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## FUNCTIONAL FOODS: PROSPECTS IN UKRAINE

**L. Kaprelyants**, Doctor of technical sciences, Professor, *E-mail*: leonid@onaft.edu.ua

**A. Yegorova**, PhD, Associate professor, *E-mail*: antoninaegorova59@gmail.com

**L. Trufkati**, PhD, Associate professor, *E-mail*: trufkati@gmail.com

**L. Pozhitkova**, PhD, Assistant, *E-mail*: pozhitkova@ukr.net

Department of Biochemistry, Microbiology and Physiology of Nutrition  
Odessa National Academy of Food Technologies, 112 Kanatna Str., Odessa, Ukraine, 65039

**Abstract.** Today, food is intended not only to satisfy hunger and provide necessary nutrients for human organism, but also to prevent nutrition-associated diseases and improve the mental and physical condition. The formula of food in the XXI century includes constant use of both traditional natural foods and foods with desired properties in the diet. The foods with desired properties are the functional food products, i. e. those enriched with essential food substances and micronutrients. These functional products cover a wide range of foods and ingredients with various biologically active substances responsible for their health-supporting and preventive effectiveness. This allows to lower the healthcare expenditures and support the economical development. The health and general well-being of today's Ukrainians is influenced by many factors: rush life tempo, age-related changes in organs and tissues, heredity, unhealthy habits, stress situations etc. But the great importance of the diet and numbers and quality of products from which meals are prepared also should be kept in mind. And while we cannot change some factors, we can absolutely control others, particularly the characteristics of foods. The article presents some features of modern diet of Ukrainian population as an integral factor of health risk. Also, we show food substance consumption profiles of Ukrainian population in years 2015–2018, and the rate of functional foods on Ukrainian market in the last two years. The article is a review and highlights the necessity to develop production of functional foods based on fundamental and applied researches in food technology, nutririology and the latest molecular biological technologies. General approaches to modern principles of functional food production technology are proposed. The role of the latest molecular biological technologies in functional food production is disclosed, especially of the proteomics, nutrigenomics and metabolomics. Important directions of functional food research are shown, they are associated with identification of new functional ingredients and increasing confidence of the consumers in such products. Motivations are proposed to stimulate the food manufactures to continue to develop the functional foods and to increase their assortment, thus providing a remarkable profit from successful products.

**Keywords:** nutririology, functional products, proteomics, nutrigenomics, metabolomics.

## ФУНКЦІОНАЛЬНІ ПРОДУКТИ ХАРЧУВАННЯ: ПЕРСПЕКТИВИ В УКРАЇНІ

**Л.В. Капрельянт**, доктор технічних наук, професор, *E-mail*: leonid@onaft.edu.ua

**А.В. Єгорова**, кандидат технічних наук, доцент, *E-mail*: antoninaegorova59@gmail.com

**Л.В. Труфкаті**, кандидат технічних наук, доцент, *E-mail*: trufkati@gmail.com

**Л.Г. Пожиткова**, кандидат технічних наук, асистент, *E-mail*: pozhitkova@ukr.net

Кафедра біохімії, мікробіології та фізіології харчування  
Одеська національна академія харчових технологій, вул. Канатна, 112, м. Одеса, Україна, 65039

**Анотація.** Призначення їжі сьогодні полягає не тільки в задоволенні голоду і забезпеченні необхідними нутрієнтами людини, але також у запобіганні захворювань, пов'язаних з харчуванням, та поліпшенні її розумового і фізичного стану. Формула їжі XXI століття – це постійне використання в раціоні харчування поряд з традиційними натуральними харчовими продуктами і продуктів із заданими властивостями, тобто функціональних продуктів харчування, які охоплюють широкий спектр харчових продуктів та інгредієнтів з різними біологічно активними речовинами, які відповідають за їхню ефективність в зміцненні здоров'я і профілактиці захворювань, тобто дають можливість скоротити витрати на охорону здоров'я і підтримати економічний розвиток. У статті представлено особливості сучасного раціону харчування українця, як інтегральний фактор ризику для здоров'я. Показано профілі споживання харчових речовин населенням України у 2015–2018 роках та частка функціональних продуктів харчування на українському ринку протягом останніх двох років. Наведено концептуальні підходи вирішення технологічних і технічних проблем при створенні функціональних продуктів харчування. Дана стаття є оглядовою та показує необхідність розвитку виробництва функціональних продуктів харчування на основі фундаментальних і прикладних досліджень в галузі харчових технологій, нутриціології та новітніх молекулярно-біологічних технологій. Запропоновано загальні підходи щодо формування сучасних принципів технологій виробництва функціональних продуктів харчування. Розкрито значення новітніх молекулярно-біологічних технологій, зокрема протеоміки, нутригеноміки та метаболоміки, у розвитку виробництва функціональних продуктів. Наведено актуальні напрямки дослідження функціональних продуктів харчування, які пов'язані з ідентифікацією нових функціональних інгредієнтів та нарощуванням довіри споживачів до таких продуктів. Запропоновано стимули, які будуть стимулювати продовольчі компанії продовжувати розвиток функціональних продуктів харчування, розширювати їхній асортимент, забезпечуючи прибутковий дохід від успішних продуктів.

