



Food fortification – problems and solutions

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Abstract

As part of the task of solving the problems of food security of the population of the northern territories of Russia, an important place is occupied by the task of providing the population with biologically valuable substances for the positive transformation of the nutrition system of a modern person is quite acute. A large part of the world's population and especially there is a strong deficiency of vitamins, minerals, dietary fiber, polyunsaturated fatty acids, which leads to oncological, cardiovascular, autoimmune and other diseases. The ability to maintain a long working state of the population (which is especially important in the light of pension reform) and a healthy old age depend on the correctness of the system and diets. The foregoing has led to the search for ways to improve the quality of existing and create promising food products, improving their quality. The most important direction in improving the quality of food throughout the world is the enrichment of food to provide the population with various nutrients in order to supplement the diet by consuming these nutrients, using basic foods as agents. The paper considers the state and trends in the development of food enrichment processes, and offers promising solutions for their production.

Keywords: vitamins, micronutrients, food fortification, nutrients, food, food security, North of Russia, nutrition system

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INTRODUCTION

The problems of ensuring food security of the population of the northern territories are given serious attention in Russia and abroad (Shegelman et al. 2018). An important direction to solve this problem is the implementation of the ideology of healthy eating. In the last decades of the twentieth century and in the twenty-first century, there was a significant transformation of the dietary structure of people compared to the previous period. As a result, a large part of the world's population has a severe deficiency of vitamins, minerals, dietary fiber, polyunsaturated fatty acids, which leads to the emergence of serious diseases such as oncological, cardiovascular, autoimmune diseases.

Studies by Russian scientists have shown a complete inconsistency of the nutritional structure with the real needs in accordance with the established normative acts. In many northern regions of Russia there is an acute shortage of vitamins and bioelements in the diet, contained in a large amount of vegetables and fruits. In many countries, there is a steady decrease in the content of trace elements, both in drinking water and in food. This trend is typical for many regions of

Russia; especially it is acute for the North of Russia. There is a low content in food of such vitamins (thiamine, ascorbic acid, folic acid, and riboflavin), minerals and trace elements (iron, calcium, iodine, fluorine and selenium). In this regard, at present, the development of new foods with a high content of useful components is of particular relevance (Trushechkin 2013).

The most important direction of improving the quality of food products throughout the world, including Russia, is the enrichment of food products to provide the population with various nutrients in order to supplement the diet by consuming these nutrients, using basic foods as agents. The paper discusses the well-known methods of solving the problems of production of enriched food products, proposed and patented new technical solutions.

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LITERATURE REVIEW

As noted in the monograph (Bobreneva 2012), studies of domestic and foreign scientists indicate a close relationship between the quality and structure of the human diet with the state of human health and its tendency to disease. The emergence of such a close relationship is due to the fact that disturbances in the nutritional system can lead to various structural and functional changes in the body, as a result of which, impaired metabolism, homeostasis and its adaptation reserves. The most important role of nutrition in the prevention of a number of diseases and maintaining the vitality and health of the population has been convincingly confirmed by numerous scientific studies (Trushechkin 2013).

As a result of active promotion of healthy nutrition and lifestyle by state and public organizations, scientists, the media, modern consumers of food recognize the importance of the quality of these products, the correctness of the system and diets. They began to take a more careful approach to choosing from a range of food and beverage products on the market that are necessary for health and are able to prevent the occurrence of diseases. As noted in Andlauer and Furst (2002), addressing the problem of providing the population with the choice and consumption of high-quality food that can support the health and well-being of the population should be an important preventive strategy aimed at improving the quality of life and promoting longevity. To the above, we consider it necessary to add that the ability to maintain a long working state of the population (which is especially important in the light of pension reform) and a healthy old age depend on the correctness of the system and diets.

It is necessary to note studies, Tret'yak and Mordvinova (2017), on the need for harmonization of nutriological and hygienic standards for food products. The authors believe that the product should be considered enriched, the content of enrichment components (micronutrients) in which should be at least 30-50% of the average daily requirement, while the content of micronutrients (micro and macro elements, vitamins) should be calculated taking into account their content in the baseline product, and the effectiveness of enriched products must be confirmed by testing on relevant groups of consumers.

The foregoing has led to the active search by scientists of various countries, developers and manufacturers of improving existing and creating promising food products, improving their quality. The most important direction of improving the quality of food throughout the world is the enrichment of food with micronutrients. In many well-known scientific sources, scientists note that a chronic deficiency in the body of essential elements is accompanied by a deterioration of

health, a decrease in working capacity, the development of various diseases (Bakumenko 2013, Spirichev et al. 2005). According to studies, 70% of the population of Russia is deficient in vitamin C, 40% are deficient in β -carotene, and almost a third of the population is in group B vitamins. Also, the problem of deficiency of selenium mineral (Snegireva 2009) and iodine (Dzakhmishcheva 2013) is acute for the population of Russia. 60–80% of children in Russia show inadequate supply of essential vitamins such as thiamine, riboflavin, pyridoxine, niacin, and folic acid (Kotlukov et al. 2013).

