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## INNOVATIVE SOLUTIONS IN BIOTECHNOLOGIES OF COMBINED YOGURT DRINKS WITH BALANCED CHEMICAL CONTENTS

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**Abstract.** Expediency of development of recipes and innovative biotechnologies for combined milk-vegetational products with balanced chemical composition, strengthened probiotic properties and extended shelf life was proven in field of establishing proper diet for adult healthy people, both in everyday consumption and during treatment of illnesses and rehabilitation after it. Principles of scientific approach to creation of biotechnologies for fermented combined products with balance of basic food nutrients are described here, as well as innovative biotechnological approaches, which provide the possibility of getting desired products (yoghurt drinks) with high probiotic properties and long shelf life. Main stages of development are described for recipes and biotechnologies of bifido-enabled combined yoghurt drinks with balanced chemical composition, rich on lively bifido- and Lactobacterium cells and long shelf life. A scheme for production of desired products with explanation of technological process parameters is provided, it was tested in industrial conditions at "Gormolzavod №1" Ltd. in Odesa, Ukraine. In samples of milk-rice and milk-spelt yoghurt drinks, which were produced in industrial conditions, we determined chemical composition and primary quality objectives. Desired products have balanced ratio of proteins : fats : carbohydrates (1 : 1 : 4), high sensory qualities, standard quality values during long shelf life (20 days in sealed tare), contain a high concentration of viable cells of probiotic cultures – such as *B. animalis Bb-12* (not less than  $3.6 \cdot 10^8$  CFU/cm<sup>3</sup>) and mixed cultures of *L. bulgaricus* + *S. thermophilus* (not less than  $4.0 \cdot 10^8$  CFU/cm<sup>3</sup>), as well as physiologically significant number of prebiotics – lactulose and fiber (30 and 10 %, according to the daily consumption norm when consuming 500 cm<sup>3</sup> of product).

**Keywords:** yoghurt drinks, combined contents of raw materials, rice flour, spelt flour, balanced chemical composition, bifidobacteria, lactobacterium, biotechnology, innovation.

## ІННОВАЦІЙНІ РІШЕННЯ У БІОТЕХНОЛОГІЇ КОМБІНОВАНИХ ЙОГУРТОВИХ НАПОЇВ ЗІ ЗБАЛАНОВАНИМ ХІМІЧНИМ СКЛАДОМ

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**Анотація.** Обґрунтовано доцільність розробки рецептур та інноваційних біотехнологій комбінованих молочно-рослинних продуктів зі збалансованим хімічним складом, підвищеними пробіотичними властивостями та подовженим терміном зберігання для організації адекватного повноцінного харчування дорослих здорових людей у повсякденному харчуванні та у процесі лікування й реабілітації після низки захворювань. Наведено принципи наукового підходу до створення біотехнологій ферментованих комбінованих продуктів зі збалансованим співвідношенням основних харчових нутрієнтів та визначено інноваційні біотехнологічні підходи, які забезпечують отримання цільових продуктів (йогуртових напоїв) з високими пробіотичними властивостями та тривалим терміном зберігання. Описано основні етапи розробки рецептур та біотехнології біфідовмісних комбінованих йогуртових напоїв зі збалансованим хімічним складом, високим вмістом життєздатних клітин біфідо- та лактобактерій і тривалим терміном зберігання. Наведено технологічну схему виробництва цільових продуктів із деталізацією параметрів технологічного процесу, апробацію якої здійснено у виробничих умовах ТОВ «Гормолзавод №1» (м. Одеса, Україна). В отриманих у виробничих умовах зразках молочно-рисових та молочно-спельтових йогуртових напоїв визначено хімічний склад та основні показники якості. Цільові продукти мають збалансоване співвідношення білків : жирів : вуглеводів (1 : 1 : 4), високі сенсорні характеристики, нормовані показники якості протягом тривалого терміну зберігання (20 днів у герметичній тарі), містять високу концентрацію життєздатних клітин пробіотичних культур *B. animalis Bb-12* (не менше  $3,6 \cdot 10^8$  КУО/см<sup>3</sup>) та змішаних культур *L. bulgaricus* + *S. thermophilus* (не менше  $4,0 \cdot 10^8$  КУО/см<sup>3</sup>), а також фізіологічно значимі кількості пребіотиків – лактулози та клітковини (30 та 10 % відповідно від добової норми споживання при вживанні 500 см<sup>3</sup> продукту).

**Ключові слова:** йогуртовий напій, комбінований склад сировини, рисове борошно, борошно зі спельти, збалансований хімічний склад, біфідобактерія, лактобактерія, біотехнологія, інновація.

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### Introduction. Formulation of the problem

Rational diet is one of most important factors, which help to preserve people's health and ability to

work, extend lifespan and improves its [1,2]. Theory of modeling the food products with pre-set chemical contents and consumer properties is developing

extensively during last decade, and it postulates that food products should not just keep body's energy balance but also be compatible with evolution-based specifics of human's digestion system. This can be done by using raw materials from human's current habitat which are compliant with his physiology, allow to properly digest food products, improve levels of acceptance for food nutrients and make lifespan longer [3-4]. Combined food products have high synergy with balanced diet principles, since planned mixing of recipe ingredients allows to get food composition with pre-set chemical content. Such approach is a basis for principle of raw materials complex usage, and its upsides lie in potential of mutual enrichment of recipe ingredients. Goal is in creation of such compositions, which will fully correspond to balanced diet formula. While at this, you can only level up reliability of food compositions' contents only thanks to their polycomponent factor. Regular consumption of new generation foods with balanced chemical composition that includes polycomponent contents, is sure to improve general health state and lower the risk of illnesses [3,5,6]. These contents are enriched by physiologically functional food ingredients, which are able to lower the harmful influence of negative food variables on human's health when used as part of food diet.

Its worthy to notice that food products with probiotics do have physiologically significant influence on human's body [3-5]. Still, none of currently existing probiotic products for adults contain basic food nutrients (proteins, fats, carbohydrates) in optimal ratio – 1:1:4 [5]. This is why creation of combined dairy products with probiotic properties, balanced chemical composition and long shelf life is solving the task of healthy diet products creation. Products, which most physiologically appropriate for providing adult people of various trades with proper nutrition. Both during everyday nutrition for making each meal properly digested (during breakfast, lunch or supper), for quick snacking, and for treatment of illnesses and rehabilitation after them.

So, relevant task of our age is to develop innovative solutions in biotechnologies of combined fermented food products with balanced ratio of proteins, fats, carbohydrates, essential amino acids and fatty acids. They must be based on utilizing raw materials from dairy, grain, fruits and berries (or vegetables and berries), as well as probiotic fermentation starters of direct introduction, made locally and with a long shelf life.

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#### Literature analysis

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Development of combined food products technologies for healthy nutrition is a matter of interest for foreign and domestic scientists in recent years. When developing combined food products on

dairy basis, milk is often gets mixed with raw ingredients of vegetable origin which are rich on:

- prebiotics, food fibers, biologically active substances (using different types of flour (including hydrolyzed), bran, flakes, extracts derived from grain and fruit raw materials, grown in the region of intended product consumption [3-13]);
- full-fledged proteins of vegetable origin, prebiotics, biologically active substances (extracts, concentrates and isolates of a number of leguminous crops are added to dairy raw materials) [12,14,15];
- essential polyunsaturated fatty acids (they enrich milk with sunflower, corn, linseed, camelina, pumpkin, sunflower high-oleic, raspberry, grape and other oils or their blends) [4,16,17].

Ukrainian scientific studies on biotechnologies of combined dairy products are mostly limited to:

- yogurts with fruit and berry and/or cereal fillers [18],
- food products for kids, especially curd snacks with rice flour for childhood nutrition [11],
- curd snacks with wheat bran, rice extrudate, pumpkin meal and cereal malt [12],
- milk-containing dairy products with milk fat substitutes [19], which often trigger negative reaction from local consumer.

