
| Selling price | 21274.0 | 20320.0 | 18183.9 |
| Sales income | 5044.5 | 5417.0 | 5288.9 |
| Profitability, % | 31.1 | 36.3 | 41.0 |

Analyzing the data in table 2, we note that the production of bread with various types textured products of grain raw materials in comparison with the control sample is higher, as a result of increased raw material costs, while the lowest cost of 1 loaf of bread in production with textured product from oats, which is more than the control sample by 11%.

Table 2. Cost estimates for the production of bread from textured products enriched with trace elements.

| Calculation article | Cost amount, thousand rubles |
|---------------------|-----------------------------|
|                     | wheat bread from flour of first-grade bread | bread with wheat textured product | bread with barley textured product | bread with oat textured product |
| Raw materials | 1506.72 | 2077.56 | 2050.76 | 1993.94 |
| Electricities | 328.95 | 328.95 | 328.95 | 328.95 |
| The cost of water supply | 24.95 | 24.95 | 24.95 | 24.95 |
| Maintenance costs of fixed assets | 37.1 | 37.1 | 37.1 | 37.1 |
| Transport cost | 69.0 | 69.0 | 69.0 | 69.0 |
| Annual salary Fund | 2535.0 | 2535.0 | 2535.0 | 2535.0 |
| Shop expenses | 135.1 | 152.2 | 151.4 | 149.7 |
| Input cost | 4636.8 | 5224.7 | 5197.1 | 5138.6 |
| Commercial expenses | 231.8 | 261.2 | 259.9 | 256.9 |
| Total cost | 4868.6 | 5486.0 | 5457.0 | 5395.5 |
| The production cost of 1 t | 32.5 | 36.6 | 36.4 | 35.9 |
| Cost of 1 loaf of bread, RUB. | 25.9 | 29.3 | 29.1 | 28.8 |
This indicates that the cost of production does not significantly increase when using textured products from grain raw materials in bread recipes.

Table 3 shows the main indicators of economic efficiency of bread production using textured products from extruded grain products enriched with trace elements (Fe) compared to the control sample.

Table 3. Indicators of economic efficiency of production of bread with textured product from grain raw materials, enriched by Fe.

| Indicator | wheat bread from flour of first-grade bread (control sample) | bread with wheat textured product | bread with barley textured product | bread with oat textured product |
|-----------|-------------------------------------------------------------|-----------------------------------|-----------------------------------|-------------------------------|
| Cost of 1 ton of commercial products, RUB. | 35780.0 | 41560.5 | 41186.3 | 40967.3 |
| Profit from the sale of 1T of finished products, RUB. | 3322.6 | 4987.4 | 4806.4 | 4997.0 |
| Profitability, % | 10.2 | 13.6 | 13.2 | 13.9 |

The calculation showed that the production of the developed products is cost-effective and is more than 13%. The level of profitability of bread replace part of the flour on textured product enriched in Fe compared with the control sample increased, the increase in the price of developed products, due to the appearance of new bread quality characteristics. It should be noted that the production of these products is economically feasible to expand the range and increase the production of bread with increased nutritional value [22].

4. Conclusion
The basis of innovative technology for the production of enriched textured products with specified functional and technological properties is the novelty of the technical solutions concepts, the developed method for obtaining products enriched with trace elements. The calculation of the planned calculation of textured products enriched with microelement (Fe) obtained by innovative technology from wheat, barley and oat extrudates per 1 ton showed the efficiency of their production.

The production of the developed assortment of bread with the using textured products is economically feasible. This confirms the calculated level of profitability, which was more than 13% for all types of bread products. Thus, while maintaining high quality and affordable prices, the developed types of products will be competitive and bring good profits to enterprises.

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