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DEVELOPMENT OF YOGURT BASED ON LACTOSE-FREE MILK WITH A FUNCTIONAL BIOACTIVE COMPOUND

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Abstract. In recent years, the problem of creating functional food products has been developed in the form of scientific developments, which makes it possible to create modern products of purposeful action and high biological value. The purpose of this study was to develop a technology for the production of yogurt based on lactose-free milk, and a vegetable component (sodium alginate extract obtained with the variability of ultrasonic processing power) to ensure the functional characteristics of the product. As part of the study, 6 yogurt samples were prepared. In the studied samples, such indicators as active and titrated acidity, syneresis (0.5, 1, 1.5 hours), viscosity, determination of the mass fraction of kefiran (exopolysaccharide) were evaluated. All the prepared samples had an undisturbed clot, and a slight separation of serum was found on the surface. This technology and formulation is promising for the formation of a new yogurt to ensure the health of the population. With an increase in the fat content of milk used for the preparation of yogurt samples, an increase in the content of kefiran exopolysaccharide is observed. The highest content of kefiran exopolysaccharide was found in sample 1 yogurt prepared on the basis of milk of 3.5 % fat content with the addition of sodium alginate extract No. 1. The content in 1 g of yogurt (sample 1) EPS kefiran is 174.52 g. This technology and formulation is promising for the formation of a new yogurt to ensure public health.

Keywords**:** yogurt, lactose-free milk, functional products, sodium alginate

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РАЗРАБОТКА ЙОГУРТА НА ОСНОВЕ БЕЗЛАКТОЗНОГО МОЛОКА С ФУНКЦИОНАЛЬНЫМ БИОАКТИВНЫМ СОЕДИНЕНИЕМ

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Аннотация. В последние годы проблема создания функциональных продуктов питания получила развитие в виде научных разработок, что позволяет создавать современные продукты целенаправленного действия и высокой биологической ценности. Целью данного исследования была разработка технологии производства йогурта на основе молока, не содержащего лактозы, и растительного компонента (экстракт альгината натрия, полученный с варьированием мощности ультразвуковой обработки) для обеспечения функциональных характеристик продукта. В рамках исследования было приготовлено 6 образцов йогурта. В исследуемых образцах оценивались такие показатели, как активная и титруемая кислотность, синерезис (0,5; 1; 1,5 часа), вязкость, определение массовой доли кефирана (экзополисахарида). Все подготовленные образцы имели неповрежденный сгусток, и на поверхности было обнаружено небольшое отделение сыворотки. Эта технология и рецептура перспективны для создания нового йогурта, обеспечивающего здоровье населения. При увеличении жирности молока, используемого для приготовления образцов йогурта, наблюдается увеличение содержания экзополисахарида кефирана. Наибольшее содержание экзополисахарида кефирана было обнаружено в йогурте образца 1, приготовленном на основе молока 3,5 % жирности с добавлением экстракта альгината натрия № 1. Содержание в 1 г йогурта (образец 1) EPS kefiran составляет 174,52 г. Эта технология и рецептура являются многообещающими для создания нового йогурта для обеспечения общественного здравоохранения.

Ключевые слова: йогурт, безлактозное молоко, функциональные продукты, альгинат натрия

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Introduction

Milk has been loved by people all over the world since ancient times, and it is also one of the four main drinks. Milk and its products are one of the important sources of protein, calcium, phosphorus, vitamin A, vitamin D and vitamin B2 in the diet. Fresh milk is a complex milk colloid consisting mainly of water, fat, protein, lactose, minerals, vitamins, etc., with a moisture content of 86 % to 90 %. Daily consumption of milk can supplement the body with protein and various trace elements, which has a beneficial effect on physical health. However, approximately 70 % of the world's population is at high risk of lactose intolerance, characterized by diarrhea, bloating in the gastrointestinal tract and abdominal pain immediately after taking lactose. The proportion of people with impaired lactose digestion varies by country and region: from 98 % to 100 % in Southeast Asia and up to 1 % in the Netherlands. However, lactose-free dairy products are currently enjoying wide and growing popularity for the health of all consumers and countries where the majority of the population suffers from lactose intolerance. Lactose-free dairy products can provide essential nutrients to milk for patients with lactose intolerance. There are many dairy products that contain little or no lactose, and people with lactose intolerance usually tolerate this lactose well, so it is necessary to produce dairy products with a low lactose content [4].