The 2015 report of "The State Policy of the Russian Federation in the Field of Healthy Nutrition" cites the following nutritional disorders of the adult population in the Russian Federation: excess caloric intake over energy expenditure - an increase in overweight and obesity; excessive consumption of animal fat - a violation of lipid metabolism, leading to the development of atherosclerosis; excessive consumption of added sugar - a violation of carbohydrate metabolism, increased blood glucose levels and the development of diabetes; excessive consumption of salt, leading to increased blood pressure and the formation of hypertension; deficiency of polyunsaturated fatty acids - a violation of lipid metabolism with the subsequent development of atherosclerosis, as well as a decrease in immunity; Vitamin deficiency: C, B1, B2, folic acid, E, beta-carotene, etc., which is accompanied by a decrease in nonspecific resistance to adverse environmental factors, which leads to increased sensitivity to infections, decreased performance, increased risk of cancer; deficiency of mineral substances, including: calcium - leads to the development of osteoporosis, iron - to the development of anemia, etc.; deficiency of certain trace elements: iodine, zinc, etc.; deficiency of dietary fiber leads to a decrease in the activity of the intestines, a violation of the intestinal microflora, an increase in the risk of atherosclerosis, cancer and other diseases.

Studies of domestic and foreign scientists convincingly show that the most effective and simple method for solving this problem is the enrichment of food with micro- and macro-elements. According to Ottawa (2010), this approach to solving this problem has been used in many developed countries for more than 100 years; already in 1900, Switzerland began to officially iodize edible salt, and this practice has been applied in other countries and is still used today. In Denmark, margarine was enriched in fish oil in 1917 due to vitamin A deficiency in children. In Great Britain, during World War II, bread flour was enriched with vitamin B1 (thiamine), niacin and iron. In addition, calcium carbonate was added to some flours. All these requirements are valid today. The requirement to make vitamins A and D in margarine is still valid in different countries. In the USA in 1938 standards for the enrichment of flour with thiamine, riboflavin, niacin and

iron were adopted. To date, to replenish the biological value of wheat flour of the highest and first grade, according to the Decree of the Chief Veterinary Doctor of the Russian Federation No. 5077 of September 16, 2003, it is enriched with vitamins of group B, PP, folic acid, ascorbic acid and iron (Sibiriyakov 2014). Vitamins, macro- and microelements in various countries around the world are widely used by food manufacturers to enrich supplied to the market substitutes for women's milk, a variety of baby and diet food products, milk and dairy products, juices, soft drinks, breakfast cereals and other grain products, margarine (Spirichev et al. 2005). Food fortification contributes to the production of functional products that positively affect individual functions of the human body or its body as a whole (Petrakova and Gurinovich 2007). The creation and introduction of functional products into production is one of the areas of the humanistic program of human nutrition proclaimed by the UN (Bobreneva 2012).

In forming a knowledge base based on patent information search, technological and technical solutions in the field of creating functional foods are considered.

A technology for the production of a functional product is proposed. It involves preparing a suspension by mixing native starch with water to a dry matter concentration of 35-38%, adding α -amylase solution, incubating the suspension mixture with enzymes at a temperature of 95-120°C to achieve the desired degree of hydrolysis of native starch 25- 32% (Anansky et al. 01.02.2017).

An important direction of development is the formation of functional products with high nutritional and biological value. Among them is a functional product that can be used for therapeutic purposes to reduce excess weight, reduce appetite, and improve food control (Ginzburg et al. 07.28.2017).

Dry nutrient blend functionality with increased biological and physiological value for the nutrition of the elderly contains the following components, in wt. %: carrot powder - 15.0-15.5, onion powder -10.0-10.5, seaweed powder - 0.05-0.06, powder from ginseng root meal - 1.0-1.5 , powder from rosehip meal - 3.5-4.5, powder from nettle leaves meal - 2.5-3.0 and lentil flour - the rest (Ivanova et al. 10.04.2015). Another option nutrient mixture with increased biological and physiological value contains the following components, wt. %: pumpkin seed powder - 10.0-10.5; powder from calamus rhizomes - 1.0-1.5; milk thistle powder - 5.0-5.5; spirulina powder - 2.0-2.5 and buckwheat flour - the rest (Pyanikova et al. n.d.).

Functional foods are being developed for use by athletes during intense training and competition, as well as to improve skin condition, strengthen and prevent injuries, and rehabilitate joints, tendons, ligaments, cartilage and other human connective tissues. For example, the functional product (Shterman et al.