**Ключові слова:** нутриціологія, функціональні продукти, протеоміка, нутригеноміка, метаболоміка.

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**Introduction. Formulation of the problem**

Today, the problem of introducing new foods in the consumer market becomes more and more important because of active economical and ecological changes and changes in fundamental base of food production. The changes are caused by requirements to utility and safety and rational use of all possible food resources. Today the food is intended to not only satisfy hunger and provide the humans with necessary nutrients, but also to prevent nutrition-associated diseases and improve the human mental and physical condition [1,2].

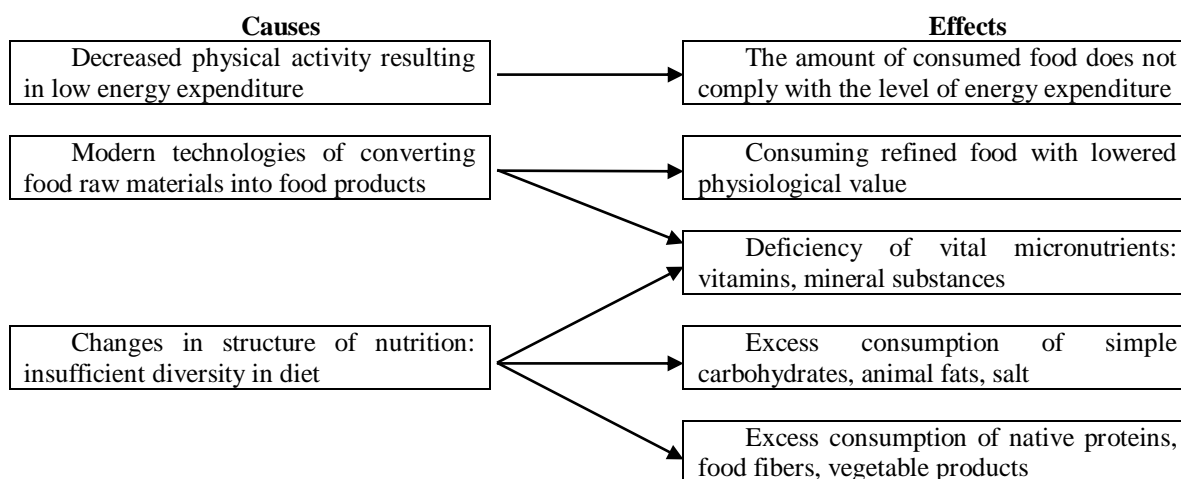
The formula of food in the XXI century includes constant use of both traditional natural foods and foods with desired properties in the diet. The foods with desired properties are the functional food products (FFP), i. e. those enriched with essential food substances and micronutrients.

Statistical data, official documents of Ministry of Healthcare of Ukraine and results of scientific researches indicate that the morbidity level of the population in Ukraine constantly increases. In the last 10 years, the number of patients with arterial hypertension has increased 3 times, mortality from myocardial infarction 2 times, and the numbers of patients with type 2 diabetes,

oncological diseases, obesity and others also increase dramatically.

The Institute for Health Metrics and Evaluation (USA) states that in the last 25 years the infant mortality in Ukraine has declined and the life span has increased. In 1990, Ukrainian women had an average life span of 74 years while in 2016 it was 77 years. In men, the life span increased from 65 to 67 years, respectively. Although, along with this, scientists had analysed data from 51 European countries from 1990 to 2016 and concluded that Ukraine tops the rating of mortality from malnutrition. Ukraine exceeds not only the Western developed countries, but also its former USSR neighbours like Georgia, Belarus, Moldova and Uzbekistan [3].

