The effect of prebiotic components on the quality of yogurt

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Abstract. The aim of our study was to study the effect of prebiotic components on the quality indicators of enriched yogurt. Yogurt was produced by fermenting pasteurized normalized milk with yoghurt sourdough, which included lyophilically dried strains of Streptococcus thermophilus, Lactobacillus delbrueckii ssp.bulgaricus, Lactobacillus acidophilus, and Bactidiochemia sulphonideae with the addition of lactobacillus cultivar and yeast lactobacillus complex, in addition, in order to enrich the product with vitamins, minerals and polyphenolic compounds, mashed potatoes from blueberries and dogwood were used. In the course of the study, we evaluated organoleptic, physicochemical and microbiological indicators, carried out a comparative analysis of the content of vitamins and trace elements in a traditional and enriched product. It was established that enrichment of yogurt with a prebiotic complex and fruit and berry puree contributed to the improvement of quality indicators, due to an increase in nutritional value, an increase in the content of vitamins (C, B1, B2, E and PP) and microelements (Ca, K, Mg, P, Fe). The prebiotic properties and immunogenic effects of wheat bran and yeast cell wall components, as well as the polyphenolic compounds of blueberries and cornel berries, make it possible to use yogurt as an adaptogenic product with probiotic, prebiotic neuroprotective, cardioprotective, antioxidant, immunomodulating and anti-inflammatory properties.

1. The relevance of the study
The microbiome of the gastrointestinal tract is colonized by various groups of microorganisms. With optimal functioning, it is actively involved in the metabolism of nutrients, energy homeostasis and regulates immune responses, protecting the digestive tract from harmful foodborne pathogens [1]. Global environmental pollution with various chemicals, their deliberate introduction into food, and the irrational use of antibiotics leads to a change in the quantitative and qualitative composition of the intestinal microflora, with the subsequent development of metabolic and immunological disorders - dysbiosis.

We set the task to develop bio-yogurt with pronounced pro- and prebiotic effects. When choosing the prebiotic component, of particular interest to us was the complex, which includes wheat bran and an inactivated treatment culture of the yeast Saccharomyces cerevisiae (vini). To enrich yogurt with minor biologically active substances, mashed potatoes from blueberries and cornel fruit were used. Prebiotics are selectively fermented non-digestible nutritional food ingredients that do not have nutritional value, but are capable of stimulating growth and enhancing the metabolic activity of normal
intestinal microbiocenosis [2]. Wheat bran bran shells contain arabinoxylanoglucuronxyl (64%), cellulose (29%), non-cellulose glucan (6%), lignin (8.3%) and protein (9.2%). Fiber carbohydrates in the large intestine undergo bacterial fermentation resulting in the formation of short-chain fatty acids (mainly acetic, butyric and propionic) [3]. In addition to the widely studied biological effects of prebiotics, one should note data on the interaction of the microbiome – intestine – brain axis obtained as a result of studying the dependence of shifts in the composition of the intestinal microbiota with central nervous disorders of an autistic nature, anxiety-depressive behavior, and functional gastrointestinal disorders [4]. Influencing the composition of microbiota, prebiotics are protectors of numerous diseases (irritable bowel syndrome, asthma, allergies, metabolic syndrome, type 2 diabetes, obesity, cardiovascular disease and colorectal cancer) [5, 6].

The most important component of the prebiotic complex is the inactivated treatment culture of the yeast Saccharomyces cerevisiae (vini). The composition of the membranes of yeast cells is represented by oligosaccharides - mannan, glucan and glycogen-like component. Mannan is resistant to hydrolysis by digestive enzymes. The studied properties of mannan include anti-inflammatory and immunomodulatory. Thus, the use of mannan in diets for two weeks led to a decrease in macrophage secretion of pro-inflammatory TNF-α cytokines and an increase in the secretion of anti-inflammatory IL-10 cytokines in response to ex vivo stimulation with lipopolysaccharide [7, 8]. Yeast beta-glucans also act as stimulants of the immune response. The cytoplasm of yeast cells contains amino acids, enzymes, ubiquinone, micro and macro elements, vitamins A, D3, E, C, group B.

Blueberries and cornel fruits are sources of phytochemical compounds, polyphenols with high biological activity, including flavonoids, derivatives of hydroxycinnamic and hydroxybenzoic acids, anthocyanins and procyanidins. These polyphenolic compounds exhibit a wide range of biological effects, including antibacterial, anti-inflammatory, anti-allergic anti-atherosclerotic and antithrombotic effects [9, 10].

