Directed transformation of food raw materials - as a key factor in the transition to "personalized nutrition» [1]

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Abstract. In the article, based on the results of the analysis of the relationship between public health and the nutrition structure of the Russian population, the main problems are identified and tasks in the field of personalized dietetics, functional and specialized nutrition are updated. The key points in solving these problems, taking into account scientific and technological achievements in the field of biochemistry, nutrigenetics, nutrigenomics and nutrimicrobiome in the 21st century, is the transition to "personalized nutrition". The main fundamental tasks in the field of agricultural science are determined, aimed primarily at identifying the patterns of transformation of food raw materials throughout the life cycle in order to create modern forms of food. On the example of pectin, it is shown that the study of the mechanisms and patterns of transformation of pectin-containing raw materials under the influence of physical, chemical, biotechnological methods in cooperation with scientists and specialists in the field of medicine and computer science makes it possible to create pectins with different chemical composition and structure and intended, in particular, for the prevention of intoxication heavy metals and organochlorine pesticides.

The quality of nutrition and its structure is the key to the health of the population, contributes to its standard of living, reduces risk factors against the backdrop of widespread environmental degradation. The analysis of the relationship between the health of the population and the nutrition structure of the population of Russia for the period 2000-2021 made it possible to identify the following main problems:

– - increase in alimentary-dependent diseases of the population (growth of diseases of the digestive system; metabolic disorders, etc.) [1-4];

– not a complete nutrition structure of the population [5, 6];

[1] Segment of technologies for analyzing the nutritional and micronutrient status of a person, including using genomic and post-genomic methods, personalized food products, services for selecting individual diets, as well as innovative delivery services.

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– poor information support of the population on the issues of healthy nutrition and the relationship between the nature of nutrition and the state of human health [7, 8].

It should be noted that recently the population aged 20-40 years has begun to pay great attention to the issues of a healthy lifestyle, including healthy nutrition.

Despite the fact that science has created and offers a wide range of fortified food products, their production volume is small and is associated primarily with the established food culture and the low effective demand of the population, which limits the possibility of consuming functional and therapeutic food products, which, as usually a higher price.

These aspects actualize the issues of cost optimization for the production of functional and specialized nutrition products, the development of research in the field of personalized dietology, nutrimicrobiome, nutrigenetics, nutrigenomics, as well as the development of bioinformation technologies for designing products and managing the nutrition of the population based on the operational selection of food products taking into account human characteristics. In the 21st century, "personalized nutrition" is becoming especially relevant. [9-13].

Modern achievements of science in the field of nutrimicrobiome, nutrigenetics, nutrigenomics make it possible to establish the relationship between the nature of nutrition and the individual characteristics of a person, and the widespread development of information technology provides the possibility of a person's quick access to information about his state of health and the recommended diet, that is, the transition to "personalized nutrition", improving the quality and length of human life [14, 15].

To achieve these effects, it is necessary to combine the potentials of various sectors of the economy (health, agriculture, food industry and education), focused on the development and implementation of:

– methods for early diagnosis of alimentary-dependent diseases caused by malnutrition;
– promising technologies for analyzing the nutritional and micronutrient status of a person, incl. using genomic and post-genomic methods; "metabolomic" human passports;
– scientifically based nutritional standards and biomedical requirements for food products, including for children of various age categories;
– new physiological standards in the field of healthy human nutrition, taking into account the consequences of the impact of nutrition on the body, its resistance to disease and longevity, medical requirements for "personalized food products" for determined population groups;
– specialized products for children, therapeutic and preventive nutrition, for athletes, astronauts, special contingents, hypoallergenic and gerodietic products, etc.); functional foods[3]; products enriched with probiotics and prebiotics, biologically active substances; foods low in salt, sugar, fat, etc.;
– regulatory documents, recommendations, instructions on healthy nutrition for various age groups of the population, as well as taking into account the individual characteristics of a person;
– information support programs in the field of nutrition and dietetics, promotion of the right choice of food products, taking into account the individual characteristics of the body;
– modern information technologies for the selection of individual diets.