February 6, 2017) includes collagen hydrolyzate, BCAA amino acids (leucine, isoleucine, valine), vitamin C, L-carnitine, inulin, agar-agar, erythritol, sucralose, citric acid, food coloring, flavoring, potassium sorbate and water in the following ratio of initial components, wt. %: collagen hydrolyzate - 18.0-22.0, amino acids of the BCAA group (leucine, isoleucine, valine) - 1.0-1.2, vitamin C - 0.16-0.18, L-carnitine - 0.3-0.4, inulin - 2.8-3.0, agar-agar - 1.2-1.4, erythritol - 3.0-4.0, sucralose - 0.010 - 0.012, citric acid - 1.6-1.8, food coloring - 0.08-0.10, flavoring - 0.3-0.4, potassium sorbate - 0.08-0.10 and water - the rest.

Functional product for sports nutrition (Tokayev et al. 12/01/2017) contains limonene, a mixture of extracts of apple and grapes, glycine, inositol, griffonia extract and pyridoxine hydrochloride in the following ratio, wt. %: a mixture of extracts of apple and grapes - 10-17, glycine - 12-14, inositol - 11-14, extract of griffonia - 3-6, pyridoxine hydrochloride - 0.5-2.0, limonene - the rest. Functional food for the correction of psychophysiological state and neuromuscular transmission in athletes at high physical exertion (Tokayev et al. 05.06.2018) contains fir extract, limonene, a mixture of grape and apple extracts, superoxide dismutase and choline bitartrate in the following ratio of initial components, wt. %: limonene - 6-9, a mixture of extracts of grapes and apples - 2.0-2.4, superoxide dismutase - 1-2, choline bitartrate - 0.01-0.1, fir extract - the rest.

In studies, Johnson et al. (2013), it has been established that lentils have significant potential for bio-enrichment of Fe with the proper genetic and environmental source. In work, Abdualrahman et al. (2016), it was established that flour made from ground beans can be used to improve the quality of food products based on grain crops.

An important direction of the synthesis of patentable solutions is medicine, in particular - nutrition. For example, the technological solution (Derevitskaya and Aslanova 11.09.2017) relates to the release of hydrolyzate with a high concentration of target biologically active substances with tissue-specific effects, which have a stimulating effect on the regenerative processes of the gastric mucosa, intended for the production of functional meat products for the nutrition of people with diseases of the gastrointestinal tract. To the pharmaceutical industry, incl. Food supplements enriched with essential micronutrients - phytoecdysteroids, for use in functional nutrition, rehabilitation medicine, geriatrics and sports, as well as in the treatment of carbohydrate and lipid metabolism disorders, prevention and compensation of abdominal obesity, memory improvement include a technological solution for a patent (Volodin et al. 08.08.2017). A functional food product has been patented for the complex prevention of atherosclerotic lesions of arteries, vessels and capillaries (Bubenchikov 08.09.2017).

A number of innovative solutions aimed at the production of dietary preventive nutrition products. For example, a functional triglyceride composition contributes to a reduction in the content of toxic oxidation products of oils and an increase in the biological value due to the preservation of natural biologically active substances (Zaitseva et al. 01.02.2017).

The analysis found technological solutions for the target group - children. For example, pharmaceutical and nutraceutical compositions, functional food and nutritional mixture (Bar et al. 03/01/2017).

Technological solution (Lisovoy et al. 08.06.2017) ensures the production of functional products with a high content of physiologically functional ingredients and allows you to expand their range.

It is known that the enrichment of grain-based products is an effective way to provide the population with various nutrients in order to supplement the diet by consuming these nutrients, using basic foods as agents. Such supplements can be an important tool in the fight against nutritional deficiencies. Cereals are one of the suitable bases for the enrichment of food, where minerals or vitamins can be added directly by mixing or in the form of a coating. Rosell (2016) emphasizes that enrichment policy depends on government decisions and in some countries enrichment is voluntary, while in others it is mandatory.

The paper, Samaniego-Vaesken et al. (2013), addresses issues related to the potential for voluntary fortification of food with folic acid in Spain, the market of which offers a significant amount of voluntarily enriched food products containing folic acid (FA) and a forecast of the corresponding contribution to the diet of children. The results showed that fortified foods provide more than ten times the FA than (6S) -5-CH₃-H₄PteGlu.

The feasibility of enriching flour for breadmaking with thiamine is shown in Tiong et al. (2015), since in Australia thiamine is necessarily added to flour for breadmaking with the main goal of enriching and reducing the prevalence of Wernicke-Korsakov syndrome.

The analysis showed that the synthesis of new solutions in the field of creating functional products should be aimed both at the production of functional products with increased caloric content, nutritional value, digestibility, and their production for various target groups: the elderly, athletes, tourists, people leading healthy lifestyle, the sick, children, etc.

MATERIALS AND METHODS

The materials used in this work included the results of systemic patent information searches for the Russia grant (Shegelman et al. 2018).

These materials formed the basis for the formation of a knowledge base used to synthesize new intellectual property objects in the field of end-to-end technologies,

integrating the operations of procurement - transportation of food raw materials - production of functional foods.