2. Materials and research methods

Yogurt was produced by fermenting pasteurized normalized milk with yoghurt sourdough, which included lyophilized strains of Streptococcus thermophilus, Lactobacillus delbrueckii ssp.bulgarius, Lactobacillus acidophilus, Bifidobacterium lactis and lactic acid producer (LLC manufacturer NPK BIK LLC, St. Petersburg) at the stage of fermentation of the mixture, at a concentration of 1%, previously dissolved in milk at 38 ... 420°C. The fermented mixture is poured into consumer packaging with a layer of mashed blueberry and dogwood puree already added in an amount of 10% of the total product weight.

The objects of research were samples of yogurt without additives (control) and yogurt with a prebiotic complex (experience). The quality of the fruit and berry puree was separately evaluated, since the product is two-layer. The main research methods: organoleptic, titrimetric (determination of titratable acidity), high performance liquid chromatography. Statistical analysis of the data was carried out using the program Statistica 6.0. To assess the differences between the average values in the comparison groups, Student t-test was used with an error probability of p<0.05.

3. The results of the study

Organoleptic, physico-chemical and microbiological indicators of enriched yogurt are shown in tables 1, 2.

| Table 1. Organoleptic indicators of yogurt. |
|------------------------------------------|
| Name of indicator | Characteristic |
| Appearance and consistency | Homogeneous, with an undisturbed clot, creamy, inclusions of insoluble particles of the prebiotic complex are present. Sour milk, with a slightly perceptible specific smell of the prebiotic complex, moderately sweet taste |
| Taste and smell | Homogeneous, with an undisturbed clot, creamy, inclusions of insoluble particles of the prebiotic complex are present. |
Sour milk, with a slightly perceptible specific smell of the prebiotic complex, moderately sweet taste

Colour
Milky white, with brown spots of insoluble particles of the prebiotic complex

Table 2. Physico-chemical and microbiological indicators of yogurt.

| Name of indicator                                      | Indicator value          |
|--------------------------------------------------------|--------------------------|
| Physical and chemical indicators                       |                          |
| Mass fraction of fat, %                                | 0.5±0.001                |
| Mass fraction of protein, %                            | 3.2±0.1                  |
| Mass fraction of dry skim milk residue (COMO),%         | 9.5±0.1                  |
| Titratable acidity, °T                                  | 90-130                   |
| Storage temperature, °C                                 | 4±2                      |
| Microbiological indicators                             |                          |
| The number of lactic acid microorganisms at the end of  | Not less 1*10⁷            |
| the expiration date, CFU / cm³ (gr)                    |                          |
| Product mass, cm³ (gr), which is not allowed           |                          |
| BGKP (coliforms)                                       | 0.1                      |
| Staphylococcus S.aureus Pathogenic, including salmonella| 1.0                      |
| BGKP (coliforms)                                       | 25                       |
| Staphylococcus S.aureus Pathogenic, including salmonella|                          |

From the presented data it can be seen that the developed product meets the standards of the Technical Regulation of the Customs Union "On the safety of milk and dairy products" (TR TS 033/2013) and GOST 31981-2013 "Yoghurts. General technical conditions ", safe for use, and also has high quality indicators.

The data presented in the tables indicate that the developed yogurt has a sufficiently high nutritional value and is safe for consumption, which confirms its physiological value.

One of the components of the product is a layer of mashed potatoes made from blueberries and cornel fruit; this component was used to enrich yogurt with minerals and vitamins. Organoleptic and physico-chemical characteristics of mashed potatoes from blueberries and cornel fruit are presented in tables 3 and 4.

Table 3. Organoleptic characteristics of mashed potatoes.

| Name of indicator    | Characteristic                                                                 |
|----------------------|-------------------------------------------------------------------------------|
| Taste and smell      | Well-defined, close to natural, characteristic of blueberries and others      |
| Appearance and consistency | A puree, thick, slightly flowing mass. The presence of single blueberry seeds |
| Colour               | Homogeneous throughout the mass, dark red                                    |

Table 4. Physico-chemical characteristics of mashed potatoes.

| Name of indicator | Indicator value |
|-------------------|-----------------|
|                   |                 |
In fact

| Mass fraction of ethyl alcohol, % | 0.12 | Not more 0.2 |
| Mass fraction of mineral impurities, % | Not detected | Not allowed |
| Foreign matter | Not detected | Not allowed |
| Mass fraction of soluble solids, % | 11.5 | No less 9.0 |
| Mass fraction of titratable acids, % | 1.27 | No less |

During the research it was found that puree from blueberries and cornel fruit in terms of safety and quality meets the requirements of SanPiN 2.3.2.1078-01 "Hygienic requirements for safety and nutritional value of food" and GOST 32742 "Semi-finished products. Canned fruit and vegetable purees aseptically. Technical conditions. " The vitamin composition of enriched yogurt, with pre-mixed layers, was determined at the end of the expected shelf life (table 5).

