

# Supply Chain Management Application in Functional Food Industry

Shegelman I. R.<sup>1\*</sup>, Kirilina V. M.<sup>2</sup>, Vasilev A. S.<sup>3</sup>, Blazhevich L. E.<sup>4</sup>, Smirnova O. E.<sup>5</sup>

<sup>1</sup>*Cross-cutting technology and Economic Security, Petrozavodsk State University (PSU), Petrozavodsk, Republic of Karelia, Russia.*

<sup>2,4,5</sup>*Petrozavodsk State, University (PSU), 33, Lenina pr., 185910, Petrozavodsk, Republic of Karelia, Russia.*

<sup>3</sup>*Technologies and Organizations of the Forest Complex, Petrozavodsk State University (PSU), Petrozavodsk, Republic of Karelia, Russia.*

<sup>1</sup>*education.com.ru@gmail.com*

**Abstract**— As follows from the analysis, the producers of functional food production do not increase their production and its supply in the domestic market intensively enough and have a quite low export capacity. During production of functional foods, producers do not pay sufficient attention to patenting of the developed intellectual property objects. It was revealed that Russia, that shows a considerable potential of agricultural land and positive experience of agricultural sector development, needs to ensure the development of domestic supply chain management in businesses and industries to provide promising new-generation functional foods competitive in the internal and external markets. Competitiveness of such products can be improved by development of supply chain management – specialized functional foods. This paper explores ways of improving supply chain management within the food processing industry looking into characteristics on justification and development of advanced functional food, its formulations and production technologies. This work presents a supply chain strategy in terms of food industry subsectors and producers, food effects obtained from functional foods, and in terms of consumers of functional food products depending on product purpose.

**Keywords**— *functional foods, supply chain management, food products, food security, boreal plants.*

## 1. Introduction

In recent years, the global market has increased attention to the solution of justification, development and supply chain management to world markets of promising functional foods, recognizing it as the most important factor in the transfer of the various population groups to a healthy lifestyle, including healthy diet. It is no accident that in recent years, researchers and producers of functional foods around the world have been working to solve these problems.

Russia, that shows a considerable potential of agricultural land and positive experience of agricultural sector development, needs to ensure the development of domestic supply chain management in businesses and industries to provide promising new-generation functional foods competitive in the internal and external markets. Competitiveness of such products can be improved by development and patenting of scientifically grounded and innovative intellectual property objects – specialized functional foods for different population groups. This justifies the need for research on the characteristics and areas of patenting new intellectual property objects in the field of justification and development of advanced specialized functional food, its formulations and production methods.

Based on the research performed, the need for collecting, summarizing and analyzing information was determined. It was planned to create a knowledge base built upon the expanded patent-information search and use of the database of the Federal Institute for Industrial Property (FIPS) in the field of patenting of Russian inventions and utility models for functional foods as the main source materials. The database elements considered in this paper can be used for analysis and as analogues and prototypes in the synthesis and patenting of new original intellectual property objects.

According to the goal set in this work, the following tasks were addressed: 1) to evaluate the characteristics and areas of patenting of intellectual property; 2) to categorize utility patents in terms of food industry sub-sectors and producers; 3) to categorize the patents in terms of obtaining food effects from functional foods; 4) to categorize the patents in terms of consumers of functional food products, depending on product purpose; 5) to identify organizations that have patented

intellectual property objects in the field of composition, formulations and production methods of functional food products.

## 2. Literature Review

A non-segregated making network that typically includes people, firm, movement, information and assets is known as a supply chain management. Supply chain management is more important in food processing industry because timing play a vital role for productivity with high quality, low-cost and with limited resources of raw material. Achieving a high quality of finish product needs high quality of raw material in safe condition and also within time in food processing industry, Supply chain management facing a problem in food processing industry like inconsistencies which occur in supply chains that make a problem for the industry to be consistent. Irregularity and unreliability create risk and may destroy profitability for the parties involved in supply chains. works of many Russian and foreign researchers proved the diversity and scale of the problem of research on various aspects of food security for vast regions of Russia, its separate regions and in particular with regard to state of this problems in regions, located in the country's Northern territories [1-5].

The research conducted in [6], shows that food security represents a state of the country's economy that ensures the country's food independence, guarantees the physical and economic accessibility to the country's population of food products, that comply with the legislation on technical regulation, in amounts not less than rational norms of food consumption necessary for the active and healthy lifestyle, and also guarantees the safety and good quality of food products.

The methodology of research on food security should consider the general problems of food security in the country and innovative foreign experience. It should also factor in the specifics of the traditional diet of the population living in these territories, including diet changes that have arisen due to large-scale migration flows. In the post-war years in the Republics of Karelia and Komi, for example, these changes occurred during a period when the transition from seasonal to permanent workers was largely ensured by the influx of population from other regions of the USSR, including from such Union republics as Ukraine and Belarus. It is very important to have regard to

the specifics of living and working in certain territories of the Russian Federation. Moreover, it is necessary to consider the existing trends, according to which the population of these territories should be provided not only with the required physical amounts of food, but also with high-quality food.

Ranking the tasks of food security, [7], rightly state that the problem of food security in Russia often highlighted only in terms of the issues of increasing the food production to necessary volumes on the territory of Russia. The authors believe that food security problem cannot be considered disregarding the need for full and high-quality physical and economic access of various population groups to these food products.

The most important role of high-quality and functional nutrition in the prevention of a number of diseases and maintaining the viability and health of the population is clearly confirmed by numerous research studies of Russian and foreign researchers [8-13].

The analysis shows that the existing trends indicate that in recent years the world market has increased attention to the bringing to market the promising types of functional food products, as the most important factor in the transition of the population of different countries to a healthy lifestyle, including solving the problem of producing and using healthy food in the practical life of the population. It is no accident that researchers and producers of functional foods in many world countries have been actively working to solve this problem in recent years [11-14].