The methodology of functional and technological analysis and synthesis of patentable solutions is used. Based on a detailed analysis, the factors characterizing the imperfection of the system being improved (technology, equipment, recipe), its elements or the process of their functioning, undesirable effects, time losses, insufficient parameters - "bottlenecks" and reserves of development of the analyzed systems are studied. At the analytical and synthetic stage, technological and technical solutions are developed: by separating (redistributing, reducing) operations or technical systems, the subject of labor in time (space); changing the principle of operations; introducing (excluding) transactions; changing the nature of the interaction and connection of the system with the external environment; changing input (output) effects (type of product), etc.

The most important differences of the methodology used from the known methodologies are as follows: the system to be replaced (improved) is analyzed not in the manufacturing process, but in the process of its functioning (consumption); the analysis process includes the well-known method of building a "tree of goals"; the most rational iterative sequence of stages of the analysis and synthesis of systems is used; the combination of analysis and building a "tree of goals" activates the potential of mental activity, changes the direction of thinking, causing new associations and mental generation of technological and technical solutions. The methodology performs heuristic functions, remaining loosely connected by a set of cognitive actions and principles that guide specific research and allow evaluating traditional technological processes and systems of machines for setting and solving new problems.

The author's method of formation and analysis of knowledge bases and the formation of protectable results of intellectual activity was implemented, which included the following work stages: setting the task by the research leader (leader) or nominating her as a member of the creative research team (research assistant, graduate student, doctoral student); formation of the composition of research participants from the number of creative team members; the formation of a knowledge base and their use for solving scientific and technical problems on the basis of an expanded collection and analysis of domestic and foreign scientific and technical information for specific types of technologies and equipment; Special attention in the development of knowledge bases is given to an extended patent information search; discussion of the knowledge base in the creative team for all members of the team to have a clear understanding of the state and trends in the development of technologies and

technology in the field being studied; synthesis of ideas for new patentable objects of intellectual property using functional, structural and technological analysis and brainstorming; selection and execution of ideas in the form of applications for patenting of inventions and utility models.

RESULTS AND DISCUSSION

In Russia, legislative acts, regulatory documents and scientifically based guidelines for the production and sale of food products, developed on the basis of extensive scientific research, allow food manufacturers to develop new enriched products based on reasonable consumption rates of biologically active substances of consumers of various target groups.

In work, Sui et al. (2016), the qualitative characteristics and digestibility of bread enriched with extract from black rice rich in anthocyanin, as a nutraceutical, were investigated under laboratory conditions. In the study, bread was enriched with anthocyanin-rich black rice extract powder (ABREP) as a nutraceutical source. The results of the study show that the enrichment of bread with anthocyanins may be an alternative way of obtaining functional bread with a lower digestion rate and additional health benefits.

The composition of nutrients and the digestibility of fresh pasta, enriched with garden bean in the laboratory, was studied in Tazart et al. (2016). Nutritiously enriched fresh pasta was prepared from semolina, enriched with garden bean flour. Enriched pasta showed less cooking time and a higher loss of dry matter, but with similar water absorption. The contribution to the recommended mineral intake rates was higher in enriched pasta, and the enrichment rate of 30% was the highest, thus improving iron availability. The laboratory digestibility of proteins increased in proportion to the level of substitution of fodder beans. The starch hydrolysis rate decreased with enrichment of beans, which resulted in a decrease in the glycemic index in enriched pasta (91.9, 83.4 and 71.3 in 10%, 30% and 50% pasta, respectively) compared to traditional pasta (95.9) and white bread (100).

In work, Patel (2015), the potential of enriched functional products based on grain bran for the treatment of obesity and diabetes is considered. Grain bran, a by-product of grain processing, has gained important status in the development of functional foods. Bran, derived from rice, wheat, oats, barley, sorghum, millet, rye and corn, has been characterized with many healthy ingredients. Their anti-lipemic, anti-atherogenic, anti-hypertensive and hypoglycemic properties were confirmed. It has been tested to combat oxidative stress, weaken insulin resistance, prevent the risk of obesity, causing satiety and alleviate cardiovascular complications.

In Ronda et al. (2015), the effect of commercial beta-glucan concentrates in oats or barley, included at different levels (actual β -glucan concentration (1.3–3.9%), flour basis) in the gluten-free (GF) formulations of the dough for based on rice, differing in water content (89-141%, flour basis) on the rheological properties of the dough (empirical and fundamental tests) and the efficiency of bread production. The effect of the baking process on the content and molecular weight of β -glucan in the final bread was also evaluated. The specific volume of bread was negatively correlated with the elastic modulus of the dough (G') and viscosity (η_0) and positively with the loss tangent. Under optimal hydration, the rheological properties of dough rich in beta-glucans of barley and the qualitative attributes of the breads obtained from it were under the noticeable influence of the content of soluble fibers; G' at 1 Hz increased to $\sim 100\%$, and the volume of bread decreased by $\sim 32\%$ relative to the values of the control dough and bread. The added β -glucans in the dough were also quantified in breadcrumbs and there was a significant decrease in their molecular weight, most likely due to the activity of β -glucanase in the starting materials included in the GF flour mixtures. Consequently, while EFSA applications are achievable in gluten-free breads enriched in commercial β -glucan concentrates, controlling the activity of β -glucanase in raw materials can be a critical issue in showing all the physiological benefits associated with the consumption of these bioactive polysaccharides.