Researches indicate that in 2016, 38.2% of all deaths in Ukraine were associated with malnutrition to a varying degree. The health and general well-being of today's Ukrainians is influenced by many factors: rush life tempo, age-related changes in organs and tissues, heredity, unhealthy habits, stress situations etc. But the great importance of the diet and numbers and quality of products from which meals are prepared also should be kept in mind. And while we cannot change some factors, we can absolutely control others, particularly the characteristics of foods (fig. 1) [4,5].



**Fig. 1. Features of a modern diet – an integral factor of health risk [4,5]**

The today's structure of nutrition of Ukrainian population does not meet modern concepts of rational (optimal) nutrition and practical dietology. Bakery products, potatoes and sugar predominate in the population's diet, while consumption of main sources of native food protein, food fibers and micronutrients is insufficient.

The results of investigations of the current nutrition condition of population in various regions of Ukraine show that the structure of nutrition and the dietary condition in both children and adults typically exhibit serious disorders. The disorders include deficiency of native proteins (of animal origin from meat, fish, and dairy), polyunsaturated fatty acids, vitamins (C, B group, folic acid, retinol), beta-

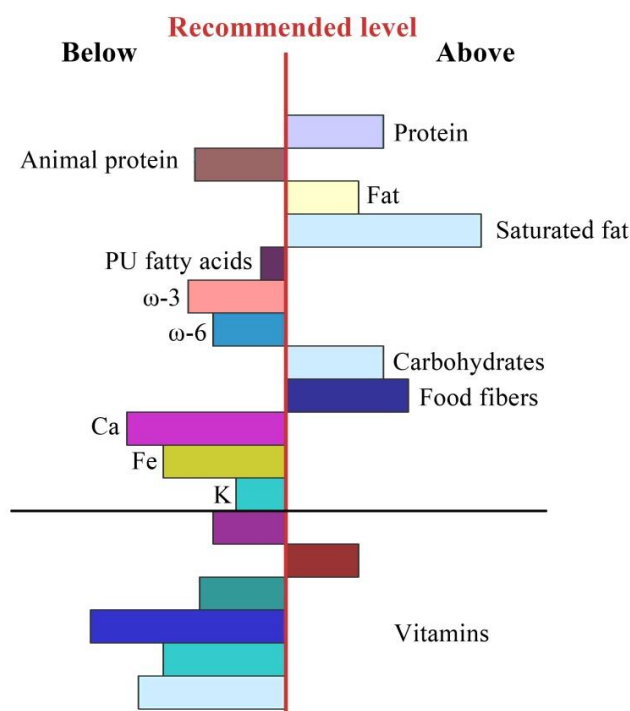
carotene, macro and micronutrients (Ca, Fe, Zn, F, Se, I and other), food fibers and various phytonutraceuticals. And, in contrast, consumption of animal fats and easily digested carbohydrates is in excess (fig. 2) [5,6].

Consumption of fats above the recommended normal level accounts for more than 32% of the dietary calories. The deficiency of protein is 20% at average, most vitamins and micronutrients 15 to 55% and food fibers 30%. The Ukrainians die prematurely because of dietary deficiency of wholegrain products, nuts, seeds, vegetables, fruit, legumes, omega-3 fatty acids, and also because of high level of salt consumption.

In the estimation of most analysts this is due to the national traditional cuisine and increasing life pace:

this is why the Ukrainians prefer fatty and carbohydrate-rich food, often eat on the run or totally omit meals and then catch up, and the steady increase

in prices makes high-quality food products less and less affordable for many people.



**Fig. 2. Profiles of food substance consuming by Ukrainian population, years 2015–2018 [5,6]**

Many natural food products are well known to be concentrates of the most important nutrients and biologically active substances capable of supporting the health and preventing diseases.

Diversity of these products results in diversity of components present in them. Over 2500 different chemical compounds have been found in fruit, vegetables and other plants consumed by humans. Over 500 compounds are known to be identified as modifiers of carcinogenic processes in the human organisms [7].

The human organism has distinct features of functioning in different age periods, and the requirements of main nutrients (vitamins, mineral substances and other vital components) change according to them. It is possible to enhance the quality of life of a human individual and provide it with strength and energy for comfortable life in any period of life by satisfying the organism's requirements in nutrients at a maximum level. The functional products, i. e. those containing biologically active components, are the best in this. Due to their balanced composition, their use is one of the best ways to help a human individual to adapt to physiological changes in the organism and ensure its resistance to the external factors.