However, the analysis showed that at present Russian producers of functional food products are not actively increasing their production and supplies to the domestic market and, unfortunately, still have low export capacity.

An important factor is that when creating new types of functional foods, producers do not pay enough attention to patenting the developed intellectual property objects. The main patenting in Russia in this field is conducted by universities, which are often insufficiently integrated into joint work with functional food producers. Therefore, many university developments are of initiative nature and are under exploratory studies, and the life cycle of creating new types of functional food products from introducing ideas to the commercialization of developments is over-long.

The analysis allows concluding that Russia, on the one hand, has a considerable potential of agricultural land and, on the other hand, state policy should ensure the development of domestic producers and industries to produce promising new-generation functional food competitive on the domestic and foreign markets.

The situation described above necessitates conducting scientific and applied research on the characteristics and areas of patenting new intellectual property objects in the field of justification and development of advanced specialized functional food, its formulations and production methods.

### 3. Materials and Methods

The purpose of this work is to research the characteristics and areas of supply chain for – specialized functional food products. At this stage of research, the authors' studies were limited to intellectual property objects patented in Russia.

The methodology for collecting, summarizing and analyzing information provided for the formation of a knowledge base built upon an expanded patent-information search and the use of the database of Federal Institute for Industrial Property (FIPS) in the field of patenting Russian inventions and utility models for functional food products as the main source materials.

According to the research methodology, the materials of the patent-information search were categorized by keywords and key phrases, with a characteristic of the patenting dynamics by year over the past 5 years. To perform research, a knowledge base has been formed, which fragment is presented below.

By the keyword “functional food”, a total of 244 inventions and utility models were revealed, including in the dynamics of inventions and utility models by year, respectively: in 2015 – 12 / 2; in 2016 – 4 / 0; in 2017 – 9 / 3, in 2018 – 13 / 1; in 2019 – 6 / 2.

By the keyword “functional products”, a total of 2079 inventions and utility models were revealed, including in the dynamics of inventions and utility models by year, respectively: in 2015 – 145 / 10; in 2016 – 117 / 6; in 2017 – 149 / 11, in 2018 – 111 / 9; in 2019 – 108 / 8.

According to the keyword “dietetic nutrition”, a total of 1289 inventions and utility models were revealed, including in the dynamics of inventions and utility models by year, respectively: in 2015 –

2 / 1; in 2016 – 12 / 0; in 2017 – 16 / 1, in 2018 – 0 / 0; in 2019 – 27 / 0.

By the keyword “baby (infant) food”, a total of 657 inventions and utility models were revealed, including in the dynamics of inventions and utility models by year, respectively: in 2015 – 18 / 8; in 2016 – 14 / 3; in 2017 – 15 / 3, in 2018 – 14 / 2; in 2019 – 20 / 4.

By the keyword “sport nutrition”, a total of 144 inventions and utility models were revealed, including in the dynamics of inventions and utility models by year, respectively: in 2015 – 6 / 6; in 2016 – 2 / 3; in 2017 – 6 / 7, in 2018 – 7 / 2; in 2019 – 2 / 7.

By the keyword “nutrition of athletes”, a total of 69 inventions and utility models were revealed, including in the dynamics of inventions and utility models by year, respectively: in 2015 – 4 / 1; in 2016 – 1 / 0; in 2017 – 6 / 1, in 2018 – 3 / 0; in 2019 – 6 / 2.

Using the obtained knowledge base, the methodology was applied to categorize patented intellectual property objects in terms of functional food sub-sectors and producers and in terms of areas for obtaining food effects from the functional food products, as well as in terms of their consumers.

According to the methodology, the analysis considers the features of technological and technical solutions embedded in the patented intellectual property objects, identifies universities, research organizations and economic entities that develop and patent functional food, its formulations and production methods.

### 4. Results and Discussion

How supply chain management work in any food processing industry is define as the agri-industrial system aims for plantation, cutting, transport and processing form farm to mill and mill to market. All food processing industry supply chain is highly integrated and contains:

- a) Food Plantation
- b) Cutting
- c) Food Transportation to Industry
- d) Industry for Processing
- e) To Market

The analysis made it possible to categorize utility patents by the following groups of food industry sub-sectors and producers listed below.

*Production of functional meat products*

Saratov State Vavilov Agrarian University has developed and patented a method for producing a functional product – a chicken soufflé containing the necessary nutrients that contribute to the health preservation and maintenance – that is suitable for gluten-free, dietetic and healthy nutrition (Patent RU2700638). The method involves double-grinding the boiled chicken breast fillet in a meat grinder to make minced meat with the addition of egg yolks and milk sauce, consisting of milk, butter and polysaccharide, then whipping the minced meat and adding the whipped egg whites, and after filling of lamister (foil) tin forms with the resulting mixture, heat treatment is performed in the way of steaming.

Gorsky State Agrarian University has patented an invention for the production of boiled sausages (Patent RU2681990). The method involves cutting beef and pork carcass, cooling, boning and trimming of raw materials, chopping meat, salting, cooking minced meat, making form, tying and heat treatment. The novelty of the method lies in the fact that after the meat chopping before salting, starting cultures are introduced into the raw material – the bacterial starter culture *Lactobacillus gallinarum* I-12 and *Enterococcus hirae* BK-37 in a ratio of 1:1 in a total amount of 1.2 kg / 100 kg. Studies have shown that the introduction of the starting cultures “*Lactobacillus gallinarum*” and “*Enterococcus hirae*” (in a dosage of 1.2 kg / 100 kg) into the model systems of boiled sausages has a positive effect on the functional and technological properties, improves the organoleptic, microbiological, physical and chemical properties of the end product.