Table 5. Vitamin composition of enriched yogurt, mg / 100g.

| Name of indicator | Control | Fortified yogurt |
|-------------------|---------|------------------|
| Vitamin С        | 0.6±0.012 | 3.15±0.014 |
| Vitamin В₁       | 0.04±0.021 | 0.0413±0.024 |
| Vitamin В₂       | 0.02±0.003 | 0.022±0.0031 |
| Vitamin E        | -       | 0.07±0.0021 |
| Vitamin PP       | 0.2±0.029 | 0.229±0.002 |

Analyzing the vitamin composition of enriched yogurt, it should be noted that, compared with the control sample, the vitamin content in the enriched product increased: vitamin C by 2.55 mg / 100g; vitamin B1 per 0.0013 mg / 100g; vitamin B2 per 0.002 mg / 100g; vitamin E at 0.07 mg / 100g; vitamin PP at 0.029 mg / 100g.

Ascorbic acid stimulates the formation of steroid hormones of the adrenal cortex, participates in the formation of collagen in the connective tissue, improves the absorption of iron, affects the metabolism of sulfur. The antitumor and antiviral activity of ascorbic acid derivatives, which have selective and potent antiproliferative activity against breast cancer cells and colorectal cancer, as well as specific anticytomegalovirus potential and non-specific activity against chickenpox, is relevant [11]. We noted a significant increase in the content of vitamin C (5.25 times) in the enriched product.

B vitamins are important in the functioning of cells, acting as coenzymes in a wide range of catabolic and anabolic enzymatic reactions. Their collective effects are especially common in many aspects of brain functioning, including energy production, DNA and RNA synthesis, genomic and non-genomic methylation, as well as the synthesis of numerous neurochemical substances and signaling molecules [12]. Niacin (acid PP) helps prevent cardiovascular diseases, stabilizes blood cholesterol, performs an energy function, and participates in the regulation of hormonal levels.

The results of the evaluation of the mineral composition of the products are presented in table 6.

Table 6. The mineral composition of enriched yogurt, mg / 100g

| Name of indicator | Control     | Fortified yogurt |
|-------------------|-------------|------------------|
| Potassium, K      | 147.01±1.5  | 153.11±1.1 |
| Calcium, Ca       | 122.14±0.9  | 125.7±1.7 |
| Magnesium, Mg     | 15.05±0.3   | 16.50±0.2 |
| Sodium, Na        | 52.02±1,1   | 53.6±0.9 |
| Phosphorus, Ph    | 96.13±1.12  | 97.7±1.1 |
| Iron, Fe          | 0.1±0.001   | 0.335±0.01 |
The main part of phosphorus (P), like Ca, is located in the skeleton (80%), and only about 10% - in the skeletal muscles and internal organs. Only a small fraction of P is inorganic and can be used for the synthesis of adenosine triphosphate. Violations of the calcium-phosphorus balance lead to a change in the serum levels of parathyroid hormone, calcitonin, calcitriol and are accompanied by the development of bone pathology and ectopic calcification of blood vessels and soft tissues, as well as a violation of neuromuscular excitation, blood coagulation, permeability of cell membranes, and the activity of a number of enzymes [13]. The introduction of plant enrichment components contributed to an increase in phosphorus content of 1.7 mg / 100g. and calcium at 3.7 mg / 100 g.

We found an increase in the magnesium content in the product by 1.45 mg / 100g. Magnesium is a macromolecule that takes part in 300 enzymatic reactions. Mg plays an important role in the physiological function of the brain, heart, and skeletal muscle. Mg has anti-inflammatory properties and acts as a Ca antagonist. Mg deficiency increases the secretion of pro-inflammatory cytokines, such as tumor necrosis factor (TNF)-α, interleukin (IL)-1β, which were involved in increased osteoclastic bone resorption [14]. Neuronal concentrations of Mg are of great importance in regulating the excitability of N-methyl-d-aspartate receptors (NMDA). NMDA receptors are necessary for exciting synaptic transmission, neural plasticity, and excitotoxicity and therefore play an important role in the development of cognitive functions [15].

Iron provides oxygen transport (part of hemoglobin), provides electron transport in the redox reactions of the body (part of cytochromes and iron-seroproteins). Iron plays a fundamental role in the functioning of mitochondria and various enzymatic functions. Given the high energy demand of the heart, iron deficiency has a particularly negative effect on heart function and worsens heart failure [16]. The iron content in the enriched product has more than tripled.

4. Conclusion
It was established that the enrichment of yogurt with a prebiotic complex and fruit and berry puree contributed to an increase in the quality indicators of the product, due to an increase in nutritional value, an increase in the content of vitamins and microelements. The prebiotic properties and immunogenic effects of wheat bran and yeast cell wall components, as well as the polyphenolic compounds of blueberries and cornel fruits, make it possible to use yogurt as an adaptogenic product with probiotic, prebiotic, neuroprotective, cardioprotective, antioxidant, immunomodulating and anti-inflammatory properties.

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