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DEVELOPMENT OF FUNCTIONAL BEVERAGES ON THE BASE OF WHEY

Abstract. Nowadays, there are new facts on the connection of intestinal microbiome with diseases of not only the digestive tract. Because of violations in immune status and in composition of normal microbiome largely due to a decrease in food quality and safety, the humanity is experiencing an epidemic of opportunistic infections. In these conditions, the development, based on modern achievements of science and technology, fundamentally new original processes and technologies, which allow receiving innovative and functional products based on traditional and non-traditional raw materials that will contribute to the public health is of great importance. A special place in this respect belongs to curd and cheese whey, which is not inferior to the whole milk in terms of its biological value but mainly falls into the waste because of its taste qualities. The scientific data and rationale for the use of whey as a high-grade raw material for the production of beverages, improving the digestive function, immune system and metabol ic processes in the human body, regulating them through the use of lactic acid microorganisms and natural plant supplements containing biologically active substances, preventing the emergence of a number of pathological conditions of the body are given. Specific examples of the production of whey-based beverages with improved organoleptic properties for a wide range of consumers are shown.

Key words: whey, functional beverages, lactic acid bacteria, phyto-additives, organoleptic properties.

The need to create functional foods is caused by a significant deterioration in the health status of the population, which is largely due to the decline in food quality and safety [1, 2]. Nowadays, there are new facts on the connection of intestinal microbiome with diseases of not only of gastrointestinal tract, but also with obesity, diabetes, malignant tumors, allergic, autoimmune, cardiovascular diseases and other [3-7]. Currently, everyday products are added with a large number of various physiologically unjustified food additives that lead to "diseases of civilization" and to a violation in the composition of the normal microflora of the gastrointestinal tract. In addition, contamination of raw materials and foodstuffs by extraneous microorganisms and their metabolic products, which have a toxic effect on the human body, takes place at all stages of production. In these conditions, the development, based on modern achievements of science and technology, fundamentally new original processes and technologies, which allow receiving innovative and functional products based on traditional and non-traditional raw materials that will contribute to the public health is of special importance.

Because of violations in the composition of normal microbiome and the decrease of immune status, the humanity is experiencing an epidemic of opportunistic infections, one of the leading places among which belongs to mycoses. The most frequent mycotic infection in all age groups is candidiasis of the mucous membranes of the digestive organs. Yeast of the genus *Candida* is widely spread in nature and their constant contact with a person explains the significant prevalence of transient candidiasis in human population.

Candida albicans is a commensal fungus of the oral, gastrointestinal and genital tracts in up to 80% of healthy individuals [8, 9]. Under specific host and environmental conditions, *C. albicans* can transit from its commensal state to a parasitic state causing mucosal (oral and vaginal) candidiasis and life-

threatening systemic disease. Yeasts of the genus *Candida* are easily included in microbial associations, contributing to exacerbation of chronic diseases [10]. They complicate surgical interventions, are the cause of systemic intractable mycoses, mimic oncological and tuberculosis diseases [11]. Cure of candidiasis requires diligence and time, as the fungus can take various forms, encapsulate, develop immunity to drugs and revive after treatment [12-14]. All the foregoing calls for the urgent need for scientific development of ways to prevent and eliminate the imbalance of microbiota, using specially selected functional foods [15-17]. Currently, one of the priority areas in healthy nutrition in international practice is the creation of functional wellness products. Worldwide, there is a growing demand for natural non-toxic compounds with a wide spectrum of action against pathogenic and opportunistic micro-organisms, the use of which does not cause side effects. So, the actual task in this regard is the search for natural antibacterial and antimycotic agents.

Treatment of dysbiosis is largely based on the probiotic lactic acid bacteria and their metabolites. The consumer market of functional products is formed by 50-65% by lactic acid products suppressing putrefactive bacteria, preventing dysbiosis and intoxication of the body. Bacterial starter cultures used in such products are in fact unique probiotics adapted to the human digestive tract. At present, new functional properties of lactic acid bacteria, in addition to antimicrobial and antifungal ones, continue to appear: the ability to accumulate antioxidants, peptides, fibrinolytic activity, synthesis of polyglutamic acid, degradation of harmful components etc., which are the essential criteria for choosing starter cultures in increasing the biological value of dairy products and their directed physiological and biochemical properties [18-32].