Saratov State Vavilov Agrarian University has also patented inventions in the field of production of dry-cured skinless sausages for functional nutrition, sausages based on hydrocolloid technology from seaweed extract, fibers and stabilizers (Patent RU2703484). According to the invention, raw meat is ground on a grinder, mixed with additives, aged, formed in sausages, on the surface of which a film-forming composition is applied. As the basis of the film-forming composition, a solution of sodium alginate and a solution of calcium chloride are used. Sausages are recommended for use in diets for the prevention of cardiovascular diseases, since the active substances in its composition remove bad cholesterol and increase the vascular tone. They are beneficial for people suffering from blood pressure spikes. The product activates the neurons of the

brain, making it work more productively, normalizes the level of sugar in the blood flow. In the composition of sausages there is a high content of tryptophan, which can produce a “spirit-lifting” effect, that is, it can suppress depression, since tryptophan contributes to the production of serotonin (the hormone responsible for a person’s good humor). The developed product regulates the hormonal balance of the entire body, which improves the functioning of the reproductive system.

The Nizhny Novgorod State Agricultural Academy has patented a method for producing a functional semi-finished product from poultry meat enriched with amino acids with reduced caloric content (Patent RU2710168). Enrichment of the lump semi-finished product is made with milk (curd) whey, with table salt, paprika and oregano in an amount that ensures the prevention or replacement of the existing nutritional deficiency in the human body. The resulting product can be used to ensure a healthy diet for all groups of healthy populations.

“Proteus industries, Inc.” (USA) has patented a method for producing a protein product from animal muscle tissue for adding in a raw food product, which is a protein composition with a reduced risk of its contamination by various microorganisms (Patent RU2681289). This protein product is pasteurized and / or sterilized, it retains the functionality of raw meat and has a reduced level of pathogens.

To correct the diet of pregnant women, the All-Russian Scientific Research and Technological Institute of Poultry has patented an enriched poultry semi-finished product (Patent RU2663608). This semi-finished product, in addition to previously used ingredients, also includes coagulated egg melange as a full protein.

The invention of OOO “VISPOR” (Patent RU2689729) can be used in the production of animal-protein-enriched food products, including for the production of functional foods in the form of snacks, broths, and additives. According to the invention, a method for producing a protein-collagen emulsion based on the meat and bone residue of poultry mechanical boning includes its water hydrolysis at a temperature of 100 °C for 180 minutes, then its cooling to 35-40 °C, and bioconversion by microorganisms. The novelty of the method is that for bioconversion of meat and bone residue, a preparation of microorganisms containing “*Bacillus subtilis*” is used, and the

subsequent heat treatment is performed in an infrared oven at 60 °C and at a residual pressure of 4-5 kPa.

#### *Production of meat by-products*

Saratov State Vavilov Agrarian University has patented the invention suitable for gluten-free, dietetic and functional nutrition (Patent RU2689665). The invention provides for preparation of the beef liver cream soup. The method includes preparation of recipe components, chopping, blanching and cutting parsley root, cutting liver, mixing these components together with a flavor additive. According to the formulation, beef liver is used as the main product; it is lightly fried together with carrots and onions, then stewed until ready in a small amount of water; afterward, minced liver with vegetables is mixed with prepared parsley root, polysaccharide, to which water was previously added in an amount of 3-5 % of the total water weight, then the mixture is brought to the boil and then liaison is added.

#### *Production of functional fish or fish-plant foods*

Kuban State Agrarian University named after I. T. Trubilin has patented an invention in the field of production of fish or fish-plant foods for preventive nutrition (Patent RU2701659). The technical result of the invention consists in preserving the useful properties of the initial components of fish semi-finished products – fish quenelle – and obtaining functional fish products. For the invention, a new method has been developed that involves obtaining fillets from fish raw materials, preparing a complex of plant additives and spices consisting of wheat bran, table salt, sauteed carrots and onions, fine grinding, preparing minced fish, forming, heat treatment, cooling and storage. According to the invention, catfish, halibut, mahi-mahi (common dolphinfish) are used as fish raw materials, then plant additives and spices are introduced: celery, artichoke, sweet pepper, peppermint, dill, amaranth flour, wheat bran, pre-soaked in milk for 5 minutes, allspice, preventive table salt with a low sodium content, carrots and onions, browned in butter, then all the components of the formulation are mixed, ground finely and whipped for 7-10 minutes at a temperature of 17-24 °C. This fish product can be referred to as functional due to the use of fish with the least amount of connective tissue as raw materials, for example: catfish, halibut, mahi-mahi, which are rich in vitamin and mineral content, contain mineral salts, participate in most vital processes of the human body, prevent cancer, are

easily-absorbed, have a beneficial effect on the state of internal organs, skin, nervous system; heat treatment of fish product is performed in a steamer, which maintains the useful properties of the original components; minced fish contains mints, which has a tonic effect on the body, has antioxidant activity, calms the nervous system, improves digestion, relieves hepatic colic, provides a diuretic effect, stimulates cardiac activity, contains vitamins and microelements. The use of wheat bran, which includes fiber, improves the digestive system, slows down the process of assimilation of carbohydrates, and therefore reduces the rate of glucose level increase. Wheat bran normalizes the cardiovascular system, and also contains B vitamins that lower cholesterol in the blood, normalize metabolism. Artichoke is considered a dietetic product that is well absorbed, has a balanced set of nutrients, is rich in vitamins C, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, P, carotene and inulin. Celery has diuretic properties, prevents the formation of calculus, strengthens blood vessels in obesity, improves sleep, improves water-salt metabolism. Carotene (provitamin A) is responsible for good eyesight, good developmental effects. Vitamin P (bioflavonoid), which inhibits the growth of cancer cells, improves the immune system, supports normal blood pressure. B vitamins are useful elements for the liver, and have good dietetic characteristics. Preventive table salt with additional iodine enrichment has a low sodium content, it includes the necessary potassium and magnesium salts that stimulate the heart muscle.