Since milk is rich in lactose, lactose is a disaccharide, the decomposition of which requires lactase secreted by the body. Most adults may lose the human function of breaking down lactose as they get older. Mammalian larvae naturally produce lactase, but lactase secretion gradually decreases or stops after the age of three. People with lactose intolerance currently do not need to completely abandon dairy products and their nutritional value [11]. A very good solution depends on the hydrolysis of lactose to glucose and galactose by lactase. These monosaccharides are easily absorbed by the small intestine, preventing the occurrence of symptoms of lactose intolerance. There are currently two different types of lactase on the market: neutral lactase and acid lactase. Neutral lactase is mainly used in the production of lactose-free dairy products on an industrial scale, although in some countries this enzyme is also provided to consumers for processing milk at home. Acid lactase is offered to consumers as a dietary supplement that can be taken together with conventional dairy products, and which plays an important role in the decomposition of lactose in the stomach [14].

In the food industry, there are many ways to produce lactose-free milk, such as enzymes used to produce lactose-free dairy products, which are traditionally neutral β-galactosidase obtained from the milk yeast Kluyveromyces lactis. Use lactase to break down lactose in milk and other dairy products to get lactose-free milk. Ting Qi and others used ceramic membrane technology to filter and rapidly remove lactose 4 from milk. Using these technologies, it is possible to produce lactose-free milk, which can also be consumed by people with lactose intolerance [13].

Yogurt is a fermented milk product obtained by mixing specific fermenting agents Streptococcus thermophilus and Lactobacillus bulgaricus. Historical evidence shows that yogurt has been used for food for at least 4,500 years. The earliest yogurt may be the milk of nomads in sheepskin bags, which was naturally fermented by bacteria attached to the bags and turned into cheese. The live ingredients of Streptococcus thermophilus and Lactobacillus bulgaricus contained in yogurt are beneficial to human health. In addition, the consumption of yogurt is also associated with beneficial health properties, such as strengthening the immune response, cancer prevention and lowering cholesterol levels [15].

Although yogurt contains about 30 % less lactose than milk, at certain levels of lactose malabsorption it is still considered high.

Thus, there is no obvious difference in color, taste, smell, etc. between low-lactose yogurt made from dairy products processed by enzymatic hydrolysis and regular yogurt. When (neutral) lactase and yogurt culture are added to milk at the same time, there is only a limited time left for lactose digestion. Most of the neutral lactase is completely inactivated at pH < 5.5, which is achieved after incubation for 2.5–3 hours during the production of regular yogurt. Therefore, the lactase dosage should be relatively high to obtain a lactose-free state.

Lactose is usually a carbohydrate derived from whey, and also has the highest content by weight in dry dairy products. Lactose is a disaccharide and reducing sugar that, under certain conditions, can freely react with various amino acids in proteins.

Due to the fact that the milk of most mammals contains lactose, it is reasonable to assume that lactose or its constituent monosaccharides have a certain nutritional value. Lactose is not digested and is not absorbed in the human stomach and can directly enter the intestines. Lactose is easily decomposed into glucose and galactose by lactase in the human gastrointestinal tract for absorption. Galactose is a component of glycolipids, which make up the brain and nervous tissue, which is very important for the intellectual development of infants. This may contribute to the production of galactose cerebrosides and mucopolysaccharides. Lactose can promote the reproduction of certain lactic acid bacteria in the human intestine, inhibit the growth of bacteria that cause spoilage, and promote intestinal peristalsis. Due to the favorable absorption of calcium and other substances due to the production of lactic acid, this can prevent the occurrence of rickets [16].

Polysaccharides are natural macromolecular polymers, which usually consist of more than 10 monosaccharides connected by a glycoside bond with a straight chain or branched chain, with a molecular weight of tens of thousands or even millions [12]. It is widely present in plants, microorganisms, algae and animals. Like proteins and polynucleotides, polysaccharides are irreplaceable macromolecular substances in vital activity and play an important role in intercellular communication, cell adhesion and molecular recognition in the immune system [10, 17].

In recent years, polysaccharides isolated from natural resources, such as plants, animals, fungi and seaweed, have received increasing attention due to their extensive pharmacological activity, such as antitumor, immunoregulatory, antioxidant and anti-inflammatory effects.

In the process of yogurt production, stabilizers are often added in the production process to preserve its stability and physico-chemical properties, as well as to prevent shrinkage and dehydration of yogurt. Among the stabilizers used, gelatin has become the preferred choice due to its unique characteristics.

Polysaccharides, as one of the new projects developed in recent years, not only have a wide range of physical and chemical functions and properties, but are also used in various industries. In fermented milk products, polysaccharides have the ability to maintain their stability, and various polysaccharides can also give yogurt different functions. The use of polysaccharides instead of lactose in milk for milk fermentation allows you to maintain the stability of yogurt and increase its functionality. However, there is currently little research on the use of polysaccharides instead of lactose fermentation, and there are many unknown parameters that need to be determined [5, 7, 8, 9].