Many developed countries of the world also develop combined products from milk for kids [9,13]. However, they also have combined dairy products for adult population. For example: dairy drinks with probiotics *L. rhamnosus* IMC 501® and *L. paracasei* IMC 502® with added buckwheat flour and rice bran [7], yogurt drinks with probiotics *L. casei* [8], *L. rhamnosus*, *L. Acidophilus* [14] and added corn extract [8] as well as various legumes [14,15]. Dairy drinks with probiotics *L. acidophilus* La-5, *B. animalis* Bb-12 and added fruit flour and oatmeal [3,16]; yogurt drinks, enriched by Omega-3 fatty acids [16]; curd snacks with wheat bran [6] and so on. These developed combined products also have their drawbacks, among which: choice of raw ingredients ratio on basis of sensory analysis [7-11], lack of a complex approach to the design of combined products' contents, which would also take into account all the requirements of modern nutritionology [3,7-11,16]. That's why developed products do not have balanced content of primary food nutrients (proteins, fats, carbohydrates) [7-11,14] or defined by a balance only in some of them [16]. So, there is actual need for scientific studies on creation of biotechnologies for combined food products for adult people, with balanced composition of all food nutrients, probiotic properties and long shelf life.

Authors' suggested scientific approach to creation of biotechnologies for combined fermented products with probiotic properties, which according to their nutritional, biological value and biological

efficiency correspond to physiological norms expects the following:

1. Optimization of target products composition (or so-called "designing of food products"), in order to ensure that nutritionology's recommended ratios of main food nutrients (proteins:fats:carbohydrates – 1:1:4, polyunsaturated fatty acids Omega-6 : Omega-3 – (5–10) : 1, indispensable amino acids – in accordance with composition of "ideal protein", physiologically functional food ingredients – in amount of 10 – 30 % from recommended daily norm), while using domestic dairy and vegetable raw products;

2. Proving the optimal ratio of milk-adapted *Bifidobacterium* and *Lactobacterium* cultures (*L. acidophilus* and *L. plantarum* monocultures, *L. bulgaricus* + *S. thermophilus* and *Lactococcus lactis* sp. mixed cultures) as part of the fermentation compositions for production of target products;

3. Scientific validation of methods related to biotechnological treatment of combined raw materials process intensification, by developing fermentation compositions from bifido- and lactic bacteria;

4. Evaluation of used natural stabilizers', pro- and prebiotics stabilizing role, during storage of fermented combined products with a balanced chemical composition.

There is a special group of dairy drinks in form of yoghurts - sour-milk products with boosted amount of dry substances, produced by souring of milk with *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus salivarius subsp. thermophilus* cultures. In Ukraine, some also distinguish bio yoghurts (yoghurt-based bioproducts, which additionally contain *Lactobacillus acidophilus* as a probiotic in an amount of at least  $10^7$  CFU/g at the end of shelf life) and bifido-yoghurts (yoghurt-based bifido-products, which additionally contain *Bifidobacterium* as probiotic in amounts not less than  $10^6$  CFU/g at the end shelf life) (DSTU 4343:2004). Protein richness, optimal ratio of natural calcium and phosphorus, live active cells of lactic acid bacteria and products of their metabolism make yoghurts extremely beneficial from rational nutrition point of view [3,20,21]. Thus, yoghurt drinks were chosen as this work's study subject.

**Purpose** of study is development of innovative biotechnologies for combined yoghurt drinks with bifido- components and balance of basic food nutrients, strengthened probiotic properties and extended shelf life.

Tasks of study:

– Propose innovative biotechnological solutions for production of combined bifido-enabled yoghurt drinks with strengthened probiotic properties;

– Validate technological process parameters and develop innovative biotechnology of production

for bifido-enabled combined yoghurt drinks with balance of basic food nutrients, strengthened probiotic properties and extended shelf life;

– Test developed biotechnology for required products in industrial conditions, determine chemical composition and quality measures for industrially manufactured samples of bifido-enabled combined yoghurt drinks and estimate economic effect from realization of this innovative proposal.

### Materials and methods of research

Following raw materials and ingredients were used in research: unskimmed cow milk of highest quality, corresponding to DSTU 3662-97, received in raw materials zone of "Gormolzavod №1" Ltd. in Odesa, Ukraine; cheese whey, received during production of curd by acidic method on "Gormolzavod №1" Ltd. in Odesa, Ukraine; rice flour for baby food, produced by "Cascade" Ltd. (Karlivka, Ukraine); spelt flour, bought from the "Zemledar" health foods store (Ivano-Frankivsk, Ukraine); flavor fillers with sugar – "Pumpkin", "Raspberry", "Briar", supplied by "Agrana Fruit Ukraine" Ltd. (Vinnytsya, Ukraine); high-oleic refined deodorized sunflower oil, purchased from "Agro-Ukraine" (Kyiv, Ukraine); unrefined pumpkin oil, produced by "AVA" Ltd. (Odesa plant of kernel and plant oils, Odesa, Ukraine); refined deodorized csmelina oil, produced by "AVA" Ltd. (Odesa plant of kernel and plant oils, Odesa, Ukraine); rice bran oil, produced by "Dial-export" and purchased from "Diamart" (Ukraine); lactulose syrup "Lactusan", purchased from "Felicata Ukraine" Ltd. (Kyiv, Ukraine); fructose, purchased at the Trading House "Semargl" (Kyiv, Ukraine); wheat fiber "Vitacel WF-600", purchased from Trading house "Lagis" Ltd. (Zhytomyr, Ukraine); pumpkin seeds fiber, bought from FOP "Ivaschenko V.M." (Velyka Bagachka, Ukraine); bacterial concentrates *FD DVS Yo-flex 180* and *FD DVS Bb-12*, supplied by "Chr. Hansen" (Denmark).

Methodology for development of innovative biotechnology for bifido-enabled combined yoghurt drinks with a balanced ratio of basic nutritional nutrients, increased probiotic properties and extended shelf life involved implementation of five consecutive interconnected experimental statistical stages.

First stage of comprehensive scientific research on development of biotechnology for target products involved proving correctness of choosing domestic dairy and vegetable raw materials, as well as physiologically functional food ingredients with desired properties for creating food with balanced composition of proteins : fats : carbohydrates – 1 : 1 : 4.

Second stage of research for designing and optimizing recipes of combined yogurt drinks used reference data on chemical composition of some of

chosen raw ingredients and results of our own experimental studies of chosen ingredients' chemical composition. For instance, composition of yoghurt clots and caseic thrusting, fatty acid composition of used vegetable oils and so on. Optimization was performed in *Microsoft Excel* and *Design Expert* environments, according to current physiological norms and while keeping in mind the recommendations, adopted by authors during development of scientific approach to this work.

Third stage of experimental research was anticipated to validate biotechnological decisions regarding production of bifido-enabled milk and cereal yoghurt products with increased probiotic properties and optimization of fermentation composition contents from monocultures *B. animalis Bb-12* and yoghurt crops for production of bifido-enabled combined yoghurt drinks.

During the fourth stage of this work, a basic technological scheme for production of target products was developed.

Fifth stage of this complex experimental research was anticipated to provide scientific and practical validation and optimization of parameters, related to technological process of production of bifido-enabled combined yoghurt beverages with a balanced chemical composition and enhanced probiotic properties.

Implementation of above-mentioned work stages allowed to develop a biotechnology of yoghurt drinks with combined composition of raw materials, balanced ratio of main food nutrients, increased probiotic properties and long shelf life. Developed biotechnology of target products was tested in industrial conditions of "Goromolzavod №1" Ltd. (Odesa, Ukraine). Chemical composition, sensory data, physic and chemical, biochemical and microbiological parameters were determined for samples of yoghurt drinks, which were produced in industrial conditions.