In another invention of the Kuban State Agrarian University named after I. T. Trubilin (Patent RU2706585), the technical result is achieved by using steamed fish as a fish raw material in functional canned fish, adding ground allspice, ground coriander, table salt and plant components (amaranth flour, onion, carrot, garlic, nettle, fresh parsley, pumpkin). This composition of functional canned fish “Fish Diet Pudding” is an important source of protein, macro- and microelements, dietary fiber, vitamins for the healthy functioning of the human body, in which the main components are steamed fish, nettle, pumpkin, amaranth flour, preventive table salt.

The Far Eastern State Technical Fisheries University has patented a method for obtaining preserves from Pacific sardine (Ivasi). The method (Patent RU2691571) involves preparing fish for salting, mixing it with a salting mixture, packing in

cans, filling it with salt solution and maturing, which is performed using a composition including a water-soluble chitosan in an amount of 0.3 % of raw material mass and a plant-based proteolysis inhibitor from potatoes or rice in an amount of 1.2 % of raw material mass, with the composition added in an amount of 1.5 % of raw material mass after placing fish to cans or in salt solution. This ensures the preservation of antimicrobial and antioxidant stability with the reduced salt content in the product during the storage period due to the use of water-soluble chitosan – a plant-based inhibitor – when salting fish, which ensures high quality of the final product.

#### *Production of functional meat and plant products*

The All-Russian Soybean Research Institute has patented a method for preparing functional meatballs (Patent RU2678005), from minced beef. As an additional component, pre-rehydrated soy-mushroom granulate is used. The formulation includes beef minced meat, granulate, milk, onion, breadcrumbs and garlic. Studies have shown that this method allows obtaining meat balls with a low content of fat and cholesterol. The mass fraction of protein is 17 % of the recommended daily intake with the increased content of potassium by 84 mg, calcium by 46 mg and magnesium by 33 mg per 100 g of the product. The mass fraction of digestible carbohydrates decreased by 15 %, the content of dietary fiber increased by 16 %, which meets the daily need for these elements. The energy value of the product decreased by 30 kcal per 100 g.

#### *Production of functional products from grains and cereals*

Kuban State Technological University has patented a functional food product of high nutritional value (Patent RU2683223), which contains hulled rice grits, with the usual color of grain coating. The novelty of the product is that it additionally contains pink-colored hulled rice obtained from rice grain processing waste, which is a mixture consisting of seeds of wild plants, mineral impurities and hulled rice grains with different colors of coatings.

The Far Eastern Federal University has patented the composition of instant cereals for children's and dietetic nutrition (Patent RU2562221). The developed product is a composition with reduced allergenic capacity, increased nutritional and biological value of the end product. The composition contains cereals, protein material,

plant complex, flavorings. It includes millet and rice flakes, and as a vegetable complex was used a mixture, that contains flaxseed flour, carrot powder, pieces of dried pumpkin, dried parsley, and milk protein is used as a protein material. This ensures that the porridge is well-balanced in its mineral composition, and reduces the allergenic capacity of the product.

OAo "Khlebprom" has patented an invention for the production method and composition of rice crisps, which are a product of dietetic and functional nutrition. The composition of rice crispbread contains first-grade rice cereals, water and flavor additives (Patent RU2702862). Its novelty is explained by that the flavor additive includes concentrated fruit/vegetable juice or a mixture of fruit/vegetable juices and concentrated berry/fruit puree or a mixture of berry/fruit purees, natural flavoring. The crispbread is a dietetic product, since it contains coarse indigestible dietetic fibers that contribute to the toxin elimination from the body. Swollen rice grains have a beneficial effect on intestinal peristalsis, normalize metabolism and are suppliers of complex carbohydrates that permanently saturate and replenish energy reserves.

#### *Production of functional foods from plant raw materials*

Ural State University of Economics has patented a functional food product for preventive use with a balanced ratio of vitamin composition from a mixture of plant raw materials and biologically active substances (Patent RU2687157). The effective concentration of natural vitamins, antioxidants and other bioactive substances has an antiviral, restorative, antitumor, antibacterial, antimicrobial, antipyretic, anti-inflammatory, antitoxic effect, protects the body from the negative effects of adverse environmental factors, slows down the body aging and improves the immune system. This is achieved by adding to the functional food product *Rhodiola rosea* roots, ascorbic acid, dry pantothenic acid, and, additionally, fructose.

Another invention of the Ural State University of Economics is aimed at obtaining a functional product based on licorice roots (Patent RU 2692651). This product contains flavonoids that slow down aging, inhibit the development of atherosclerosis, cardiovascular diseases, and are an additional source of vitamin C and iron from a

mixture of plant raw materials and biologically active substances.

Voronezh State University of Engineering Technologies has patented the method for producing snacks (Patent RU2679394) based on iodized extrudates. This is the method for producing plant extrudates of increased nutritional and biological value for the food industry and uses the effect of sprouting grains. An increase in all the amino acids of lentil protein after germination by 1.5-2 times brings the sprouted grain closer to the generally accepted standard of ideal protein. According to this method, lentil grains are soaked in a nutrient solution of potassium iodide, with a salt concentration of 10 g / liter of water, using 2 liters of nutrient solution per 1 kg of grain. Then the grains are sprouted and after reaching the length of the sprouts of 1 cm, they are dried, preventing from direct sunlight until the grain contains 18-20 % of moisture. Then the grain is extruded on a screw extruder, the porous product is dried in a special drum, after which the extrudate passes to a coating complex, where the heated vegetable oil is sprayed on the extrudate with adding the powdered flavorings.