How combinations of dietary fiber can affect the physico-chemical characteristics of pasta is shown in Foschia et al. (2015). The production of high-quality functional pasta from unconventional raw materials is a problem. Partial substitution (15 g / 100 g) of durum wheat semolina with long-chain inulin (HPX) and short-chain inulin (GR), glucagel, psyllium and oatmeal (added individually and in combination) was performed to increase the level of dietary fiber consumption. Culinary, textural and color characteristics of the paste were evaluated and compared with a control sample containing exclusively durum wheat semolina. As a rule, the addition of material to durum wheat pasta increased the sugar boil, the swelling index and water absorption, and also reduced the resistance and resistance to uniaxial pasta stretch. Raw spaghetti samples became significantly darker (L^*) and redder (a^*) than control pasta. In cooked pasta, all inulin-rich samples were brighter than semolina pasta. Pasta made from oatmeal semolina 15 g / 100 g showed better results (with the exception of color) in comparison with other experimental pasta samples, but differed significantly from the control wheat sample. Combinations of fiber-rich additives have been studied with the inclusion of inulin GR, which has a less damaging effect when added in combination with oatmeal. This illustrates that some

fiber-rich sources may act better in combinations than separately.

The effects of oxidation and gluten-free protein enrichment (egg albumin and soy protein isolate) on the thermal transitions of rice, potato and tapioca starch, as well as the viscoelastic properties of their gels obtained at two casting temperatures, 90 °C and 120 °C (Villanueva et al. 2018), were investigated. The thermal and rheological behavior of starches depended on their botanical origin and was largely dependent on the presence and type of added protein, as well as on the pH of the aqueous dispersion. Oxidation to pH 4.5 increased the gelatinization temperature of rice starch in the presence of albumin or soy proteins, while at the same time reducing it in the case of tapioca starch, regardless of the presence of proteins. Oxidation of rice starch dispersion significantly reduced the apparent gelatinization enthalpy; this effect was even greater in the presence of proteins. The addition of proteins led to a structuring effect on tapioca gels, which resulted in higher viscoelastic moduli and lower δ tannin values. In general, oxidation resulted in weaker gel structures with a more pronounced effect on potato starch, most likely due to its higher phosphate content (screening charge). Significantly weaker gels were obtained at 120 °C compared to those treated at lower temperatures; however, the inclusion of protein enhanced the structure of the gel, which was not observed in gels formed at 90 °C, which was also revealed by microstructural analysis using confocal scanning laser microscopy. In conclusion, adding protein and adjusting the pH of aqueous starch dispersion can be an effective means for modulating the functional and textural properties of gluten-free starch-based gel formulations.

The feasibility of enrichment with sorghum iron (*Sorghumbicolor* L. Moench) and African millet flour (*Pennisetum glaucum*) is investigated in the paper, Tripathi and Platel (2013), since, according to Tripathi and Platel, the enrichment of the main products with iron is one of the strategies to increase the consumption of this mineral. Millet flour, which is the main product in countries such as India, is less studied as a product for enrichment. In the above study, sorghum flour and millet flour were examined as iron enrichment products. Sorghum flour and African millet enriched with iron (6 mg / 100 g), ethylenediaminetetraacetic acid (EDTA) and folic acid and the content of bioavailable minerals were determined in laboratory conditions. Enrichment significantly increased the bioavailability of iron in both types of flour; which was greatly enhanced by the inclusion of EDTA. Products made from fortified flour, stored for 30 and 60 days, and had lower bioavailable iron content than those obtained from samples of fresh fortified flour, but the same was significantly higher than in products made from raw flour. Iron fortification did not adversely affect the bioavailability of initial zinc. Thus, sorghum and African millet can be used as iron

enrichment products to provide more total and bioavailable iron.

The analysis showed that today the population of Russia has serious problems in the nutrition system, a significant violation of rational structure and diet, which, on the one hand, is characterized by excess calories over energy costs and excessive consumption of salt and sugar, on the other hand, lack of diet vitamins, minerals and trace elements, polyunsaturated fatty acids, as well as dietary fiber. The significant transformation of the dietary structure of people over the past decades of the twentieth century and in the 21st century is characterized by a decrease in the dietary intake quantity of micro- and macronutrients, resulting in a large part of the global population of the planet showing a strong deficiency of vitamins, minerals, dietary fiber, polyunsaturated fatty acids, which leads to the emergence of serious diseases, such as cancer, cardiovascular, autoimmune diseases. The most serious problem is that it is almost impossible to provide the needs of a modern person for micronutrients with a normal steady-state diet. The world and domestic science and practice show that the most effective and simple method for solving this problem is the addition of necessary micro- and macroelements to food products (Bakumenko 2013, Spirichev et al. 2005).