Choosing samples of finished products was performed in accordance with DSTU ISO 707: 2002. Organoleptic values of combined yogurt drinks with fillers were organoleptically determined in accordance with GOST 13264-88, with help from teachers and students of ONAFT (authors of this article) and tasting commission of "Gormolzavod №1" Ltd. Mass fraction of solids in target products was determined by arbitration in accordance with GOST 3626-73, mass fraction of fat content – with Gerber's acid method and by GOST 5867-90, mass fraction of proteins – by Kjeldahl method and DSTU ISO 8968-1: 2005, mass fraction of lactose – by iodometric method and GOST 3628-88, mass fraction of sugar – according to GOST 29248-91, mass fraction of lactulose, starch and fiber – by utilizing actual bookmark. Determination of raw materials and semi-finished products heat treatment effectiveness was done on basis of presence of peroxidase in fin-

ished product, according to DSTU 7380: 2013. Titrated acidity of finished yoghurt drinks was determined using titrimetric method and in accordance with GOST 3624-92, active acidity – with potentiometric method GOST 26781-85. Biological activity – using the method, which is based on catalysis of electron transfer by system product called "restored nicotinamide adenine dinucleotide – potassium ferrocyanide" [23]. Preparation of combined yoghurt drinks samples and their dilutions for microbiological research was done according to DSTU IDF 122C: 2003. Determination of viable cells of bifidobacteria numbers – by sowing thioglycolic medium in tall tubes and thermosetting them at 37 °C without oxygen coming in during 48 to 72 hours, all this according to DSTU 7355: 2013. Likely number of lactic acid bacteria viable cells – by pouring skimmed milk into sterilized tall tubes and following thermal conditioning for 72 hours, according to GOST 10444.11-89. Coliform bacterium numbers – by sowing Kesler medium in accordance with DSTU IDF 73a:2003. *Salmonella* search – by sowing Ploskirjev medium, according to DSTU IDF 93A: 2003, yeast and mold number – sowing on Saburo medium by GOST 10444.12-88.

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**Main stages of development of innovative biotechnology for bifido-enabled combined yoghurt drinks with a balanced ratio of basic nutritional nutrients, increased probiotic properties and extended shelf life**

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During first stage of work, we chose yoghurt clots with a certain mass fraction of fat and cheese whey, which usually remains in dairy factories during mass production of curd [18,22-23], as raw dairy ingredients for manufacturing of target products. As for grain ingredients, rice flour for infant food and spelt flour [18,24], which contain a high number of complete proteins (5.9 – 6.8 and 16.7 – 17.5 % respectively), starch (74.5 – 76.5 and 52.5 – 53.0 % respectively), food fibers (1,2–2,1 and 14.3–14.5% respectively), a number of vitamins (vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>5</sub>, B<sub>6</sub>, B<sub>9</sub>, PP, E, biotin), minerals (zinc, sodium, potassium, magnesium, phosphorus) and do not contain gluten. Two types of refined deodorized oils were chosen as sources of monounsaturated fatty acids: high-oleic sunflower oil and rice bran oil as a source of polyunsaturated fatty acids – unrefined pumpkin oil and cameline refined deodorized oil (latter one as a source of PUFAs omega-3) [25]. In order to enrich combined yoghurt drinks with original organoleptic characteristics and increase their nutritional and physiological value, it is recommended to use fruit or berry fillers with sugar ("Pumpkin", "Briar" and "Raspberry") from "FP" category as vegetable raw ingredients. Homogeneous consistency fillers with fruits or berries share – from 40 to 60 % [18,24,26]. For role of physiologi-

cally functional ingredients we chose lactulose as part of "Lactusan" syrup (mass fraction of lactulose – 40 %), wheat fiber and pumpkin fiber.

During second stage of research using the *Microsoft Excel* and *Design Expert* software packages, it were designed and optimized four recipes for milk-rice yoghurt drinks with pumpkin filler, two recipes for milk-spelt yoghurt drinks with "Raspberry" filler and two recipes for milk-spelt yogurt drinks with "Briar" filler [1,18,24,25]. When designing and optimizing the composition of combined yoghurt drinks, we were guided by recommendations adopted during developing scientific approach to the above-mentioned work. Optimization of product's fatty acid composition was performed in *Design Expert* environment, in accordance with requirements of modern nutritiology, specifically – formula of "hypothetically perfect fat", proposed by Russian scientists for milk-based products [27]. Milk-rice yogurt drinks will benefit from rice bran oil, cameline and pumpkin oils. Milk-spelt ones – from high-oleic sunflower oil and cameline oil [25,28].

Enrichment of target products by lactulose was supposed to ensure the adhesion of present bifidobacteria to the inner surface of the human colon's epithelium after drink consumption. And to "support" the vitality of bifidophlora cells during prolonged storage of products at low temperatures above zero in acidic environments. Mass fraction of lactulose in finished yoghurt drinks was set at 0,2 %, according to recommendations of nutritiology [29-30]. When consuming 500 cm<sup>3</sup> of product (such quantity of yoghurt drinks corresponds to daily need in milk and sour milk products of a healthy adult), consumer's body will receive 1.0 g of lactulose, which is 33 % of the daily consumption rate [1,32]. To eliminate the deficiency of fiber in diet of adult healthy people, it is recommended to add 0.4 – 0.5 % of wheat fiber to milk-spelt yoghurts (or pumpkin fiber in milk-rice yoghurts), which will provide 10 % of daily need in fiber for healthy adults when consuming 500 cm<sup>3</sup> of product [1].

While taking aforementioned recommendations in *Microsoft Excel* into account, we modelled basic recipes of yoghurt drinks with proteins : fats : carbohydrates ratio of 1:1:4 and with using chosen raw materials.

To verify our biotechnological decisions about production of bifido-enabled milk-and-cereal yoghurt products with enhanced probiotic properties, it was done some analysis literature and of own experimental studies from past times [3-16,30-32]. During biotechnological treatment of combined raw materials by fermenting compositions with bifido- and lacto- bacteria, there happens accumulation of biomass and metabolic products which leads to formation of single dimensional pattern of fermented product – gel. Its probiotic properties are also improving [23,29-32]. Probiotic properties of yoghurt

products are directly dependent on biomass of probiotic cultures [29-30]. An increase in number of viable probiotic cells in yogurt products, as well as in other fermentable products, is possible in three ways [30]: first – thanks to using optimal ratios of cultures of bifidobacteria and lactobacillus in fermentation compositions; second – due to enrichment of raw materials by bifidogenic factors; third – thanks to adaptation of bifidobacteria probiotic cultures to milk. Combination of these three paths in biotechnology of combined yoghurt products will allow to increase their probiotic properties and extend shelf life in several times. It is recommended to use fructose as bifidogenic factor in biotechnological processing of milk and cereal mixtures (mass fraction of fructose in normalized milk and cereal mixtures should be no less than 0.1 %) [30].

Optimal values of final concentration of bifido- and lactobacillum in fermentation composition for production of yoghurt drinks were determined on basis of experimental data, related to amount of bifido- and lactobacillum in fermented milk-cereal clots, their acidity and duration of biotechnological treatment of milk and cereal mixtures in *Statistica 10* software (*StatSoft, Inc.*) while using a reflector surface [28,33]. During biotechnological treatment of milk and cereal systems with fermentation crops, duration of this process is longer than in case of milk because mass fraction of casein in milk and cereal systems is lower than in milk alone, which complicates the process of gelling. Recommended optimum ratio of final concentrations of *B. animalis Bb-12* monocultures and yoghurt cultures is  $1.0 \cdot 10^5$  and  $3.0 \cdot 10^5$  CFU/cm<sup>3</sup>, respectively. Proposed biotechnological solutions allowed to receive fermented yoghurt milk and grain clots with a maximum concentration of viable bifido- and lactobacilli cells –  $(6.5 \pm 2.0) \cdot 10^8$  and  $(3.7 \pm 1.3) \cdot 10^9$  CFU/cm<sup>3</sup> respectively, with low level of titrated acidity (75.5 ± 12.5 °T) and industrially acceptable duration of milk-rice and milk-spelt mixtures fermentation – 7.0 – 7.5 and 6.0 – 7.0 hours respectively [24,28,34-36].