The composition of plant raw materials patented by the Maikop State Technological University (Patent RU2687361) possesses the antioxidant properties. The composition is a mixture containing bilberry leaves (*Vaccinium myrtillus* L.), walnut leaves, black currant leaves, oregano and thyme, all ground to a particle size of 1-2 mm at a temperature of 18-20 °C. It contains a significant amount of antioxidants and, principally, P-active substances, which activity is enhanced in the presence of vitamin C, which causes a high intensity of the claimed antioxidant properties of composition.

Maikop State Technological University has patented another composition of plant raw materials (Patent RU2687358), which is intended for the prevention of iodine-deficient conditions. The composition is a mixture containing walnut leaves, purple coneflower (*Echinacea purpurea* L.), thyme and black currant leaves, ground to a particle size of 1-2 mm at a temperature of 18-20 °C. This composition of plant raw materials contains a significant amount of iodine, while in 100 ml of an aqueous extract obtained from the claimed composition of plant raw materials, the iodine content is 82.0, 77.0 and 78.9 µg, which corresponds to 54.7 %, 51.3 % and 52.6 % of the

recommended level of daily iodine consumption (150 µg).

Of particular interest is the specific research area of Petrozavodsk State University and the Trading House "Yarmarka" in the field of producing functional foods for the territories of the Northern and Arctic Russia, using plants growing in Northern Russia. Among the utility patents are well-known solutions developed by the University's group of authors (Patents RU2705782, RU2709764, RU2709747, RU2681676). Specialists of the Agrophysical Research Institute are also working in this area together with OOO "Fitosfera" (Patent RU189309), and have created equipment for year-round cultivation of high-quality fresh plant products in the Arctic and subarctic territories. Research, Design and Technology Institute of Agro-industrial complex of Komi Republic (Patent RU2228603) has patented a method for obtaining white cabbage seeds at 62 ° North latitude and above.

#### *Production of functional cottage cheese products*

Omsk State Agrarian University named after P. A. Stolypin has patented an invention aimed at increasing the biological and nutritional value, improving the functional properties and organoleptic characteristics of cottage cheese products (Patent RU2700090). According to the invention, a protein-lipid emulsion prepared by homogenizing salted caviar of salmon and ordinary fish, and a biologically active additive "Citrolux" are added to the dairy raw materials, and after self-pressing, cream with a fat mass fraction of 10.0-20.0 % and mustard powder are added to the cottage cheese product. The resulting cottage cheese product is recommended for mass and specialized nutrition of the population, as it contributes to the prevention of gastrointestinal and cold-related diseases.

#### *Production of functional bakery products*

The Federal Research Center "Fundamentals of Biotechnology" of the Russian Academy of Sciences has patented an invention aimed at increasing the biological value of bread products, obtaining functional products with a reduced gluten content, and expanding the range of gluten-free baked products (Patent RU2687375). The study was based on data that in gluten-sensitive people, its excessive consumption leads to allergies, celiac disease, systemic autoimmune damages, etc., therefore, people suffering from gluten intolerance should avoid its excessive use. Celiac patients feel

better after switching to a gluten-free diet, which leads to disappearing of gastrointestinal symptoms (Parfenov, 2013). The use of the invention provides a reduction in the content of gluten in the end product. The lactic acid cultures and yeast presented in the composition of the protein additive contribute to improvement of the technological indicators of the end product.

Studies by the Research Institute for Baking Industry has shown that the demographic situation in Russia is characterized by an increase in the number of people older than working age. The most significant changes relate to the digestive, cardiovascular, respiratory, nervous, and skeletal systems. Therefore, the priority areas of the state policy of the Russian Federation include maintaining health, increasing life expectancy and extending the active longevity of people. Reducing the number of patients and reducing the risk of premature aging can be achieved by regular consumption of special functional products. To that end, when developing the functional food production method by the Institute (Patent RU2628399), the task was set to improve the organoleptic, physical and chemical properties of the bread quality that meets the medical and biological requirements for elderly-targeted products, expand the range of bakery products for the elderly and increase the microbiological safety of products. The method includes the preparation of bread in two stages, the first stage involves preparing the sourdough, and the second stage implies dough kneading on the basis of sourdough and fermentation, cutting, proofing dough and baking. In this case, the sourdough is prepared by mixing the high-grade wheat baking flour, low-fat flaxseed flour and yeast in a ratio of 1:(0.11-0.43):0.02, water in an amount that ensures the sourdough humidity of 43-48 %, followed by sourdough fermentation. At the second stage, high-grade wheat baking flour, pressed baking yeast, sugar, salt, enriched with potassium and magnesium, refined vegetable oil deodorized, dried grapes and water are added to the sourdough, then the dough is kneaded with subsequent fermentation for 60 minutes at a temperature of 28-32 °C.

#### *Production of functional confectionery products*

Kemerovo State University has patented a method for the production of functional confectionery products for nutrition (Patent RU2694970). The method includes the preparation of a gelling agent and syrup on the basis of a sweet agent and glucose

syrup, boiling the syrup, adding the gelling agent to the syrup, stirring, cooling, adding functional components, mixing the marmalade mass, its pouring, forming finished products and drying. The characteristic feature of the methods in that in the syrup, stevioside is used as a sweet agent. As a gelling agent, pectin from viburnum and lemongrass berries is used, and as functional components – pulp from the same berries and the “Lavitol-B” premix. The method provides for obtaining marmalade with increased nutritional and biological value and reducing the caloric content of the product by completely replacing the sugar with stevioside.