It can be stated that the problem of providing the population with biologically valuable substances for the positive transformation of the nutritional system of a modern person is quite acute. The ability to maintain a long working state of the population (which is especially important in light of the ongoing debate about the upcoming pension reform) and a healthy old age depend on the correctness of the system and diets. A simple extensive solution to this problem only through an increase in the supply of traditional products to the consumer market cannot be considered correct. The systematic formation of a desire to maintain a healthy lifestyle among large masses of the population, an increase in the number of people seeking such a lifestyle can help domestic food producers to gain a foothold in a new niche of functional and enriched health food.

In the bakery and confectionery industry, enrichment can be achieved through the use of enriched flour, or the necessary vitamins and other nutrients in the form of solutions, premixes and emulsions can be introduced at the stage of dough preparation. Premixes are homogeneous mixtures of vitamins and minerals in the set and ratios corresponding to the tasks of enrichment and the physiological needs of the body, taking into account the peculiarities of the structure of nutrition and the availability of micronutrients of various population groups. Formulations of such premixes are developed for each specific food product or group of homogeneous products, taking into account the regulated level of vitamins and minerals that must be provided in the finished product, the natural content of these nutrients in

the raw product, the loss of added micronutrients during the enrichment and storage of food products (Shatnuk 2016).

To increase the nutritional value of functional bread for children and women during pregnancy, use of powdered whole milk as a source of high-grade protein and calcium and wheat bran, which improve the bowels and soy lecithin, is used (Andreev and Smirnov 2010).

For enriching bakery products with inulin, a prebiotic that selectively accelerates the growth and metabolism of bifidobacteria, chicory roots were used in dried form, as well as in the form of a paste, powder (Reznikova et al. 2009).

Quite often, grain or legumes that have undergone extrusion processing are used as a fortifier. In the process of extrusion, the molecules of biopolymers contained in the grain or seeds of legumes are destroyed and decompose into simpler molecules, which increase their digestibility. In legumes, the destruction of anti-nutritional substances occurs. Thus, nutrients become more accessible. In addition, there is a disinfection of raw materials, because microorganisms are destroyed (Bykovskaya 1992). Thus, extruded flour from wheat or barley grain can be added to wheat flour to produce bakery products enriched with dietary fiber, polyphenols and some minerals (Yanova 2011). To obtain grain products that are balanced in amino acid, mineral and vitamin formulations, whole grain cereals were mixed (barley, millet, buckwheat, and oats), the mixture was extruded and, thus, multicereal products were obtained (Osipanov et al. 2015).

The indigenous healthy population of the North, in contrast to the alien, has a genetically modified metabolic, immune and antioxidant status. This is connected not only with the degree of adaptation to the conditions of the north, but also with the traditions of nutrition of the indigenous population, the modern environmental situation. Obviously, in order to preserve the health of the newcomer, taking into account the modern ecology and geopolitics of the indigenous population of the North, it is necessary to develop methods and a set of measures related to the exogenous support of the metabolic, antioxidant and immune status of the organism. The traditional food of the aborigines of the North and food products, having in their composition elements of geographical origin, can be used as a kind of model for the development of a balanced diet of the alien population in Siberia, the Far East and the Far North.

Analysis of scientific sources shows that the mechanical method of food enrichment by mixing is widely used in Russia - formulations and technologies have been developed, and research work is intensively carried out related to the use of mixing in food fortification. As the review has shown, mixing is most often used in the enrichment of bakery, pasta and confectionery, snacks, breakfast cereals, cereals, etc.

The popularity of mixing is explained, not least by the fact that in Russia many of these enriched products are traditionally consumed by all groups of children and adults. Ready-made vitamin-mineral premixes are often used as sources of additional nutrients, but fruits and vegetables, greens, milk powder, etc. are no less successful. Interesting experience of enrichment through the use of extracts, emulsions, syrups. It is important that this method of enrichment is simply made hardware, is not expensive and controlled.

The analysis showed that in recent years, advanced technologies for processing grain, grain waste, field crop waste, waste from the milling industry, biological waste include extrusion technology. In the economically developed countries of the USA, Japan, Western European countries, extrusion technologies have become a priority for the development of the food and feed industries. Currently, progressive extrusion methods produce confectionery products, as well as feed for poultry, animals, and fish. The basics of extrusion processes are dealt with large research centers - Technical University of Berlin (Germany), Center for Agricultural Research in Nantes (France), University of Kansas (United States of America) (Kushnir et al. 2016).

Extrusion preparation, due to its low cost and continuous technological capability, is a popular means of modifying the functional characteristics of cereal grains (Bao and Bergman 2004).

Patil et al. (2016) considers the effects of legume enrichment and extrusion on protein digestibility in wheat-based snacks. The formulation of research is due to the fact that cereal food is an important part of the human diet, with wheat being the most frequently consumed cereal in many parts of the world.