During fourth stage of research we proved the viability of joint fermentation of milk and cereal mixtures, enriched with vegetable oils and wheat fiber. For milk-spelt mixtures (or pumpkin fiber for milk and rice mixes) with further mixing of fermented milk-cereal yoghurt basis with pasteurized whey and berry (or whey and pumpkin) mixture enriched with lactulose syrup, as well as homogenization, cooling and aseptic sorting of final target product [28,35,36].

Fifth stage of complex experimental research was expected to provide scientific and practical verification and optimization of technological process parameters, related to production of bifido-enabled combined yoghurt drinks with a balanced chemical composition and enhanced probiotic properties.

Namely: homogenization, pasteurization and fermentation regimes for enriched milk and cereal mixture; parameters of heat treatment for whey-berry (or whey-pumpkin) mixture enriched with lactulose syrup; homogenization regime for finished product; determining shelf life of milk-rice and milk-spelt yoghurt drinks with a balanced chemical composition and probiotic properties [24,28,34-36].

It were conducted complex experimental and statistical studies, which allowed to develop a basic technological scheme of production for bifido-enabled combined yoghurt drinks with a balanced chemical composition, enhanced probiotic properties and long shelf life (Fig. 1).

In most cases, when treating milk with fermenting cultures of bifido- or lacto- bacteria, process of formation of single dimensional gel grid occurs. Structured systems which arise contain irreversible, immutable and thixotropically reactive connections [22]. It is important to get clot with dominance of irreversible and immutable connections during industrial manufacturing of dairy drinks. When producing protein products – clot with a maximum amount of thixotropically reactive connections. Using grain as raw material in technology of combined yoghurt drinks, which contains natural stabilizers: starch, food fibers, prebiotics and complex of biologically active compounds, allows to regulate the process of gel creation during production of target products and create food systems with desired rheological, structural and mechanical properties, enriched with physiologically functional nutritional ingredients. Moreover, usage of herbal ingredients which contain prebiotics (pectin, hemicellulose, fiber) in combined yoghurt drinks, as well as additional enrichment with fiber and lactulose, contributes not just to enhancement of nutrient and physiological value of these products, but also extends their shelf life (up to 20 days in airtight container) and helps to maintain high probiotic properties during storage.

#### Approbation of research results

Developed biotechnology for bifido-enabled combined yoghurt drinks with balanced chemical composition, enhanced probiotic properties and long shelf life was approbated in industrial conditions on premises of “Gormolzavod №1” Ltd. (Odesa, Ukraine). This dairy facility produced two batches of milk-rice yogurt drinks with pumpkin filler, one batch of milk-spelt yoghurt drink with “Raspberry” filler and one batch of milk-spelt with “Brier” filler. In samples of target products, which were received

in industrial conditions, we determined chemical composition, sensory characteristics, as well as physical, chemical, biochemical and microbiological values (Table 1).

Table 1 data shows that developed samples of combined yoghurt drinks have a different mass fraction of dry substances (milk-rice yoghurt drinks with “Pumpkin” filler contain almost 1.5 times less dry substances than milk-spelt, which is due to higher amount of spelt flour in latter product, in comparison with rice flour for infant food. As well as the lower content of cheese whey. Still, all the developed drinks have a balanced ratio of proteins : fats : carbohydrates – 1:1:4, which is a ratio recommended by nutritionology for nutrition to adult healthy people. Products, which are manufactured in industrial conditions according to developed biotechnology, show high sensory characteristics, which should allow (dependent on competent organization of marketing) to meet the needs of the target category – namely a consumer up to 40 years of age (predominantly female), who cares for her health [37].

Developed yoghurt drinks contain a high concentration of viable cells of probiotic cultures. Such as *Bifidobacterium animalis Bb-12* (not less than  $3.6 \cdot 10^8$  CFU/cm<sup>3</sup>) and mixed cultures of *Lactobacillus belbrueckii subsp. Bulgaricus* + *streptococcus salivarius subsp. thermophilus* (not less than  $4.0 \cdot 10^8$  CFU/cm<sup>3</sup>), as well as physiologically significant number of prebiotics – lactulose and fiber (30 and 10 %, according to the daily consumption norm when consuming 500 cm<sup>3</sup> of product). These results in high probiotic properties of developed bifido-enabled combined yoghurt drinks, increases shelf life up to 20 days in sealed tare, enhances chance for survival of bifidobacteria throughout the storage period (during last day of storage, number of alive bifidobacteria cells in 1 cm<sup>3</sup> of drinks is not less than  $1.9 \cdot 10^8$  CFU). It is also likely to contribute to good adhesion of bifidophlora to the inner wall of the human intestinal epithelium [29,30].

Absence of pathogenic bacteria (including bacteria of *Salmonella* genus) in 25 cm<sup>3</sup> of the product, coliforms in 0,1 cm<sup>3</sup>, and a small amount of yeast and mold cells in yoghurt drinks (Table 1) indicate the correct choice of thermal and biotechnological treatment of combined raw material. Physic, chemical and biochemical quality indicators from samples of bifido-enabled combined yoghurt drinks, which were produced in industrial conditions, vary slightly during 20 days of storage (subject to packaging in sealed tare).