Definitely, the development of concepts of functional nutrition and production of functional food became one of major breakthroughs of modern

dietology and of development of the world's food industry, because such products provide a maximum mobilization of adaptational forces of the organism directed to the protection from pathological changes caused by various adverse factors.

**Purpose.** To study the tendency of development of functional food production in Ukraine.

**Task of the investigation.** To propose general approaches to main principles of functional food production technology.

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#### Analysis of recent research and publications

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The concept of functional nutrition is not a new one, but only today it began to gain popularity. This is primarily due to changes in the human life pace, worldwide environmental degradation, increase in morbidity in all categories of the population. Today, a vast information base has been developed by the scientists about how a product influences the human organism. It is the knowledge of features of nutrients' action on the cellular and molecular levels in the human organism that boosted active investigation and introduction of the base of functional nutrition.

The third Action Plan in Foods and Nutrition for years 2015–2020 was approved by WHO and presented in Denmark in September 2014. According to this plan, one of the main directions of WHO's activity must be a constant provision of the population

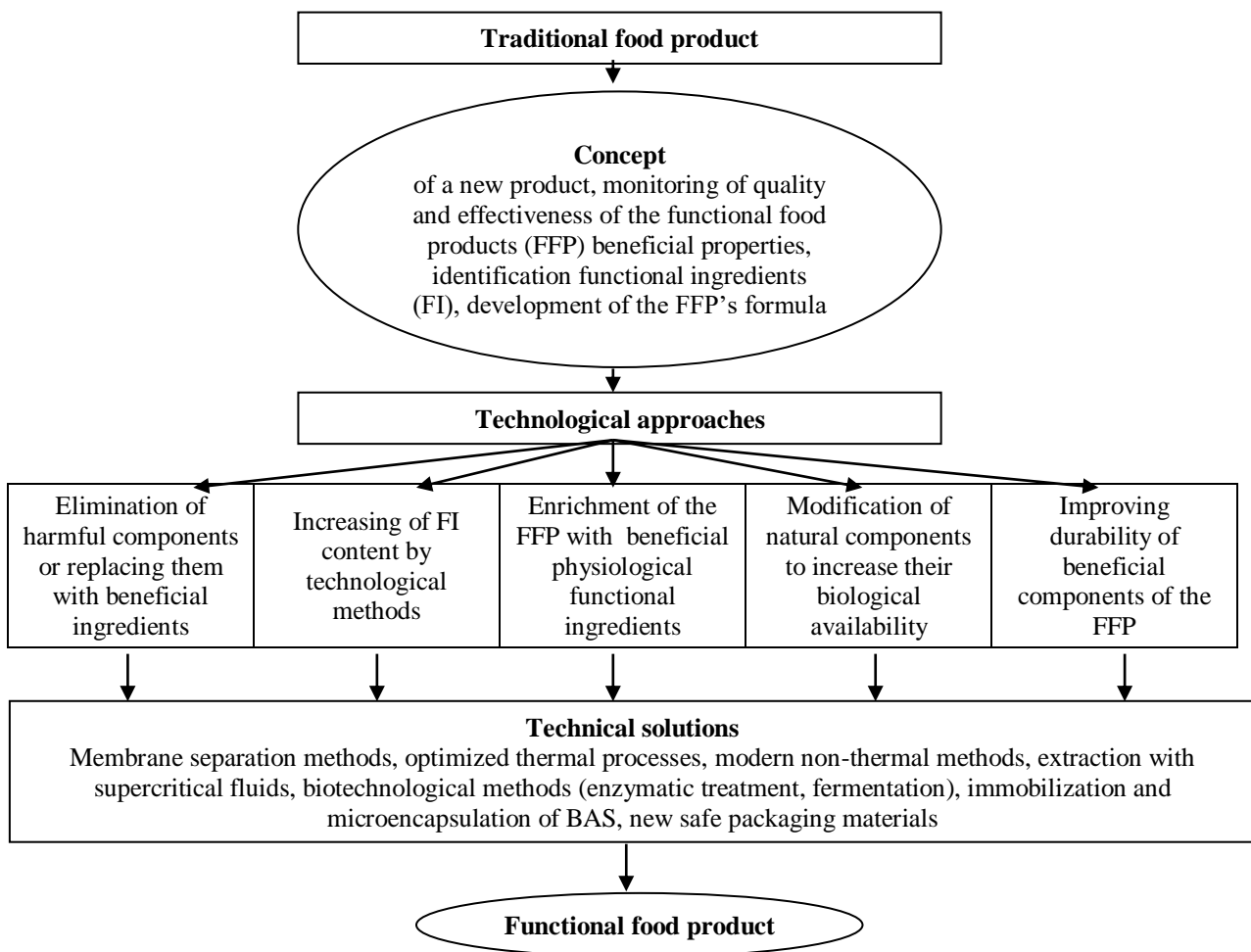
with safe and healthy foods. In this, particular articles of the plan state the necessity of contribution to a proper enrichment of main food products with micronutrients and to development of products for supplemental nutrition with a sufficient micronutrient content.