The Far Eastern Federal University has patented for the confectionery industry the composition for the production of functional chocolate with ginseng (Patent RU2679714). Its novelty lies in the fact that the cocoa nibs are used as a cocoa product, sugar as a sweetening agent, CO<sub>2</sub>-extract of the root of the Far Eastern “*Panax Ginseng C. A. Meyer*” as a biologically active additive, and cedar nuts. Increasing the biological value of the end product is provided by the technology of supercritical extraction of ginseng, providing high organoleptic characteristics and structural and mechanical properties of chocolate quality, fully natural chocolate composition and the use of available components.

The invention of Kemerovo State University (Patent RU2692658) can be used in the production of functional dairy bioproducts. The method involves mixing apple puree, milk whey, sugar, adding a gelling agent, heating and holding the mixture at a temperature of (86±1) °C, with subsequent cooling, adding a microbial consortium, and fermenting until coagulation. Its novelty is explained by that the milk protein-carbohydrate preparation “Lactobel” is added to the puree, dissolved in skim milk, with the use of pectin dissolved in water as a gelling agent. The microbial consortium consists of bacterial concentrates “*Lactobacillus acidophilus*, *Lactobacillus delbrueckii subsp. bulgaricus*, *Lactobacillus casei* and *BK-Altay-Snzh (Lactococcus lactis subsp. lactis*, *Lactococcus lactis subsp. cremoris*, *Lactococcus lactis subsp. diacetylactis*, *Streptococcus salivarius thermophilus)*”. As a result, there is an increase in the nutritional and biological value of the dessert, achieving high probiotic and functional properties that can support



and normalize the natural microflora of the human gastrointestinal tract.

The invention of the Voronezh State University of Engineering Technologies (Patent RU2685475) can be used for the production of sweets with fondant centers.

#### *Production of functional extracts*

Korean companies “Yung Shin Pharmaceutical Industrial Co. LTD” and “Korea Research Institute of Bioscience and Biotechnology” aiming to prevent or treat inflammation, allergies and asthma, have patented a functional food product based on a purified extract isolated from perennial herbs growing in Korea, China, Japan and Russia “*Pseudolysimachion rotundum var subintegrum*”. Studies have shown that the purified extract, fractionated using butanol, contains (wt./wt.): 25.64 % of catalposide derivatives (17.60 % verproside, 0.72 % veratric acid, 2.62 % catalposide, 1.08 % Picroside II, 1.26 % isovanillylcatalpol) and 2.36 % 6-O-veratroylcatalpol, respectively). This extract can be used for the following purposes: a) as a therapeutic medicine; b) as a functional dietetic food product for treatment and prevention of inflammatory, allergic or asthmatic diseases (Patent RU2682653). The same companies have proposed a pharmaceutical composition with a compound isolated from the extract “*Pseudolysimachion rotundum var. subintegrum*”, that is suitable in pharmaceuticals carriers or additive agent for the treatment or prevention of allergic and inflammatory diseases, asthma or chronic obstructive pulmonary disease (Patent RU2685732).

Kemerovo State University has patented a method for obtaining an extract from plant raw materials – cedar nut shells (Patent RU2688743). The invention resolves such an important task as utilization of cedar nut shell to obtain from it a carbohydrate-mineral extract subjected to ultrafiltration and spray drying, to obtain its high biological value (carbohydrates, vitamins, minerals), functional and technological properties (water-holding, fat-holding and swelling capacities) with a high degree of purification.

#### *Production of functional dairy, cheese and fermented milk products*

The Federal Research Center for Nutrition, Biotechnology and Food Safety has patented a dairy-grain product aimed for pregnant and nursing women (Patent RU2630297). This product has increased biological and nutritional value,

improved functional, preventive and dietetic properties due to containing standardized milk, whey protein concentrate, sugar, oatmeal or rice or millet flour, long-chain PUFA  $\omega$ 3 concentrate, vitamin and mineral premixes, and starter cultures. The use of the claimed product allows expanding the range of functional, preventive products for pregnant and nursing women. It can be recommended for dietetic nutrition of pregnant and nursing women who maintain a gluten-free diet (the product contains rice flour), as well as for women with a moderate degree of lactase deficiency.

The Research Institute of Child Nutrition, has solved the problem of obtaining a cheese product for elderly-targeted nutrition with increased biological, nutritional value, improved digestibility, functional and preventive properties (Patent RU2605322). The patented method allows producing a cheese product with a rational content of fat, salt and digestible protein for the elderly.

Crimean Federal University named after V. I. Vernadsky (Patent RU2679509) has patented a method for producing a functional fermented milk product with improved therapeutic and organoleptic properties and improved viscosity. This is achieved by optimizing the technological parameters and adding the biologically active additive – lactulose – to the fermented milk product. Adding bifidobacteria improves the end product texture by making it creamy, increases the biological value of the product and ensures that consumers of the product obtain the necessary vitamins B, folic acid and supplement the lack of necessary enzymes. At the same time, it requires reduced time for obtaining a fermented milk product, improving the therapeutic and organoleptic properties and texture of the end product.

The St. Petersburg National Research University of Information Technologies, Mechanics and Optics has patented a method for producing a dry functional complex mixture of lingonberry (*Vaccinium vitis-idaea*) and cranberry oilcake for the production of enriched fermented milk products, in particular yogurt (Patent RU2702426).

#### *Production of functional beverages*

Kuban State Agrarian University named after I. T. Trubilin has patented an invention for the preparation of preventive beverages (Patent RU2693263). The invention is aimed at obtaining a berry-whey beverage. It involves the use of curd

whey, with plant filler and food additive, their mixing for 13-15 minutes, heating, pouring and cooling. Flaxseed fiber is used as a food additive, cranberries ground with fructose taken in a ratio of 1:1 are used as a plant filler, and distilled water is used to regulate the pH of curd whey, while cranberries ground with fructose and flaxseed fiber are added to curd whey with a regulated pH. Curd whey in combination with flax fiber and cranberries with fructose makes the product functional, due to the content of biologically active substances while enriching the beverage with dietary fibers, increasing the nutritional value of the end product.