It should be noted that in view of the wide use in the creation of food products using genetically modified plants, animals, microorganisms, tissue cultures, nanotechnologies and nanomaterials, the issue of ensuring the safety and biosafety of food products obtained using these methods has become relevant [16-19].

The solution of these issues requires the development of methods and the formation of a quality and safety management system for food products produced using biotechnology and synthetic biology methods.

In view of the fact that the fundamental difference between “personalized nutrition” and other segments lies in the close linking of food products to the nutritional and micronutrient status of a particular person, close cooperation between institutions and specialists in the field of genetics and human physiology, nutrition, nutrition, food production technology comes to the fore, including functional purpose, quality control and food safety.

The creation of personalized food products and the development of modern digital technologies aimed at compiling individual diets should be based on the results of fundamental, exploratory and applied research aimed at:

– disclosure of the mechanisms of action of biochemical components of food on the human body at the molecular level;

– development of a methodology for personalized nutrition using modern genomic and post-genomic technologies to reduce alimentary-dependent diseases;

– development of "metabolomic passports" of a person using modern methods of nutrigenomics, nutrimetabolomics, nutriproteomics and nutrimicrobiomics;

– establishing relationships between the content of toxic elements in food products of various origins with metabolic disorders;

– development of individual and group recommendations on the nutrition of various population groups;

– improvement of methods for determining the biological effectiveness of personalized food products and dietary supplements;

– development of methods for targeted management of biochemical and technological processes of storage and processing, promising biotechnologies for the production of food products and dietary supplements [20-22];

– creation of new types of raw materials, selection, development and creation of genetically engineered strains of microorganisms, food additives, biologically active, prebiotic substances, probiotic organisms and other food ingredients;

– search for informative biomarkers for the determination of potentially hazardous substances of various origins, biologically active substances in food products and improvement of quantitative methods for the determination of toxicants [23-27];

– development of regulations and regulatory and methodological framework for identification of species of genetically modified organisms, including microorganisms;

– development of digital technologies for managing the processing and storage of raw materials;

– formation of a national system of IT services for the selection of individual diets.

Fundamental research in the field of agricultural science should be aimed at identifying patterns of biochemical transformation of food raw materials throughout the life cycle "from field to consumer", including the establishment of mechanisms and patterns of influence of physical, chemical, biological methods of influence on the biochemical composition of food raw materials during its processing.

An example of the relationship between the creation of food products with predetermined functional characteristics and the results of studying the mechanisms of transformation of the chemical composition of raw materials under the influence of physical and chemical methods is the technology for obtaining pectin, an indispensable component of functional foods due to their radioprotective, antioxidant, detoxifying and antibacterial properties. However, not all of their species have these properties, which is due to the chemical composition and structure of pectin. The functional specificity of pectin depends on the type of plant material and the technology of its production. To solve the problem of obtaining the target product with predictable functional properties, it is necessary to know not only the composition and structure of pectin substances, but also the relationship of their functional properties with analytical characteristics, the patterns of the influence of technological methods and modes on the chemical composition and structure of pectins isolated from vegetable raw materials.

The raw materials for the production of pectin are citrus presses, apple pomace or beet pulp. As you know, pectin is an acidic polysaccharide, the main backbone of which is rhamnogalauturnan with varying degrees of esterification of acidic carboxyl groups, to which arabinans, galactans, xylans, arabanogalactans and other neutral sugars are connected by side chains. In nature, there are various pectins in their chemical composition, from high molecular weight and high esterified in citrus raw materials to low molecular weight and low esterified pectins in beet raw materials (Table 1).

Table 1. Functional characteristics of different types of pectins

Показатель	Type of pectin		
	apple	citrus	beet
Degree of esterification, %	66,29	70,68	53,3
Uronid component, %	78,32	69,43	55,84
Molecular weight, Da	28830	32140	21750

In addition, the chemical composition of pectin substances contained in vegetable raw materials of the same group, for example, in apples, also differs significantly depending on the variety, ripening period, and agricultural practices used. In summer-ripening apple fruits, pectins are mainly represented by acidic fractions, and in winter-ripening apples - highly esterified.