Today, the majority of economically developed countries have their own documents regulating the development and use of functional foods, these countries include Japan, Canada, USA, Netherlands, UK, China and other. Thus, the primary goal for each country must be provision of all segments of population with access to healthy and safe food. And one of the links that will help bring this goal to life can be the development of functional nutrition and production of functional food.

The world practice contains numerous definitions of “functional food products”, but there is no official, universally accepted terminological standard of “functional foods” so far. Any food product in fact is functional, because it provides the organism with nutrients and makes certain physiological impacts on it.

Thus, the term “functional food product” (FFP) can be regarded as a marketing concept for products attractive due to their health-giving effect and ways of how the consumer perceives the product.

Some foods can be considered functional if they are natural, non-processed products, and the new scientific information about their health-promoting properties can be used as an evidence of their advantage to further promote them to the market. Such products include many or almost all fruit, vegetables, cereals, fish, meat and dairy that contain certain natural biologically active components that give them additional advantages. Examples of these components are lycopene in tomatoes, omega-3-unsaturated fatty acids in salmonids, saponins in soybeans, polyphenols in grapes and wild berries. Even the tea and chocolate in some researches are regarded as products with functional physiological properties along with traditional nutritional value. But some authors believe that only products enriched with physiological functional ingredients (FI) possess a health-promoting effect and can be regarded as functional (fig. 3) [1].



**Fig. 3. Conceptual approaches to solving technological and technical problems in functional foods production [1]**

The majority of definitions also suggest that a functional product must be similar to a traditional product and must be a part of our usual diet. An FFP can be intended both for the entire population or for a certain group which can be determined, for example, by age or a genetic predisposition [8]. An operative definition of functional products has been proposed in the European Union within the Functional Food Science in Europe (FUFOSE) project: an FFP is a food product which makes a positive impact on one or more physiological functions of the organism, and besides its main nutritional properties improves the human health and is beneficial in decreasing the risk of diseases. The FFP are consumed as a part of the normal diet and are not capsules, pills or other forms of food additives [3,4].

According to the scientific concept of functional foods in Europe the FFP are intended mainly to improve the health and decrease the risk of acquiring diseases due to the presence of functional physiological ingredients in them. The FFP are not medications but they prevent some diseases, inhibit the organism's ageing and are regarded as an alternative to medicamentous treatment [2].

In Ukraine in 2004 the "Concept of improving the food sustenance and the quality of population's nutrition", which also covers the special food products including the FFPs [9]. This concept is reflected in the Ukrainian "Food Quality and Safety Act", where the FFPs are defined as "food products containing a medication as a component and/or intended for preventing or mitigation of manifestations of human diseases" [10].

In our opinion, including the "medication" in the definition of FFP does not comply with the conceptual approaches to definitions established in the European Union and the North American countries, and must be corrected to harmonize it with the universally accepted concepts.

An FFP is a food product intended for regular consumption within food diets by all age groups of healthy population, which lowers the risk of food-associated diseases and possesses health-promoting properties (that surpass its food value) due to the presence of physiological functional natural dietary ingredients in it. In addition, the FFPs must contain at least 30% of daily intake of functional ingredients (probiotics and prebiotics, vitamins, macro and micronutrients, bioflavonoids, polysaccharides, antioxidants, essential amino acids, polyunsaturated fatty acids, coenzymes etc.). A fundamental difference of the FFPs from other foods (dietetic, therapeutical, preventive, biologically active, substantial, restorative etc.) is that they possess a conspicuous health-promoting function, can be used by any individual, do not require special medical recommendations, and only regulate and normalize the organism's functions.