Another invention of the Kuban State Agrarian University (Patent RU2694567) is aimed at obtaining a whey beverage by using curd whey with a plant filler and a food additive. Flax fiber is used as a dietetic additive, and sea buckthorn ground with fructose taken in a ratio of 1:1 is used as a plant filler. Distilled water is used to regulate the pH of curd whey. At the same time, sea buckthorn ground with fructose and flax fiber are added to the curd serum with adjusted pH, the resulting mass is mixed, heated to a temperature of 60-65 °C, then pasteurized at (93±2) °C, cooled to 10-14 °C and passed through a filtering device with a hole diameter of no more than 0.5 mm. Curd serum in combination with flax fiber and sea buckthorn with fructose makes the product functional, due to the content of biologically active substances while enriching the drink with dietetic fibers, increasing the nutritional value of the end product.

Amur State University has patented an invention for a method for producing a functional juice-containing beverage (Patent RU2685944). The method provides for a functional juice-containing beverage with increased nutritional and biological value, which has functional properties resulted from the use of natural ingredients, among which are flavonoids, polysaccharides, vitamins, minerals, antioxidants, adaptogens that have a high physiological significance for the human body in terms of the effects of adverse environmental factors. This is provided by supplementing the formulation with concentrated juice from functional plant raw materials: berries, root crops and extracts from medicinal raw materials in the form of: a) concentrated lingonberry juice, concentrated Actinidia juice, concentrated carrot juice, *Rhodiola rosea* extract; b) concentrated

cranberry juice, concentrated grape juice, concentrated beet juice, birch leaf extract; c) concentrated blueberry (*Vaccinium uliginosum*) juice, concentrated Actinidia juice, concentrated carrot juice, *Rhodiola rosea* extract.

The Research Institute of Child Nutrition of the Russian Academy of Agricultural Sciences has patented a fermented milk product for the elderly (Patent RU2552141). The fermented milk product contains skimmed milk, cream, whey protein concentrate, "Bifilakt-AD" starter culture, the biologically active additive "Protamine", syrup from plant raw materials, minerals, vitamins and water. It possesses probiotic properties, having a positive effect on human health by normalizing the intestinal microflora and stimulating the immune system. The product has high digestibility, helps to normalize human protein metabolism, regulate body weight, restore efficiency, and increase immunity. It has a restorative, preventive effect. The product can be recommended as additional food for allergic diseases, rehabilitation of patients, for example, with a traumatic brain injury. The fat content of the product varies from 1.5 to 3.0 %. The plant syrup based on fructose (xylytol, sorbitol and other sugar substitutes), and the product has low fat content and can be recommended for patients with diabetes.

#### *Production of functional biologically active additives*

OOO "Giprobiosintez" has patented an invention in the field of microbiology and biotechnology (Patent RU2681791). The invention relates to biologically active additives (dietary supplements) with high protein content used as the main component of food products that enhance the protective functions of the body for the nutrition of athletes, therapeutic and preventive nutrition of people working in environmental disaster areas, in extreme conditions. The protective dietary supplement is denucleated bacterial biomass of the *methylococcus capsulatus* GBS-15 strain of methan-oxidizing bacteria.

The above analysis allowed categorizing the utility patents in the following groups in terms of the food industry subsectors and producers:

1. Production of functional meat products.
2. Production of meat by-products.
3. Production of functional fish or fish-growing products.
4. Production of functional products from grains and cereals.

5. Production of functional products from plant raw materials.
6. Production of functional bakery products.
7. Production of functional confectionery products.
8. Production of functional extracts.
9. Production of functional dairy, cheese and fermented milk products.
10. Production of functional beverages.
11. Production of functional biologically active additives.

The analysis made it possible to categorize the food effects that the functional foods produce. Among them are the following:

1. Preserving and maintaining the health of various population groups;
2. Improvement of organoleptic, microbiological, physical and chemical properties of food products;
3. Prevention of cardiovascular diseases, removing bad cholesterol from the human body;
4. Increasing the vascular tone;
5. Prevention or replenishment of nutrient deficiencies in the human body;
6. Reducing the levels of pathogens in food;
7. Suitable for gluten-free, dietetic and functional nutrition;
8. Lowering fat and cholesterol content in the food product;
9. Decreasing the allergenic capacity of the product;
10. Producing gluten-free products;
11. Providing a tonic effect on the body;
12. Calming the nervous system; improving digestion; providing a diuretic effect;
13. Stimulation of cardiac activity;
14. Producing the food products that are sources of protein, macro- and microelements, dietary fibers, vitamins for healthy functioning of the human body;
15. Producing the food products that have antiviral, tonic, antitumor, antibacterial, antimicrobial, antipyretic, anti-inflammatory, antitoxic effects;
16. Improving people's productivity, including in difficult and sometimes extreme natural and industrial conditions;
17. Increasing and replenishing the energy reserves; improving the fitness of athletes and their physical qualities, the ability to sustain heavy and intense loads.

A number of functional products have a multi-purpose use, for example, in medicine, pharmaceuticals and for the production of dietetic food.

The consumption of functional foods, depending on their purpose, can be mass-scale or individual, with consumers of different ages, including children, adolescents, pregnant women, elderly people, people suffering from certain diseases, people living and working in difficult climatic and extreme conditions, including in the Northern and Arctic regions. It is worth noting that, according to the research, in Russia, patenting in the field of producing functional products is conducted mainly by universities and research organizations, as well as by individual economic entities. Also, the entry of intellectual property of foreign companies into the domestic market was noted.