A special place in the production of functional foods belongs to curd and cheese whey, a secondary product of the dairy industry. The whey mainly falls into the waste despite the fact that it contains up to 50% of milk solids, up to 250 different valuable compounds, about 20% of milk proteins, other nitrogenous, micro- and macro compounds, milk fat, mineral salts, lactose, vitamins, enzymes, and organic acids [33-39]. Whey proteins include more essential amino acids than caseins, which possess a biological value superior to that of chicken eggs that are a benchmark in nutritional evaluation of foods. The composition of milk whey indicates that it is a full-fledged kind of raw material, which is not inferior to the whole milk in terms of its biological value. The energy value of whey is 3.5 times lower than that of whole milk, which makes it expedient to use whey in the production of dietary food. Processing of secondary dairy raw materials, providing a closed production cycle, would significantly improve the efficiency and profitability of the food industry.

Methods for the production of various useful products, such as milk fat (whey cream), whey protein complex, lactose, have been developed on the basis of whey. The opportunity of extraction vitamins, peptides, amino acids, bacteriocins, bacterial pool, and water from the whey seems promising. Cued and cheese whey is the ideal medium for probiotic microorganisms, and on this paradigm, it is possible to reconsider the whole concept of obtaining dairy products. It is also the starting material for the synthesis of prebiotics, for example lactulose. On the basis of whey it is possible to implement the principles of biotechnology of synbiotics [39]. In this regard, in last few years, there has been an increase of interest in whey [41, 42]. The possibility of effective use of whey products in the treatment and prevention of diabetes, bowel diseases, hypertension, infections of integumentary and bone tissues, immunodeficiency, complications after surgical interventions has been clinically proven [43].

Unfortunately, the whey is not popular as a drink because of its taste, despite its useful properties. To increase consumer demand, the development of opportunities to regulate its organoleptic indicators is being carried out.

A popular way to increase the organoleptic parameters of whey is the addition of milk or cream, kefir, yogurt, and fruit juice, which greatly enriches the product. Fruits, berries and vegetable additives are used as phytocomponents [44-49]. The most popular functional foods on the market are beverages containing various fruit mixes, which give the drink a fruit ease and freshness. A special place is occupied among them by combined milk and vegetable products with increased nutritious and biological value. Drinks with milk and vegetable extracts can be classified as neuroceutical functional group, as they are characterized by high content of antioxidants, amino acids, vitamins, mineral compounds, polyphenols, have anti-stress and hypoglycemic effect, increase resistance and working capacity. The beneficial effect of lactic acid products is associated with their suppressive action against a number of microorganisms

including pathogens. This effect is due to the ability of lactic acid bacteria to produce lactic acid and other substances (hydrogen peroxide, acetic acid, benzoic acid, bacteriocins, etc.) that stop the development of pathogenic bacteria in the intestines, which usually leads to inhibition of putrefactive processes and the cessation of the formation of toxic decomposition products. Lactic acid not only gives certain taste qualities to the beverage, but also determines its dietary and preventive properties. The result of its action is activation of the release of digestive enzymes into intestinal tract and stimulation of their action. Lactic acid also increases the absorption of phosphorus and calcium in the body.

A number of technological solutions have been developed for the production of whey based beverages to improve digestive functions, immune system, metabolic processes in the human body, exert a bifidogenic effect, and prevent the emergence of a number of pathological conditions of the body – stress, atherosclerosis, myocardial infarction, malignant neoplasms, etc. [50-77]. A synergistic effect of herbs and extracts combinations was established [78].

The technology of new functional combined whey and vegetable nano-drinks for healthy nutrition based on whey with vitaminized additives in the form of nanostructured purees and phyto-additives in the form of phytoextracts has been scientifically proven and developed. To give the original taste and aroma to nano-drinks, they are added with additives in the form of phytoextracts from non-traditional spicy aromatic and medicinal raw materials (marjoram, basil, melilot, oregano, coriander seeds, lemon peel) and phytoextracts from natural spices, which, possessing antimicrobial activity, contribute to the products shelf life prolongation. It has been shown that the new nano-drinks exceed the known analogues in chemical composition and content of bioactive compounds (L-ascorbic acid, phenolic compounds, flavonol glycosides, tannins, catechins, etc.) and can be used as products with potential immunomodulating action [79]. In order to improve the organoleptic parameters, as well as adjust the micronutrient composition, and increase the nutritional and biological value of the final product based on a combination of whey with vegetable purees from table beet, carrots and pumpkin, fermentation of the drink with probiotic cultures was carried out. A common for all variants was a significant increase in the fermentation rate in comparison with the control, as well as intensification of the process with increasing mass fraction of puree. At the end of the fermentation time, the titrated acidity in whey samples with Jerusalem artichoke was 113-130°T, with carrots 108-121°T, with beets 104-119°T. The received data testify that the introduction of puree vegetable additives allows not only improving the organoleptic parameters of fermented whey-based beverages and balancing their micronutrient composition, but also intensifying the fermentation process due to the prebiotic effect. The greatest bifidogenic potential for *Bifidobacterium longum* had Jerusalem artichoke. Carrots and table beets had slightly less effect. The degustation evaluation of fermented samples showed that the ratio of puree and whey 25-30 : 75-80% was optimal from the point of view of taste qualities.