The FFPs are distinct in the following features:

- they are foods (but not capsules, tablets, powders or pills) prepared from natural components;
- they have a pleasant flavor, are convenient in use, and used in the routine diet;
- they possess a conspicuous health-promoting effect by regulating some functions of the organism,

enhance the mechanisms of biological protection (i. e. they are immune protectors), adaptations, self-regulation and self-recovery, inhibit the ageing processes, increase the overall reactivity of the organism, improve the regulation of physical and mental efficiency;

– their regulatory functions had been confirmed by clinical tests.

There are approaches that differentiate the FFPs from traditional products by their consumer properties. The "consumer properties" of the FFPs include three components: food value, flavor characteristics, and physiological action. The traditional products possess only the first two features [11].

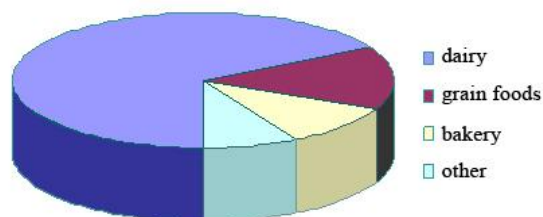
For these reasons, B. Marriot [12] emphasizes that only modified products obtained with using special technological methods should be referred to as FFPs. Nevertheless, all foods with proven impact on human health (capable of preventing widespread diseases, health and efficiency-promoting), regardless of the obtaining methods, are reckoned among FFPs worldwide.

In the case of FFPs in Ukraine, the history is richer and deeper compared to that in Western countries. Back in the middle 20<sup>th</sup> century, the Institute of Nutrition at the Academy of Medical Sciences of UkSSR was created in Kyiv. It was focused on dietetic nutrition (therapeutical and preventive), developed diets and foods for patients and healthy people with considering dietary factors of alimentary and other widespread human diseases.

Such products were obtained using enrichment with beneficial physiological components or removal (elimination) of some harmful substances which, when present in the product, interfere with the biological activity or biological accessibility of its food components. In some food-associated scientific institutions and universities of Ukraine researches on obtaining "enriched", "healthy", "therapeutical and preventive", "dietetic" and other food products became widespread. This is associated with using (both by healthy and ill people) a wide range of dietetic foods, enriched foods, special foods for people with high physiological and psychoemotional stress, elderly foods, biologically active additives to them etc. [5,6,13-15]. All of the mentioned foods fall within the FFP class, and according to the definition these products must possess a conspicuous physiological effect, besides their properties as food substance carriers (i. e. just the functions of macronutrients and energy sources) [16].

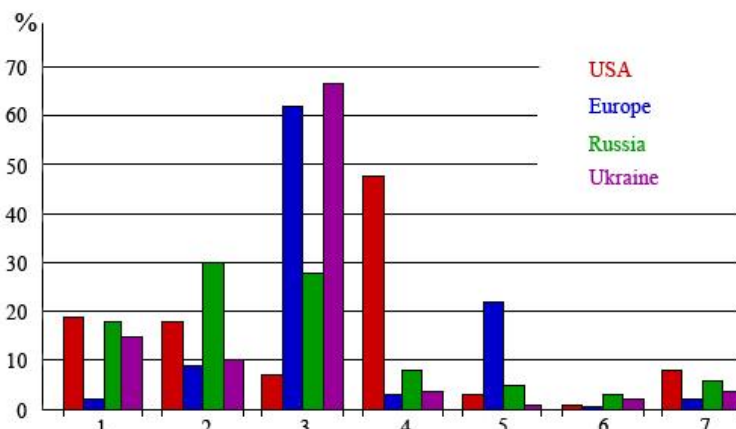
The Ukrainian market of FFPs is developed quite poorly compared to the EU market and is far from being saturated. The production output of FFPs in Ukraine covers 6 to 8% (by different estimates) of the total output of food products and is represented mainly by dairy and grain products (fig. 4 and 5) [5,8].

Thus, the main feature of modern food technologies and particularly the food technologies of the future is that, unlike the technologies of early 20<sup>th</sup> century, a great bulk of them rely on achievements of fundamental science. Today, the development of foods is impossible without fundamental scientific researches and high-technology industrial systems.