## 5. Conclusions

The research have proved the diversity and wide scale of the problem of research on various aspects of food security for vast regions of Russia, its separate regions and in particular with regard to the state of this problem in regions, located in the country's northern territories. A proper organize supply chain is usually important in food processing industry. Supply chain management is a systematic approach to improve the total productivity of food processing industries by reducing timing, providing quality raw material flow from farm to industry, review has been conducted on various properties which affect harvesting and transport issues in food processing supply chains, harvesting is done as per maturity period of food and then transportation for safe delivery and lower time to milling with the help of supply chain management. In recent years, the global market has increased attention to the solution of justification, development and supply to world markets promising functional foods, recognizing it as the most important factor in the transfer of the various groups of the population to a healthy lifestyle, including healthy diet.

During the production of functional foods, producers do not pay adequate attention to patenting the developed intellectual property objects. Russia should ensure the development of domestic supply chain management in businesses and industries to provide promising new-generation functional foods competitive in the internal and external markets. Competitiveness of such products

can be improved by the development and patenting of innovative intellectual property objects. This necessitates the research on the characteristics and areas of patenting new intellectual property objects in the field of advanced specialized functional food. The methodology for collecting, summarizing and analyzing information provided for the formation of a knowledge base built upon an expanded patent-information search and the use of the database of Federal Institute for Industrial Property (FIPS) in the field of patenting Russian inventions and utility models for functional food products as the main source materials. The database elements considered in this paper can be used for analysis and as analogues and prototypes in the synthesis and patenting of new original intellectual property objects. According to the methodology, the analysis examined the features of technological and technical solutions involved in the patented intellectual property objects, identified universities, research organizations and economic entities that develop and patent functional food, its formulations and production methods. The analysis made it possible to categorize the utility patents in terms of the food industry subsectors and producers, as well as categorize the food effects that the functional foods produce. A number of functional products have a multi-purpose use, for example, in medicine, pharmaceuticals and for the production of dietetic food. It is worth noting that, according to the research, in Russia, patenting in the field of producing functional products is conducted mainly by universities and research organizations, as well as by individual economic entities. Also, there is was noted the entry of intellectual property of foreign companies into the domestic market.

### Acknowledgment

The project “Research and development of end-to-end technology of functional food manufacture for achieving food supply security for north territories of the Russia” is carried out with granting by Russian Federation represented by Ministry of Education and Science of the Russian Federation (project identifier – RFMEFI57717X0264, agreement No. 14.577.21.0264, 26/09/2017).

### References

[1] Pozhidaeva, E. S. The concept of food security and main indicators of food security state. *Vestnik Universiteta*, 5(15), 98-101, 2008.

- [2] Savin, D. V. Relationship between financial security of food market enterprises of the Moscow region and food security of the region. *Voprosy Ekonomicheskikh Nauk*, 5(50), 85-88, 2011.
- [3] Shegelman, I. R., Vasiliev, A. S. & Shchukin, P. O. The analysis of experience of advanced countries in solving food security problems. *Astra Salvensis*, 6, 899-907, 2018.
- [4] Shkiotov, S. V. & Ugryumova, M. A. Economic aspects of country's food security: Impact of macroeconomic conjuncture on the condition of Russian's food security. *Regionalnye Problemy Preobrazovaniya Ekonomiki*, 7(93), 24-31, 2018.
- [5] Usenko, L. N. Food security as a factor of economic security of Russia: Overcoming crisis situations. *Nauchnye Trudy Volnogo Ekonomicheskogo Obschestva Rossii*, 114, 93-102, 2009.
- [6] Serkov, A. F., Vinogradova, V. A., Chekalin, V. S. & Maslennikov, A. V. Ensuring the country's food security in times of economic crisis. *Ekonomika Selskokhoziaystvennykh i Pererabatyvayushchikh Predpriyatii*, 12, 9-11, 2009.
- [7] Shagayda, N. I. & Uzun, V. Ya. Food security in Russia: monitoring, trends and threats. Moscow: Delo. 2015.
- [8] Bobreneva, I. V. Approaches to producing functional food products. St. Petersburg: Intermediya, 2012.
- [9] Spirichev, V. B., Shatnyuk, L. N. & Poznyakovskiy, V. M. Enrichment of food products with vitamins and mineral substances. Science and technology (2nd ed.). Novosibirsk: Sib. Univ. Izd-vo. 2005.
- [10] Trushechkin, A. V. Scientific support of the process of two-step vacuum evaporation of multicomponent vegetable mixes and development of equipment of its implementation (Doctoral dissertation). Voronezh. 2013.
- [11] Patil, S. S., Rudra, S. G., Varghese, E. & Kaur, C. Effect of extruded finger millet (*Eleusine coracana* L.) on textural properties and sensory acceptability of composite bread. *Food Bioscience*, 14, 62-69, 2016.
- [12] Sharif, M. K., Syed, S. H. & Paraman, R. I. Characterization of supercritical fluid extrusion processed rice-soy crisps fortified with micronutrients and soy protein. *Food Science and Technology*, 56(2), 414-420, 2014.
- [13] Shegelman, I. R., Shtykov, A. S., Gostev, K. V., Gavrilova, O. I. & Vasilev A. S. Prospects of plasma technology in cross-cutting technologies used in functional food production and seed germination for reforestation. *Journal of Computational and*

- Theoretical Nanoscience, 16(7), 2926–2933, 2019.
- [14] Bao, J. & Bergman, C. The functionality of rice starch. In Ann-Charlotte Eliasson (Ed.), *Starch in food: Structure, function and applications*. Boca Raton, FL: Woodhead Publishing Ltd. and CRC Press LLC. 258-294, 2004.
- [15] Gavrilova, O. I., Shegelman, I. R., Shchukin, P. O. & Vasilev, A.S. Analysis of territories – sources of food raw materials for the implementation of cross-cutting technologies for the production of functional foods in Russia. *EurAsian Journal of BioSciences*, 13(1), 587-594, 2019.