Based on the data obtained, the technology and recipe of whey beverages with pulp from individual vegetables and their mixtures, designed for functional nutrition, have been developed. The beverage had a pleasant sweet and sour taste, a homogeneous consistency characteristic for drinks with pulp, contained viable cells of bifidobacteria in an amount of $>10^6$ CFU/g, which allows them to be positioned as functional. The use of such drinks contributes to the multifaceted positive effects that pre- and probiotics exert on the activity of the gastrointestinal tract and the state of the whole organism [80].

To expand the assortment of food products with functional properties on the basis of whey, recipes for desserts were developed, which were optimized with the help of mathematical modelling [81]. At the same time, the optimal ratio of whey base and fruit and vegetable fillers was determined, which provided favourable taste qualities of the desserts. The results of experimental studies give the reason for recommending the introduction of developed desserts into industrial production as functional food products.

A group of gelled products with the addition of fruits and/or berries, as well as citric acid, corn starch, sugar, fragrances and colorants are also produced on the basis of whey [82-84].The introduction of these additives, as well as the use of clarification of whey in the production process are disadvantages that negatively affect the functional qualities of the processed products, lead to a decrease in the biological value of the jelly and to increase in production costs. Despite the great choice and attractiveness of modern colorants, flavors, fillers and products with their use, their application is physiologically unjustified, especially in children's nutrition, so competent consumers prefer environmentally friendly products based on natural components.

Structured whey-based products are very popular. It should be noted that, because of their high popularity, their assortment is intensively growing, mainly with the use of jelly-forming agents. For example, pectic substances, changing the consistency, give the product the desired properties. The prospects of using pectic substances for the production of functional foods based on whey are proved [85].

It is known that the addition of mono- (xylitol, sorbitol), poly- (pectins, dextrin, inulin) and oligosaccharides (monosaccharides linked together by glycosidic bonds), antioxidant vitamins (A, C, E), microelements (selenium), plant extracts containing bioflavonoids, polyunsaturated fatty acids and other biologically active substances to useful microorganisms and their metabolic products positively affect the functions of the digestive tract. The presence of dietary fibres that are not digested in the gastrointestinal tract but effectively improve digestive functions and stimulate the beneficial intestinal microflora is of particular importance. This allows us to consider that the combination of lactic fermentation products and plant additives is one of the most promising ways of creating functional food products with the desired properties.

However, the list of developments with the use of bioactive cultures of microorganisms, as well as products aimed at normalizing the intestinal microflora with preventive action against fungal microorganisms, is limited.

At present, a special role in functional nutrition is given to products that contribute to optimizing the microecological status of the human body, since eubiosis is the key to immunobiological stability and potentially to the health in general [86]. Synbiotic products meet these criteria to the greatest extent, because they promote the colonization of the digestive tract by probiotic microorganisms and increase the biological activity of its own positive microflora due to the presence of prebiotic ingredients in the product. The starting cultures immobilized on the sorbent, which are plant fibers, have an additional degree of protection, including resistance to bile [87], due to which they are better reactivated upon ingestion in the digestive tract. The process of reactivation will also be accelerated due to quorum sensing of closely located cells on the sorbent [88]. In addition, the biodegradable sorbent will also serve as a source of nutrition not only for introduced bacteria, but also for resident microflora representatives.