**Fig. 4. Proportions of the FFPs on Ukrainian market of food products (2017–2018) [5,8]**

Indeed, the food technologies of the future include new raw materials and new properties of traditional raw materials, new methods of converting the initial agricultural raw materials of vegetable and animal origin into foods, new formulas of foods, new packaging materials, and flexible technologies that provide a vast range of foods and their high quality. Thus, it is critical for Ukraine to develop concept bases of future food technologies and to create a scientific base of future inventions and ways of their engineering realization.



**Fig. 5. Main groups of functional foods in four countries: 1 – grain products, 2 – bakery, 3 – probiotic dairy, 4 – beverages, 5 – canned (conserved) foods, 6 – confectionary, 7 – other products (oils and fats, meat etc.) [5,8]**

The main direction is creation and further development of a well grounded concept of functional food products in Ukraine. Today this term is defined as foods intended for regular consumption within the diets by all age categories of the healthy population in order to lower the risk of diet-associated diseases and to promote health due to the presence of physiologically functional dietary ingredients in such products. The functional products will definitely come into the routine life of all people. It is the sole way that really allows to solve the global problem of optimizing the nutrition, supporting health and prolonging the human life. For this reason, the efforts of scientists all over the world today are focused on development and production of the newest functional products.

The growth of FFP production is closely associated with achievements in nutritiology, particularly with the newest molecular-biological technologies: genomics, nutrigenomics, metabolomics and proteomics, combined under a common term bionics. Any living organism possesses a set of genes, and a characteristic set of proteins and dynamically changing metabolites. Unlike the genome, the set of proteins and metabolites in the organism changes with time depending on the condition, age or physical activity. Proteomics studies the structure and main functions of proteins in order to obtain new scientific data or discover characteristic features of diseases.

Nutrigenomics is a science at the intersection of dietetics and genetics which studies the impact of

nutrients on the genes and, therefore, on the human health, and develops new products and individual “genetical diets” [17]. Nutrigenomics studies the correlations between the dietary conditions and cellular-genetic processes in order to find out how can the dietary components impact the health positively or negatively. Over 30 centers and laboratories of nutrigenomics have been opened worldwide in recent years. And some food companies, that used to provide grants to specialized scientific nutrigenomical centers, started to open their own laboratories of this speciality. In order to exchange information, the *Strategic International Alliance to Harness Nutritional Genomics for Public and Personal Health* has been created by scientists of 23 countries, and the *Journal of Nutrigenomics, Genes and Nutrition* was created to publish the results of researches. A course of nutrigenomics was introduced in programs for food technologists, since there is a good reason to believe that the new science will promote the modification of the existing technological processes of obtaining many food products. So far, the researches on nutrigenomics have been focused mainly on developing fundamental bases. But, judging by the materials of the 3<sup>rd</sup> symposium on nutrigenomics and the latest publications, there is now a conspicuous tendency to conduct specific investigations for particular food products (grapes, wine, cereals etc.) [4].

Metabolomics studies the complex of all metabolites that are the final products of metabolism of

a cell, tissue, organ or organism. While the data on gene expression and the results of a proteomic analysis do not give a full picture of what can happen in the cell, the metabolic profiles can give a shot of physiological processes in the cell. A metabolome is a full set of low-molecular metabolites which can be found both in a biological sample and in single organism. The investigation of metabolites allows to create a shot of current condition of the organism (metabolic profiling) [3].

The main mechanism of preventive action of the FFP is their positive impact on the following processes:

1) Improving the early development and growth of children (nutrition of women during pregnancy and lactation; enrichment of the FFP with omega-3 and omega-5 fatty acids, amino acids and micronutrients, including folic acid, iron, zinc and iodine; infant food enriched with omega-3 or omega-6 polyunsaturated fatty acids (PUFA), mineral substances like calcium or iodine, vitamins D and K, prebiotics and probiotics);

2) Supporting the organism's immune system (antioxidants, omega-3 and omega-6 PUFA, L-arginine, nucleotides and nucleosides, probiotics, prebiotics, symbiotics, micronutrients like zinc, copper and magnesium);

3) Preventing diseases of gastrointestinal tract (probiotics, prebiotics, symbiotics);