In work, Sharif et al. (2014), the characteristics of rice-soy chips processed by supercritical fluid extrusion, enriched with microelements and soy protein are investigated. Rice-soy chips (RSC) enriched with protein and microelements were prepared using supercritical fluid extrusion and their effect on the quality characteristics was determined.

On the basis of the formed knowledge base, the authors developed and patented new technical solutions (Shegelman et al. 2018a, 2018b) and (Sharif, Syed & Paraman, 2014).

The authors have developed a new original version of the device for mixing plant materials, in the development of which the closest in essence and taken as a prototype is an extractor for a solid-liquid system containing a vertical housing with a steam jacket, with process connections and a dispenser. In the housing on the hollow shaft there is a coaxially mounted mixing device, which is made in the form of upper and lower cross-shaped agitators. The lower mixer of the mixing device is hollow and provided with hollow L-shaped combs with openings at the ends bent upwards. The

mixing device contains knives mounted on the hollow shaft at different heights with side cutting edges. Each knife when viewed from above is located relative to the other knife at an angle of 45 °. Under the combs is a lattice partition. The disadvantages of the known extractor are insufficient quality mixing of the raw materials, the slow dissolution of the extractant in the feedstock, and as a consequence of the low productivity of the device.

The technical result of the new device for mixing is to accelerate the extraction process, increase the productivity of the device due to the intensification of mixing of the raw material and extractant. Achieved technical result in that the proposed device for mixing plant materials, including a vertical body with a steam jacket and process pipes, the lower part of which has a horizontal lattice partition, above which is mounted on the hollow shaft mixing device, in the form of upper and lower agitators, between which, at different heights, knives with side cutting edges are fixed, a collection of extract, between knives with side cutting edges mounted on different m level, installed round link chains. The proposed version of the device for plant materials works as follows. When the drive is switched on, the vegetable or animal raw materials are fed to the body through the metering device, and the extractant is also poured in through the branch pipe. The rotation is transmitted to the hollow shaft and the mixing device. In the field of centrifugal forces, the extraction mixture is stirred. The agitators mounted on the hollow shaft, as well as knives located at different heights, connected by round-link chains loosen the stagnant zones of the raw materials throughout the entire volume of the vertical body 1, facilitating the access of the extractant to the entire surface of each solid particle. To maintain the required temperature, a steam jacket is installed in the housing, where coolant is supplied through the nozzle. Removal of the spent coolant through the nozzle. As it saturates, the extract passes through a lattice partition, where coarse filtration is carried out and is poured through the nozzle into a filter to separate impurities and is sent to collection 20, where it is separated from the remaining elements after filtration. Depending on the degree of saturation of the extract, the latter is sent for recirculation through the pipe 8 using a vacuum pump into the shaft cavity. Due to the vacuum created by the pump, the extract aimed at re-saturation enters the extraction mixture under pressure. After the extraction process is completed, while the drive is running, the extract is completely drained from the vertical housing, and the extracted raw material is removed through a nozzle connected to a discharge device, where the raw material is completely squeezed out. Next, the cycle of the extractor is repeated, and the selected extract is drained from the collection.

The authors of the work, Kirilina et al. (12.03.2019), proposed a food product, including plants of northern

latitudes, characterized by a weight of 538.5 grams. It is a mixture of dry ingredients in the following ratio of components, g: Dried lentils - 100.0; Dried potatoes - 100.0; Dried carrots - 100.0; Dried white mushrooms - 100.0; Tomatoes dry powder - 100.0; Dried onion - 20.0; Dried parsley - 7.0; Dried basil - 1.5; Iodized salt - 10.0. Dried lentils and dried potatoes are used as the basis. As functional additives, dried carrots, dried white mushrooms, dried tomatoes, dried onions, dried parsley are used. As a flavor, dried basil, iodized salt. The composition of the food product includes the components of plants growing in the Seven region: potatoes, carrots, white mushrooms, onions, parsley. The method of preparation of the product is as follows. The mixture is cooked in a saucepan in hot water for 60 minutes, after which the mixture should be drained through a colander.

In the calculations: the norms for macronutrients are taken from the recommended standards in the studies of Panin (1983); standards for micronutrients are taken from the work of Gorshkova and Lipatova (1987); information on the content of macro- and micronutrients is taken from the database of the Institute of Nutrition, Russian Academy of Medical Sciences.

The proposed food product, including plants of the Northern latitudes, was created specifically for residents of the North, taking into account their high energy costs and regular stress associated with uncomfortable climatic conditions. The product contains an increased amount of vegetable protein and has high calorie content. The product is very rich in vitamins E, B1, B2, B3, B6, C, and K. In large quantities contains a mixture of potassium, magnesium, phosphorus, iron, zinc, copper, manganese. 100 grams of the product contains about the daily requirement of dietary fiber, phosphorus, copper, vitamins E, B2, C and K. Vitamins B3, B6 and potassium are contained in an amount not less than the daily requirement. The composition of the mixture includes components of plants growing in the northern region: potatoes, carrots, white mushrooms, onions, parsley. The result of the proposed technical solution is to provide an increased amount of vegetable protein and high caloric content, contributing to the recovery of the body at high energy costs, stress caused by the discomfort of the climatic conditions of the North and high physical exertion.