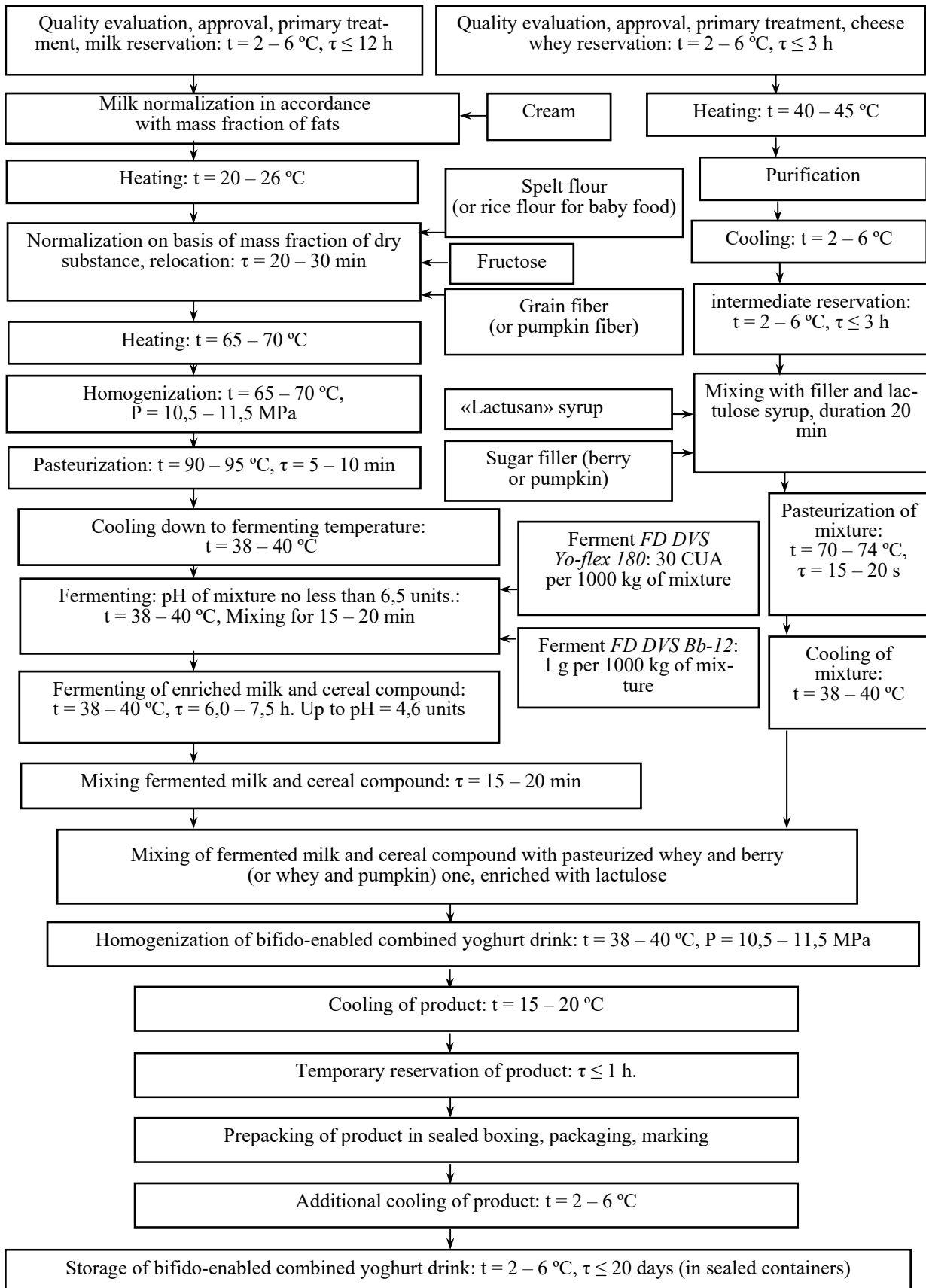


Fig. 1. Technological scheme of production for bifido-enabled combined yoghurt drinks with balanced chemical composition, enhanced probiotic properties and long shelf life

**Table 1 – Chemical composition, sensory characteristics, physical, chemical, biochemical and microbiological values of bifido-enabled combined yoghurt drinks, which were received in industrial conditions (n=3, p≥0,95)**

Value name	Value for bifido-enabled combined yoghurt drinks on basis of			
	milk and rice with “Pumpkin” filler, produced according to basic recipe [18]		milk and spelt with filler	
	3	4	«Raspberry»	«Brier»
Taste and smell	Pure, sour milk-like, sweet, with light flavor and “Pumpkin” filler aroma, with barely noticeable pleasant taste of pumpkin oil		Pure, sour milk-like, sweet, with a light flavor taste and aroma of added fillers (spelt flour and berry)	
Consistency and appearance	Homogeneous, viscous, with insignificant inclusions of added fillers – fiber and flour			
Color	Light orange, with small amount of fiber		Light crimson, with a bit of spelt and fiber	Expressed creamy, with a bit of spelt and fiber
Mass fraction, %:				
– dry substances, including:	12.9±0.53	13.45±0.50	18.90±0.52	19.88±0.50
– proteins	2.15±0.06	2.25±0.03	3.15±0.05	3.31±0.03
– fats	2.15±0.05	2.25±0.05	3.15±0.05	3.31±0.05
– carbohydrates, incl.:	8.70±0.10	9.05±0.10	12.60±0.10	13.24±0.10
– starch	2.10±0.10	1.70±0.10	2.88±0.10	3.14±0.10
– lactose	3.40±0.10	3.35±0.10	3.10±0.10	3.18±0.10
– sucrose	2.80±0.10	3.50±0.10	4.80±0.10	6.00±0.10
– lactulose	0.20±0.01	0.20±0.01	0.20±0.01	0.20±0.01
– fiber	0.40±0.01	0.40±0.01	0.40±0.01	0.40±0.01
Acidity:				
— titled, °T	77.0±1.0	79.5±0.5	85.5±1.0	87.0±1.5
— active, pH	3.9±0.1	4.0±0.1	3.5±0.1	3.4±0.1
Biological activity, CUA	96±2	80±3	74±5	107±2
Peroxydase	Absent			
Number of viable cells, CFU/cm <sup>3</sup> :				
— Bifidobacteria	(3.6...7.0)·10 <sup>8</sup>	(5.1...9.1)·10 <sup>8</sup>	(4.5...6.7)·10 <sup>8</sup>	(5.3...7.2)·10 <sup>8</sup>
— Lactobacillus	(4.0...6.0)·10 <sup>8</sup>	(4.0...6.0)·10 <sup>8</sup>	(5.0...7.0)·10 <sup>8</sup>	(5.0...7.0)·10 <sup>8</sup>
Coliforms in 0,1 cm <sup>3</sup>	Absent			
Presence of pathogenic bacteria, including bacteria <i>Salmonella</i> in 25 cm <sup>3</sup> of product	Absent			
Number of yeast and mold in 1 cm <sup>3</sup> of product, CFU	< 10	< 10	< 10	< 10

### Conclusions

1. Viability of development of recipes and innovative biotechnologies, related to combined milk and vegetable products with balanced chemical composition, enhanced probiotic properties and extended shelf life, for adequate nutrition of healthy adults, was proven.

2. Principles of scientific approach to creation of biotechnologies of fermented combined products with a balanced ratio of the main nutritional nutrients have been characterized, and innovative biotechnological approaches have been defined. They allow obtaining of yoghurt drinks with high probiotic properties and long shelf-life.

3. Main stages of development of recipes and biotechnology for bifido-enabled combined yoghurt

drinks with a balanced chemical composition, high content of viable cells of bifidobacteria and lactobacilli, and long shelf life are described.

4. Technological scheme for production of bifido-enabled combined yoghurt drinks, with detailed parameters of technological process, is presented.

5. Chemical composition and main quality indicators for samples of bifido-enabled milk-rice and milk-spelt yoghurt drinks, which were obtained in industrial conditions of “Gormolzavod №1” Ltd. (Odesa, Ukraine), have been determined for developed biotechnology. It was discovered that developed products have a balanced ratio of proteins : fats : carbohydrates (1 : 1 : 4), high probiotic properties and sensory characteristics, as well as normalized quality values during a long shelf life (20 days in sealed tare).