4) Positive impact of some FFPs on an individual's mental abilities and behavior (mental and cognitive ability, mood, response to stress, memory, attention, changes in memory and other mental processes in elderly). Some researches have demonstrated that caffeine improves the cognitive abilities and the psychoemotional state of an individual. The mental health in elderly is improved by consuming group B vitamins. Tryptophan can improve the process of falling asleep in people with insomnia, and tyrosine combined with tryptophan can remedy the circadian rhythm disorders caused by flights across several time zones. Some ingredients like n-3 fatty acids, S-adenosyl methionine and folic acid have been given a special status as potential functional ingredients to inhibit depression;

5) Preserving health in elderly by treating such age-associated diseases as cardiovascular disorders, cancer, cataract, Parkinson's disease, Alzheimer's disease, osteoarthritis etc. The oxidative stress of the organism is the base of emergence of the mentioned diseases, it should be treated by mobilizing the organism's defences by introducing into the diets oxidative enzymes, micro and macronutrients (selenium, manganese and copper as co-factors of antioxidant enzymes), vitamins C and E, carotenoids, glutathione, polyphenols, n-3 polyunsaturated fatty acids, biologically active components (like *Ginkgo biloba*).

6) Minimizing the risk of cardiovascular disorders by correcting the lipid profile in nutrition. The FFPs containing monounsaturated and polyunsaturated fatty

acids can lower the content of low-density lipoproteins without changing the content of high-density lipoproteins. Soluble food fibers can influence the content of cholesterol and regulate the metabolism (psyllium, inulin, oligofructans, beta-glucans etc.). Phytosterols (plant sterols and stanols) used in the FFPs lower the content of cholesterol in blood plasma to 10%. Fruit, vegetables, nuts and cereals are phytosterol-rich. Diets enriched with polyphenols (flavonols, flavanones, flavones, flavan-3-ols, isoflavones, anthocyanins and protoanthocyanidins) represent a large group of anticardioprotective FFPs.

7) Regulating body weight, since obesity is a current problem of some European and North American countries. Nutritional approaches in weight management include decreasing the dietary calorie density, lowering the appetite and regulating the organism's satiety. Fats and sugar substitutes are potential candidates for FFPs in order to lower the calorie density, while foods with a low glycemic index or food fibers can increase the fullness sense. A large number of functional ingredients in the FFPs are used to act preabsorptively in the gastrointestinal tract: chitosan, diglycerides, conjugated linoleic acid, green tea, caffeine, calcite and capsaicins.

8) Bolstering the bone tissue in order to prevent osteoarthritis which is a widespread disease in elderly. The following functional ingredients promote this: glucosamine, chondroitin, collagen hydrolysates, methylsulfonylmethane, S-adenosylmethionine, soybean saponins. Bone health also requires nutrients like Ca, Mg, vitamins D, K and C, micronutrients like Cu, Mn and Zn.

The key directions in the investigations of FFPs are the necessity to identify new functional ingredients and increasing the consumer trust to these products. In particular, it is necessary to conduct researches on:

1) identification of potential functional ingredients which can impact positively the human organism and become effective means of enhancing its protective functions;

2) identification of individual biological responses to the FFPs;

3) determination of biological availability degree of the functional ingredients;

4) development of proper biomarkers for a vast number of final functional products;

5) involving nutrigenomics, bioinformatics, proteomics, metabolomics and nanotechnologies in development of the FFPs;

6) development of preliminary requirements to personalized nutrition and potential role of the FFPs in it;

7) guaranteeing stability of functional ingredients during manufacture and passage along the gastrointestinal tract to reach the target organs and systems;

8) creation of dietary reference intakes for nutrients which make it possible to use them widely in industrial production of the FFPs.

### Conclusion

The driving force of researches and production of the FFPs and the growing consumer interest in these products is in the plane of understanding of correlations between nutrition, specific food ingredients and human health.

Developing a new FFP is an expensive process. Food companies traditionally finance the researches of new food formulas, but for the FFPs the stakes are higher both for food companies and consumers. State investments in fundamental and applied researches will promote the development of FFPs, but additional motivations are required to award the private

companies that would be the first to advocate the new health-concerning requirements [18-20].

Researches required for the FFPs to meet the scientific standards of effectiveness and safety are essential investments, but today the payback of these investments is not exclusive for the company which conducted the investigation and developed the initial regulatory documents [21-22]. As soon as the health-concerning requirements are properly documented, the competing companies will be able to use them. Motivations like the period of exclusivity or tax exemption will stimulate the food companies to continue the development of FFPs, providing a profit from successful products.

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