Particularly relevant is the use of propionic acid bacteria producing B_{12}vitamin, increasing the immune status of the human body, its anti-stress and antimutagenic properties, and preserving dairy products [89-91], as well as of yeast microorganisms, the cell walls of which actively absorb toxins and toxic metabolites, have a high lacto- and bifidogenic effect, acting not only as nutraceuticals, but also as parapharmaceuticals [92, 93], in the compositions of starter cultures.

A review of the existing scientific literature on the importance of curd and cheese whey as a secondary raw material for the production of food products with high levels of nutritional and biological value testifies to the inadmissibility of neglecting it and to an urgent need for its targeted use.

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СҮТ САРЫСУЫНЫҢ НЕГІЗІНДЕ ФУНКЦИОНАЛДЫҚ СУСЫНДАР ДАЙЫНДАУ

Аннотация. Қазіргі кезде ішек биоценозының тек қана асқазан-ішек тракты ауруларымен ғана емес байланысы жайында мәлімет беретін жаңа дәлелдемелер пайда болуда. Иммундық жүйе мен қалыпты микрофлора құрамының бұзылуларына байланысты, айтарлықтай дәрежеде азық-түлік өнімдерінің сапасы мен қауіпсіздігі төмендеуіне байланысты адамзат оппортунисттік инфекциялар індетін басынан кешіруде. Бұл жағдайларда ерекше маңызға қоғам денсаулығының күйін жақсартуға мүмкіндік беретін функционалдық міндетке ие инновациялық азық-түліктер, дәстүрлі және дәстүрлі емес шикізаттар негізінде алуға болатын ғылым мен техниканың заманауй жетістіктерінің базасында, мақсатты түрде жаңа түпнұсқалық процесстер мен технологиялар ие. Осыған байланысты маңызды орынға, өзінің биологиялық құндылығы жағынан табиғи сүттен қалыспайтын, бірақ дәмдік сапасы нәтижесінде қалдықтарға жатқызылатын сүт сарысуы ие. Адам организміндегі иммундық жүйе мен зат алмасу процестерін, асқорыту қызметтерін жақсартатын, сүтқышқылды микроорганизмдер мен табиғи өсімдік текті қоспаларды пайдалану арқылы реттеу, организмнің бірнеше патологиялық күйінің пайда болуының алдын алушы, сусындар өндірісіне арналған толық қанды шикізат ретінде сүт сарысуын пайдалану жөніндегі ғылыми мәліметтер мен дәлелдеулер келтіріледі. Тұтынушылардың кең аясы үшін тартымдылығын жоғарылатуға мүмкіндік беретін жақсартылған органолептикалық көрсеткіштеріне ие, сүт сарысуының негізіндегі сусындар өндірісінің нақтылы мысалдары келтірілген.

Түйін сөздер: сүт сарысуы, функционалды сусындар, сүтқышқылды бактериялар, фитоқоспалар, органолептикалық көрсеткіштер.

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РАЗРАБОТКА ФУНКЦИОНАЛЬНЫХ НАПИТКОВ НА ОСНОВЕ МОЛОЧНОЙ СЫВОРОТКИ

Аннотация. В настоящее время появляются все новые факты, свидетельствующие о связи кишечного биоценоза с заболеваниями не только желудочно-кишечного тракта. Из-за нарушений иммунной системы и состава нормальной микрофлоры, в значительной степени из-за снижения качества и безопасности продуктов питания, человечество переживает эпидемию оппортунистических инфекций. В этих условиях особое значение приобретают разработки на базе современных достижений науки и техники принципиально новых оригинальных процессов и технологий, позволяющих получать на основе традиционного и нетрадиционного сырья, инновационные продукты функционального назначения, способствующие улучшению состояния здоровья населения. Особое место в этом плане занимает молочная сыворотка, которая не уступает цельному молоку по своей биологической ценности, но преимущественно попадает в отходы вследствие своих вкусовых качеств. Приводятся научные данные и обоснование использования молочной сыворотки как полноценного сырья для производства напитков, улучшающих функции пищеварения, иммунной системы и обменных процессов в организме человека, регулирования их путем использования молочнокислых микроорганизмов и натуральных растительных добавок, содержащих биологически активные вещества, предотвращающих возникновение ряда патологических состояний организма. Показаны конкретные примеры производства на основе молочной сыворотки напитков с улучшенными органолептическими показателями, способствующими повышению привлекательности для широкого круга потребителей.

Ключевые слова: молочная сыворотка, функциональные напитки, молочнокислые бактерии, фитодобавки, органолептические показатели.

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