## References

- Zubar NM. Jsnovy fiziologii ta gigiyeny kharchuvannia. Pidruchnyk. Kyiv, Tschentr uchbovoi literatury; 2010. ISBN 978-966-364-996-2
- Mardar M, Zhygunov D, Znachek R. QFD – methodology to develop a new health-conducive crain product. Eastern-European Journal of Enterprise Technologies. 2016; 2/11(80):42-47. <http://dx.doi.org/10.15587/1729-4061.2016.65725>
- Anikina EN, Pasko OV, Kononov SA. Proektirovaniie i razrabotka tekhnologii bioprodukta s ovsiannim toloknom. Agrarniy vestnik Urala. 2013; 5(111):26-29.
- Havrylova NB. Byotekhnologiya kombynyrovannikh molochnykh produktov. Monografiya. Omsk: «Varyant-Sybyr»; 2004. ISBN 5-7065-0243-9
- Tkachenko NA. (2017). Kombinovani bifido-napoyi zi zbalansovanyim khimichnym skladom – produkty dlia zdorovoho kharchuvannia. Zbirnyk tez dopovidey 77 naukovoyi konferentsiyi vykladachiv akademiyi 18–21 kvitnya 2017 g. Odesa: ONAKhT; 2017:110-112.
- Penzina OV. Issledovanie i razrabotka tekhnologii tvorozhnogo bioprodukta s pshenichnimi otrubiami: dis. ... kand. tekhn. nauk: 05.18.04. Omsk; 2014.
- Coman M, Verdenelli M, Cecchini C, et al. Effect of buckwheat flour and oat bran on growth and cell viability of the probiotic strains *Lactobacillus rhamnosus* IMC 501® and *Lactobacillus paracasei* IMC 502® and their combination SYN BIO®, in synbiotic fermented milk. International Journal Of Food Microbiology. 2013; 167(2):261-268. <http://dx.doi.org/10.1016/j.ijfoodmicro.2013.09.015>
- Sedarnawati Y, Ayuni M. Development of corn milk yoghurt using mixed culture of *Lactobacillus delbruekii*, *Streptococcus salivarius*, and *Lactobacillus casei*. HAYATI Journal of Biosciences. 2014; 21(1):1-7. <http://dx.doi.org/10.4308/hjb.21.1.1>
- Ferreira S, Caliani M, Soares Júnior M, Del Pino A. Beleia Infant dairy-cereal mixture for the preparation of a gluten free cream using enzymatically modified rice flour. LWT - Food Science And Technology. 2014; 59(2):1033–1040. <https://doi.org/10.1016/j.lwt.2014.06.047>
- Casarotti S, Penna A. Acidification profile, probiotic in vitro gastrointestinal tolerance and viability in fermented milk with fruit flours. International Dairy Journal. 2015; 41:1-6. <https://doi.org/10.1016/j.idairyj.2014.08.021>
- Rudakova TV. Tekhnologiya vyrobiv syrkovykh dlya dytyachoho kharchuvannia z vykorystanniam produktiv pererobky zerna. Zernovi produkty i kombikormy. 2015; 2(58):9-14.
- Onoprychuk OO, Hrek OV, Potapenko SI. Rozroblennya tekhnologiyi kombinovanoho molochno-bilkovoho produktu z roslynnymy inhrediyentamy. Tavriyskyyi naukovyyi visnyk. 2006; 43:92-100.
- Galkina SL. Issledovanie i razrabotka tekhnologii tvorozhno-krupianogo produkta s probioticheskimi svoistvami. Agrarniy vestnik Urala. 2012; 8:45-47.
- Zare F, Champagne CP, Simpson BK, Orsat V, Boye JI. Effect of the addition of pulse ingredients to milk on acid production by probiotic and yoghurt starter cultures. LWT. Food Science And Technology. 2012; 45(2):155-160. <https://doi.org/10.1016/j.lwt.2011.08.012>
- Zabodalova LA. Biotekhnologiya kombinirovanykh molochnykh produktov s ispolzovaniem komponentov soi: dis. ... dokt. tekhn. nauk: 05.18.04. Kemerovo; 2000.
- Dal Bello B, Torri L, Piochi M, Zeppa G. Healthy yogurt fortified with n-3 fatty acids from vegetable sources. Journal of Dairy Science. 2015; 98(12):8375-8385. <https://doi.org/10.3168/jds.2015-9688>
- Nekrasov PA, Tkachenko NA, Kasianova AJu. Nauchno-prakticheskie osnovy tekhnologii nizkozhirnogo bifi-dosoderzhashchego spreda so sbalansirovannym zhirkokislotoym sostavom. «Prodovolstvennaia bezopasnost v kontekste novykh idei i reshenii» mezhdunarodnaia nauchno-prakticheskaia konferentsiia. 10 marta 2017 g. Semei: Gosudarstvennyi universitet imeni Shakarima. 2017; 2:329-332.
- Tkachenko NA, Nekrasov PO, Kopyiko AV. Matematychno modelyuvannya komponentnoho skladu kombinovanykh yohurtovykh napoyiv. Zernovi produkty i kombikormy. 2016; 1:20-25.
- Pidsumky roboty kharchovoyi promyslovosti za 2015 rik. [Internet]. 2015. [cited 2015 Jun 27];[about 6 pp.]. Available from: <http://minagro.gov.ua/ministry?nid=20612>
- The Benefits of Yogurt. [Internet]. 2016. [cited 2016 Mar 30];[about 5 pp.]. Available from: <http://www.webmd.com/food-recipes/benefits-yogurt?pa>
- Elli M. Survival of Yogurt Bacteria in the Human Gut. Applied and Environmental Microbiology. 2006; 72(7):5113-5117.
- Tkachenko NA, Nekrasov PO, Vikul SI. Optymizatsiya retsepturnoho skladu napoyu ozdorovchoho pryznachennya na osnovi syrovatky. Eastern-European Journal of Enterprise Technologies. 2016; 1/10(79):49-57. <http://dx.doi.org/10.15587/1729-4061.2016.59695>
- Chagarovskii OP, Tkachenko NA, Lysogor TA. Khimiia molochnoi syrovyny: navchalnyi posibnyk dlia studentiv vytschykh navchalnykh zakladiv. Odesa, Simeks-print; 2013. ISBN 978-966-2601-44-2
- Tkachenko N, Kruchek O, Ramazashvili H. Probiotychni yohurtovi napoyi zi speltouy - fermentovani molochni produkty novoho pokolinnya. Materialy 83 mizhnarodnoyi naukovoyi konferentsiyi molodykh uchenykh, aspi-rantiv i studentiv “Naukovi zdobutky molodi - vyrisshennu problem kharchuvannia lyudstva u KhKhI stolitti”, 5-6 kvitnya 2017 r. Kyiv: NUKhT. 2017; 1:359.
- Tkachenko N, Nekrasov P, Kopyiko A. Optymizatsiya zhymokyslotnoho skladu kombinovanykh molochno-rysovnykh yohurtovykh napoyiv z harbutovym napovnyuvachem. Materialy 83 mizhnarodnoyi naukovoyi konferentsiyi molodykh uchenykh, aspi-rantiv i studentiv “Naukovi zdobutky molodi – vyrisshennu problem kharchuvannia lyudstva u KhKhI stolitti”, 5-6 kvitnya 2017 r. Kyiv: NUKhT. 2017; 1:361.
- Tkachenko N, Nekrasov P, Vikul S, Honcharuk Ya. Modelling formulae of strawberry whey drinks of prophylactic application. Food Science and Technology. 2017; 1:80 - 88. <http://dx.doi.org/10.15673/fst.v11i1.303>
- Shiller GG, Poiarkova GS, Levachev MM. Gipoteticheski idealnyi zhir v produktakh pitaniia zdorovogo cheloveka. Kratkoe soobshchenie XXI Mezhdunarodnogo molochnogo kongressa. 1982; 1/1(9):273-274.
- Tkachenko NA, Chagarovskii AP, Kopeiko AV. Kombinirovannye probioticheskie napitki so sbalansirovannym khimicheskim sostavom: innovatsionnost tekhnologicheskikh reshenii. «Prodovolstvennaia bezopasnost v kontekste novykh idei i reshenii» mezhdunarodnaia nauchno-prakticheskaia konferentsiia. 10 marta 2017 g. Semei: Gosudarstvennyi universitet imeni Shakarima. 2017; 2:202-206.
- Biavati B, Bottazzi V, Morelli L. Probiotics and Bifidobacteria. Novara (Italy): MOFIN ALCE; 2001.
- Didukh\*\* NA, Chaharovskiy OP, Lysohor TA. Zakvashuvai ni kompozytsii dlia vyrobnytstva molochnykh produktiv funktsional'noho pryznachennia. Odesa: Vydavnytstvo Polihraf; 2008. ISBN 978-966-8788-79-6
- Didukh\*\* NA. Obgruntuvannya parametriv zberihannia molochno-zernovoho hero-kefiru. Zernovi produkty i kombikormy. 2009; 2:47-51.
- Chaharovskiy OP, Didukh\*\* NA. Funktsional'ni kyslomolochni produkty herodiyetchnoho pryznachennia. Problemi starenia y dolholetyia. 2001; 2(20):214-222.
- Tkachenko NA, Nekrasov PA, Kopyiko AV. Obosnovanye sostava zakvasochnoy kompozytsyyi dlya proyzvodstva byfydosoderzhashchykh molochno-rysovnykh yohurtovykh napytkov. Tekhnika y tekhnologiya pyshchevikh proyzvodstv: tezysi