CONCLUSION

1. The problems of ensuring food security of the population of the northern territories are given serious attention in Russia and abroad (Shegelman et al. 2018a, 2018b). An important direction to solve this problem is the implementation of the ideology of healthy eating. In the last decades of the twentieth century and in the twenty-first century, there was a significant transformation of the dietary structure of people

compared to the previous period. As a result, a large part of the world's population has a severe deficiency of vitamins, minerals, dietary fiber, polyunsaturated fatty acids, which leads to the emergence of serious diseases such as oncological, cardiovascular, autoimmune diseases. Studies by Russian scientists have shown a complete inconsistency of the nutritional structure with the real needs in accordance with the established normative acts. In many northern regions of Russia there is an acute shortage of vitamins and bioelements in the diet, contained in a large amount of vegetables and fruits. In many countries, there is a steady decrease in the content of trace elements, both in drinking water and in food. This trend is typical for many regions of Russia, especially it is acute for the North of Russia.

2. The indigenous healthy population of the North, in contrast to the alien, has a genetically modified metabolic, immune and antioxidant status. This is connected not only with the degree of adaptation to the conditions of the north, but also with the traditions of nutrition of the indigenous population, the modern environmental situation. Obviously, in order to preserve the health of the newcomer, taking into account the modern ecology and geopolitics of the indigenous population of the North, it is necessary to develop methods and a set of measures related to the exogenous support of the metabolic, antioxidant and immune status of the organism. The traditional food of the aborigines of the North and food products, having in their composition elements of geographical origin, can be used as a kind of model for the development of a balanced diet of the alien population in Siberia, the Far East and the Far North.

3. The analysis showed an active search by scientists of various countries, developers and manufacturers of improving existing and creating promising food products, improving their quality. The most important direction of improving the quality of food throughout the world is the enrichment of food with micronutrients. In many well-known scientific sources, scientists note that a chronic deficiency in the body of essential elements is accompanied by a deterioration of health, a decrease in efficiency, and the development of various diseases. Studies of domestic and foreign scientists convincingly show that the most effective and simple method for solving this problem is the enrichment of food with micro- and macro-elements.

4. Studies of domestic and foreign scientists convincingly show that the most effective and simple method for solving this problem is the enrichment of food with micro- and macro-elements. An important direction of development is the formation of functional products with high nutritional and biological value.

5. The analysis showed that the synthesis of new solutions in the field of creating functional products should be aimed both at the production of functional products with increased calorific value, nutritional value,

digestibility, and at their production for various target groups: the elderly, athletes, tourists, people, leading a healthy lifestyle, the sick, children, etc.

6. It can be stated that the problem of providing the population with biologically valuable substances for the positive transformation of the nutritional system of a modern person is rather acute. The ability to maintain a long working state of the population (which is especially important in light of the ongoing debate about the upcoming pension reform) and a healthy old age depend on the correctness of the system and diets. A simple extensive solution to this problem only through an increase in the supply of traditional products to the consumer market cannot be considered correct. The systematic formation of a desire to maintain a healthy lifestyle among large masses of the population, an increase in the number of people seeking such a lifestyle can help domestic food producers to gain a foothold in a new niche of functional and enriched health food.

7. Analysis of scientific sources shows that the mechanical method of food enrichment by mixing is widely used in Russia - formulations and technologies have been developed, intensive research is being carried out related to the use of mixing in food fortification. As the review has shown, mixing is most often used in the enrichment of bakery, pasta and confectionery, snacks, breakfast cereals, cereals, etc. The popularity of mixing is explained, not least by the fact that in Russia many of these enriched products are traditionally consumed by all groups of children and adults. Ready-made vitamin-mineral premixes are often used as sources of additional nutrients, but fruits and vegetables, greens, milk powder, etc. are no less successful. Interesting experience of enrichment through the use of extracts, emulsions, syrups. It is important that this method of enrichment is simply made hardware, is not expensive and controlled.

8. The analysis showed that the synthesis of new solutions in the field of creating functional products should be aimed both at the production of functional products with increased caloric content, nutritional value, digestibility, and at their production for various target groups: the elderly, athletes, tourists, people leading a healthy lifestyle, the sick, children, etc.

9. The paper discussed well-known and proposed promising methods for solving the problems of production of enriched food products and promising recipes. Using the developed knowledge base and methodology combining functional and technological analysis and brainstorming, new technical solutions, Extractor for Plant Raw Material and Food Product, Including Plants Grown in the Conditions of Northern Latitudes, were developed and patented.

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