Being thermolabile, pectins in the process of processing vegetable raw materials also, depending on the technological regimes at all stages of the production process, undergo a significant chemical transformation. For example, when carrying out the process of hydrolysis of protopectin and extraction of pectin from vegetable raw materials at high temperatures and acid concentrations, the processes of depolymerization, deesterification, demethoxylation, deacetylation, and deelimination develop in parallel. Similar processes take place at other stages of pectin production - separation of the solid and liquid phases, concentration of pectin extracts, coagulation, drying, purification of pectin. All this leads to a change in the chemical composition and structure of pectin.

The most important property of pectin is its detoxification ability in relation to heavy and radioactive metals, which is associated with its complexing ability. However, not all types of pectins are effective radioprotectors and heavy metal detoxifiers, but only those that have a sufficient number of functional groups that interact with toxicants. Pectins having a high uronide component and content of free carboxyl groups, and a low degree of esterification of carboxyl groups of pectin have a high complexing ability. Therefore, it is required to study the influence of various technological methods and regimes on the chemical composition and structure of pectins, which will allow developing technologies for obtaining pectins with a predictable chemical composition and properties.

The conducted studies of the dependences of the influence of technological modes of the processes of hydrolysis-extraction of various pectin-containing raw materials, concentration of pectin extracts, coagulation and drying of pectins by various methods made it possible to identify patterns of chemical transformation of pectin macromolecules throughout the technological cycle of multi-stage pectin production, to determine the optimal parameters for obtaining pectins with a predetermined chemical composition on based on the use of mathematical modeling methods and develop technologies for the production of pectin for various functional purposes. The complexing ability of isolated pectins with respect to heavy metals Pb++, Cd++, Sr++, Zn++, Hg++, Ni++ was determined under laboratory conditions.

At the same time, pectin substances, entering the human body, travel a long way through the digestive tract, being subjected to repeated acidic and enzymatic effects, as a result of which the detoxifying properties of pectins can significantly deteriorate. In this regard, studies of the process of enzymatic hydrolysis of pectins under in vitro conditions were carried out, the influence of the degree of enzymatic degradation of pectins as a result of enzymatic cleavage on their ability to form stable complexes with heavy metals and the effect of the monosaccharide composition of pectin on the binding ability was established.

Together with scientists from the Kuban State University on the basis of the Russian Center for Functional Surgical Gastroenterology (Krasnodar), citrus pectin (69% esterification degree) was clinically tested against incorporated toxic heavy metals (lead and cadmium). In the saliva and blood serum of healthy donors, toxic metals lead (II) and cadmium (II) were found in the amount of 0.24±0.06 mg/l and 0.002±0.001 mg/l, respectively. After a detoxification course with citrus pectin, the lead content was almost halved, and cadmium was almost completely eliminated. In addition, clinical trials have shown that, along with toxic elements, pectin removes essential elements (zinc and copper) from the body).

To develop recommendations for detoxification therapeutic nutrition in patients with various pathologies of the digestive system with identified carriage of heavy metals and organochlorine pesticides, tests were carried out on the effectiveness of taking apple and citrus pectins in patients with chronic pancreatitis.

The research results showed that, despite the enzymatic hydrolysis of pectin macromolecules in the human digestive tract, their ability to form stable complexes with heavy metals remains quite high. The course intake of citrus pectin contributed to the complete elimination of organochlorine pesticides in 11.0% of the subjects, while in the rest, the content of pesticides decreased to the minimum level of concentrations determined by the gas chromatographic method. The difference between the mean values before and after taking pectin is statistically significant. At the same time, in the comparison group (in subjects who did not take pectin), the content of organochlorine pesticides remained at a level close to the initial level after repeated determinations.

The conducted studies have shown a rather high sorption efficiency of enterosorbents based on pectin substances in the biological carriage of toxic heavy metals and residual amounts of organochlorine pesticides and the prospects for their use in a complex of therapeutic measures, when the environmental component is one of the important factors of the pathological process.

Thus, the study of the mechanisms and patterns of transformation of food raw materials under the influence of physical, chemical, biotechnological methods of influence in cooperation with scientists and specialists in the field of medicine and informatics will allow creating "personalized nutrition" products, solving issues of improving public health and increasing life expectancy.

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