- dokladov XI Mezhdunarodnoy nauch.-tekhn. konferentsyy, 20-21 aprelya 2017 h., Mohylev. Uchrezhdenye obrazovanyya «Mohylevskyy hosudarstvenniy unyversytet prodovol'stvyi»; redkol.: A.V. Akulych (otv. red.) [y dr.]. Mohylev: MHUP; 2017:195.
34. Tkachenko NA, Chaharovskiy OP, Izbash YeO, Kopyko AV. Obgruntuvannya parametriv fermentatsii molochno-rysovykh sumishei yohurtovymy zakvaskamy. Nauk. pratsi ONAKhT. Odesa: ONAKhT. 2016; 80(2):83—90.
  35. Ramazashvili HR, Tkachenko NA, Kruchek OA. Tekhnologiya yogurtovich napoiv zi speltoiu ta yaginy my napovniuvachamy. Materialy mignarodnoii konferentsii «Dni studentskoi nauky u Lvivskomu unyversyteti vetrynarnoi medytsyny ta biotekhnologii im. S.Z. Hgytskogo 11—12 travnia 2017 r. Lviv: LNUVMtaB im. S.Z. Hgytskogo. 2017; 3:102—103.
  36. Tkachenko NA, Kopyko AV. Tekhnologiya kombinovanykh molochno-rysovykh yogurtovich napoiv. Materialy mignarodnoii konferentsii «Dni studentskoi nauky u Lvivskomu unyversyteti vetrynarnoi medytsyny ta biotekhnologii im. S.Z. Hgytskogo 11—12 travnia 2017 r. Lviv: LNUVMtaB im. S.Z. Hgytskogo. 2017; 3:86-88.
  37. Mardar M, Tkachenko N, Lilishentseva A, Burlaka H. Marketing research in positioning and launching of yogurt drinks with a balanced chemical composition. Food Science and Technology. 2016; 10(4):3—8. <http://dx.doi.org/10.15673/ft.v10i4.246>

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## ИННОВАЦИОННЫЕ РЕШЕНИЯ В БИОТЕХНОЛОГИИ КОМБИНИРОВАННЫХ ЙОГУРТНЫХ НАПИТКОВ СО СБАЛАНСИРОВАННЫМ ХИМИЧЕСКИМ СОСТАВОМ

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**Аннотация.** Обоснована целесообразность разработки рецептур и инновационных биотехнологий комбинированных молочно-растительных продуктов со сбалансированным химическим составом, повышенными пробиотическими свойствами и удлиненным сроком хранения для организации адекватного полноценного питания взрослых здоровых людей в повседневном питании и в процессе лечения и реабилитации после ряда заболеваний. Приведены принципы научного подхода к созданию биотехнологий ферментированных комбинированных продуктов со сбалансированным соотношением основных пищевых нутриентов и определены инновационные биотехнологические подходы, которые обеспечивают получение целевых продуктов (йогуртовых напитков) с высокими пробиотическими свойствами и длительным сроком хранения. Описаны основные этапы разработки рецептур и биотехнологии бифидосодержащих комбинированных йогуртовых напитков со сбалансированным химическим составом, высоким содержанием жизнеспособных клеток бифидо- и лактобактерий и длительным сроком хранения. Приведена технологическая схема производства целевых продуктов с детализацией параметров технологического процесса, апробация которой осуществлена в производственных условиях ООО «Гормолзавод №1» (г. Одесса, Украина). Целевые продукты имеют сбалансированное соотношение белков : жиров : углеводов (1 : 1 : 4), высокие сенсорные характеристики, нормированные показатели качества в течение длительного срока хранения (20 суток в герметичной таре), содержат высокую концентрацию жизнеспособных клеток пробиотических культур *B. animalis Bb-12* (не менее  $3,6 \cdot 10^8$  КОЕ/см<sup>3</sup>) и смешанных культур *L. bulgaricus* + *S. thermophilus* (не менее  $4,0 \cdot 10^8$  КОЕ/см<sup>3</sup>), а также физиологически значимое количество пребиотиков – лактулозы и клетчатки (30 и 10 % соответственно от суточной нормы потребления при употреблении 500 см<sup>3</sup> продукта).

**Ключевые слова:** йогуртовый напиток, комбинированный состав сырья, рисовая мука, мука из полбы, сбалансированный химический состав, бифидобактерия, лактобактерия, биотехнология, инновация.

### Список литературы:

1. Зубар, Н.М. Основы физиологии та гігієни харчування: Підручник [Текст] / Н.М. Зубар. – К.: Центр учбової літератури, 2010. – 336 с. ISBN 978-966-364-996-2
2. Mardar, M. QFD – methodology to develop a new health-conducive crain product [Text] / M. Mardar, D. Zhygunov, R. Znachek // Eastern-European Journal of Enterprise Technologies. – 2016. – № 2/11(80). – P. 42 – 47. <http://dx.doi.org/10.15587/1729-4061.2016.65725>
3. Аникина, Е.Н. Проектирование рецептуры и разработка технологии биопродукта с овсяным толокном [Текст] / Е.Н. Аникина, О.В. Пасько, С.А. Коновалов // Аграрный вестник Урала. – № 5 (111). – 2013. – С. 26 – 29.
4. Гаврилова, Н.Б. Биотехнология комбинированных молочных продуктов: монография [Текст]. – Омск: «Вариант-Сибирь», 2004. – 224 с. – ISBN 5-7065-0243-9
5. Ткаченко, Н.А. Комбіновані біфідо-напої зі збалансованим хімічним складом – продукти для здорового харчування [Текст] / Н.А. Ткаченко // Збірник тез доповідей 77 наукової конференції викладачів академії 18–21 квітня 2017 р. – Одеса: ОНАХТ. – С. 110 – 112.
6. Пензина, О.В. Исследование и разработка технологии творожного биопродукта с пшеничными отрубями: дис. ... канд. тех. наук: 05.18.04 [Текст] / Пензина Оксана Валерьевна. – Омск, 2014. – 119 с.
7. Coman, M. Effect of buckwheat flour and oat bran on growth and cell viability of the probiotic strains *Lactobacillus rhamnosus* IMC 501®, *Lactobacillus paracasei* IMC 502® and their combination SYNBIО®, in synbiotic fermented milk [Text] / M. Coman, M. Verdenelli, C. Cecchini et al. // International Journal Of Food Microbiology. – V. 167 (2). – 2013. – P. 261 – 268. <http://dx.doi.org/10.1016/j.ijfoodmicro.2013.09.015>.
8. Sedamawati, Y. Development of corn milk yoghurt using mixed culture of *Lactobacillus delbruekii*, *Streptococcus salivarius*, and *Lactobacillus casei* [Text] / Y. Sedamawati, M. Ayuni // HAYATI Journal of Biosciences. – V. 21 (1). – 2014. – P. 1 – 7. <http://dx.doi.org/10.4308/hjb.21.1.1>
9. Ferreira, S. Infant dairy-cereal mixture for the preparation of a gluten free cream using enzymatically modified rice flour [Text] / S. Ferreira, M. Caliani, M. Soares Júnior, A. Del Pino Beleia // LWT – Food Science And Technology. – V. 59 (2). – 2014. – P. 1033 – 1040.

- <https://doi.org/10.1016/j.lwt.2014.06.047>
10. Casarotti, S. Acidification profile, probiotic in vitro gastrointestinal tolerance and viability in fermented milk with fruit flours [Text] / S. Casarotti, A. Penna // *International Dairy Journal*. – V. 41. – 2015. – P. 1 – 6. <https://doi.org/10.1016/j.idairyj.2014.08.021>
  11. Рудакова, Т.В. Технологія виробів сиркових для дитячого харчування з використанням продуктів переробки зерна [Текст] // *Зернові продукти і комбікорми*. – № 2(58). – 2015. – С. 9 – 14.
  12. Онопрійчук, О.О. Розроблення технології комбінованого молочно-білкового продукту з рослинними інгредієнтами [Текст] / О.О. Онопрійчук, О.В. Грек, С.І. Потапенко // *Таврійський науковий вісник*. – 2006. – № 43. – С. 92 – 100.
  13. Галкина, С.Л. Исследование и разработка технологии творожно-крупяного продукта с пробиотическими свойствами [Текст] / С.Л. Галкина // *Аграрный вестник Урала*. – 2012. – № 8. – С. 45 – 47.
  14. Zare, F. Effect of the addition of pulse ingredients to milk on acid production by probiotic and yoghurt starter cultures [Text] / F. Zare, C.P. Champagne, B.K. Simpson, V. Orsat, J.I. Boye // *LWT – Food Science And Technology*. – V. 45 (2). – 2012. – P. 155 – 160. <https://doi.org/10.1016/j.lwt.2011.08.012>
  15. Забодалова, Л.А. Биотехнология комбинированных молочных продуктов с использованием компонентов сои: дис. ... докт. тех. наук: 05.18.04 [Текст] / Забодалова Людмила Александровна. – Кемерово, 2000. – 233 с.
  16. Dal Bello, V. Healthy yogurt fortified with n-3 fatty acids from vegetable sources [Text] / B. Dal Bello, L. Torri, M. Piochi, G. Zeppa // *Journal of Dairy Science*. – V. 98 (12). – 2015. – P. 8375 – 8385. <https://doi.org/10.3168/jds.2015.9688>.
  17. Некрасов, П.А. Научно-практические основы технологии низкожирного бифидосодержащего спреда со сбалансированным жирнокислотным составом [Текст] / П.А. Некрасов, Н.А. Ткаченко, А.Ю. Касьянова // «Продовольственная безопасность в контексте новых идей и решений» международная научно-практическая конференция. 10 марта 2017 г. – Семей: Государственный университет имени Шакарима, 2017. – Том 2. – С. 329 – 332.
  18. Ткаченко, Н.А. Математичне моделювання компонентного складу комбінованих йогуртових напоїв [Текст] / Н.А. Ткаченко, П.О. Некрасов, А.В. Копійко // *Зернові продукти і комбікорми*. – 2016. – № 1. – С. 20–25.
  19. Підсумки роботи харчової промисловості за 2015 рік [Електронний ресурс]. – Електрон. дан. – 2015. – Режим доступу: <http://minagro.gov.ua/ministry?nid=20612>
  20. The Benefits of Yogurt – Режим доступу: <http://www.webmd.com/food-recipes/benefits-yogurt?pa>
  21. Elli, M. Survival of Yogurt Bacteria in the Human Gut [Text] / M. Elli // *Applied and Environmental Microbiology*. – 2006. – V.72. – №.7. – P. 5113 – 5117.
  22. Ткаченко, Н.А. Оптимізація рецептурного складу напою оздоровчого призначення на основі сироватки [Текст] / Н.А. Ткаченко, П.О. Некрасов, С.І. Вікуль // *Eastem-European Journal of Enterprise Technologies*. – № 1/10 (79). – 2016. – С. 49–57. <http://dx.doi.org/10.15587/1729-4061.2016.59695>
  23. Чагаровський, О.П. Хімія молочної сировини [Текст]: навч. пос. для студ. вищих навч. закладів/ О.П. Чагаровський, Н.А. Ткаченко, Т.А. Лисогор; – Одеса: «Сімекс-прінт», 2013. – 268 с. ISBN 978-966-2601-44-2
  24. Ткаченко, Н. Пробиотичні йогуртові напої зі спельтою — ферментовані молочні продукти нового покоління [Текст] / Н. Ткаченко, О. Кручек, Г. Рамазашвілі // *Матеріали 83 міжнародної наукової конференції молодих учених, аспірантів і студентів “Наукові здобутки молоді – вирішення проблем харчування людства у XXI столітті”*, 5–6 квітня 2017 р. – К.: НУХТ, 2017 р. – Ч.1. – С. 359.
  25. Ткаченко, Н. Оптимізація жирнокислотного складу комбінованих молочно-рисових йогуртових напоїв з гарбузовим наповнювачем [Текст] / Н. Ткаченко, П. Некрасов, А. Копійко // *Матеріали 83 міжнародної наукової конференції молодих учених, аспірантів і студентів “Наукові здобутки молоді – вирішення проблем харчування людства у XXI столітті”*, 5–6 квітня 2017 р. – К.: НУХТ, 2017 р. – Ч.1. – С. 361.
  26. Modelling formulae of strawberry whey drinks of prophylactic application [Text] / N. Tkachenko, P. Nekrasov, S. Vikul, Ya. Honcharuk // *Food Science and Technology*. – 2017. – № 1. – С. 80–88. <http://dx.doi.org/10.15673/fst.v1i1.303>
  27. Шиллер, Г.Г. Гипотетически идеальный жир в продуктах питания здорового человека [Текст] / Г.Г. Шиллер, Г.С. Полякова, М.М. Левачев // *Краткое сообщение XXI Международного молочного конгресса*. – М., 1982. – № 1. – Кн.1. – Т.9. – С. 273–274.
  28. Ткаченко, Н.А. Комбинированные пробиотические напитки со сбалансированным химическим составом: инновационность технологических решений [Текст] / Н.А. Ткаченко, А.П. Чагаровский, А.В. Копейко // «Продовольственная безопасность в контексте новых идей и решений» международная научно-практическая конференция. 10 марта 2017 г. – Семей: Государственный университет имени Шакарима, 2017. – Том 2. – С. 202 – 206.
  29. Biavati, V. Probiotics and Bifidobacteria / V. Biavati, V. Bottazzi, L. Morelli. — Novara (Italy): MOFIN ALCE, 2001. — 79 p.
  30. Дідух\*\*, Н.А. Заквашувальні композиції для виробництва молочних продуктів функціонального призначення [Текст] / Н.А. Дідух\*\*, О.П. Чагаровський, Т.А. Лисогор. – Одеса: Видавництво «Поліграф», 2008. – 236 с. – ISBN 978-966-8788-79-6
  31. Дідух\*\*, Н.А. Обґрунтування параметрів зберігання молочно-зернового геро-кефіру [Текст] / Н.А. Дідух\*\* // *Зернові продукти і комбікорми*. – № 2. – 2009. – С. 47 – 51.
  32. Чагаровський, О.П. Функціональні кисломолочні продукти геродієтичного призначення [Текст] / О.П. Чагаровський, Н.А. Дідух\*\* // *Проблеми старення і доглядання*. – 2011. – № 2, Т. 20. – С. 214 – 222.
  33. Ткаченко, Н.А. Обоснование состава заквасочной композиции для производства бифидосодержащих молочно-рисовых йогуртовых напитков [Текст] / Н.А. Ткаченко, П.А. Некрасов, А.В. Копийко // *Техника и технология пищевых производств: тезисы докладов XI Международной науч.-техн. конференции, 20-21 апреля 2017 г., Могилев / Учреждение образования «Могилевский государственный университет продовольствия»; редкол.: А.В. Акулич (отв. ред.) [и др.]. – Могилев: МГУП, 2017. – С. 195.*
  34. Обґрунтування параметрів ферментації молочно-рисових сумішей йогуртовими заквасками [Текст] / Н.А. Ткаченко, О.П. Чагаровський, Є.О. Ізбаш, А.В. Копійко // *Наук. праці ОНАХТ*. – Вип. 80. – Т.2. – Одеса: ОНАХТ, 2016. – С. 83 – 90.
  35. Рамазашвілі, Г.Р. Технологія йогуртових напоїв зі спельтою та ягідними наповнювачами [Текст] / Г.Р. Рамазашвілі, Н.А. Ткаченко, О.А. Кручек // *Матеріали міжнародної конференції «Дні студентської науки у Львівському університеті ветеринарної медицини та біотехнологій ім. С. З. Гжицького»* 11—12 травня 2017 р. — Львів: ЛНУВМтаБ ім. С.З. Гжицького, 2017 р. – Ч.3. – С. 102 – 103.
  36. Копійко, А.В. Технологія комбінованих молочно-рисових йогуртових напоїв [Текст] / А.В. Копійко, Н.А. Ткаченко // *Матеріали міжнародної конференції «Дні студентської науки у Львівському університеті ветеринарної медицини та біотехнологій ім. С. З. Гжицького»* 11—12 травня 2017 р. — Львів: ЛНУВМтаБ ім. С.З. Гжицького, 2017 р. – Ч.3. – С. 86 – 88.
  37. Marketing research in positioning and launching of yogurt drinks with a balanced chemical composition / M. Mardar, N. Tkachenko, A. Lilishentseva, H. Burlaka // *Food Science and Technology*. – 2016. – V.10, № 4. – P. 3 – 8. <http://dx.doi.org/10.15673/fst.v10i4.246>

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