The main purpose of the study is to develop a technology for the production of yogurt based on lactose – free milk, and a vegetable component (sodium alginate extract obtained with the variability of ultrasonic processing power) to ensure the functional properties of the product.

Objects and methods of research

To prepare yogurt based on lactose-free milk with a functional orientation, three types of milk with fat content concentrations were used: 0.05 %, 1.8 % and 3.5 %. The study used sodium alginate, which is a water-soluble salt of alginic acid, found naturally in all types of brown algae. Sodium alginate contains a mixture of two uronic acids, (1-4)–bound β-D-mannuronic acid and (1-4)–bound α-L-guluronic acid. To enrich the future yoghurts, aqueous extracts of sodium alginate obtained by ultrasound were prepared. The ultrasonic technological device "Wave" model UZTA was used as an acoustic source of elastic vibrations-0,4/22- OM. The principle of operation is based on the use of the properties of high-intensity ultrasonic vibrations in liquid and liquid-dispersed media.

The main characteristics of the obtained aqueous extracts of sodium alginate:

1. 0.1 % sodium alginate extract was obtained by ultrasonic treatment of a suspension with a duration of 15 minutes and an output power of 50 W/cm2 from the partial passport value. The antioxidant activity of sodium alginate was 33.7 % with a particle size of 259 nm.

2. 0.1 % sodium alginate extract was obtained by ultrasonic treatment of a suspension with a duration of 15 minutes and an output power of 75 W/cm2 from the partial passport value. The antioxidant activity of sodium alginate was 34.2 % with a particle size of 170.5 nm.

Technology of preparation of yogurt samples based on lactose-free milk: to 150 ml of milk of 0.05 %, 1.8 % and 3.5 % fat content, 5 ml of aqueous extract of sodium alginate and 3 ml of sourdough were added, fermented (fermented) at room temperature for 20 hours [1, 3].

Description of the studied samples:

Sample 1 – Yogurt prepared based on milk of 3.5 % fat content with the addition of sodium alginate extract No. 1;

Sample 2 – Yogurt prepared on the basis of milk of 1.8 % fat content with the addition of sodium alginate extract No. 1;

Sample 3 – Yogurt prepared based on milk of 0.05 % fat content with the addition of sodium alginate extract No. 1;

Sample 4 – Yogurt prepared based on milk of 3.5 % fat content with the addition of sodium alginate extract No. 2;

Sample 5 – Yogurt prepared based on milk of 1.8 % fat content with the addition of sodium alginate extract No. 2;

Sample 6 – Yogurt prepared based on milk of 0.05 % fat content with the addition of sodium alginate extract No. 2;

Control 1 – Yogurt prepared based on milk of 3.5 % fat without extract.

Control 2 – Yogurt prepared based on milk of 1.8 % fat without extract.

Control 3 – Yogurt prepared based on milk of 0.05 % fat without extract.

After fermentation, the following parameters were determined: active and titrated acidity, syneresis (0.5, 1, 1.5 hours), viscosity, determination of the mass fraction of kefiran (exopolysaccharide) in the obtained samples.

Results and their discussion

At the first stage of the study, physico-chemical parameters were evaluated in samples of yogurt based on lactose-free milk with the addition of aqueous extracts of sodium alginate obtained by ultrasound. The research was carried out in order to identify the effect of the additive (sodium alginate extract) in lactose-free milk of different fat content on the fermentation process and the functional and consumer properties of yogurt. All the yogurt samples had an undisturbed clot, and a slight separation of serum was found on the surface. The results of the study of the physico-chemical parameters of yogurt samples are presented in Table 1.

Based on the data presented in Table 1, we can say that the active acidity of yogurt samples is in the aisles from 4.1 to 4.2. While the norm of active acidity of classic yogurt without added sugar is from 4.5 to 5. The active acidity of yogurt samples is lower than that of the declared norm. These changes may be related to the introduced extracts of sodium alginate. The highest titrated acidity was found in sample 2 of yogurt produced on the basis of milk of 1.8 % fat content with the addition of sodium alginate extract No. 1 (the ultrasonic exposure power was 50 W/cm2). Low titratable acidity was found in sample 5 of yogurt prepared on the basis of milk of 1.8 % fat content with the addition of sodium alginate extract №. 2 (ultrasonic exposure power was 75 W/cm^2). The acidity of all samples is higher than the stated norm, which ranges from 75 °T to 140 °T. These changes could be caused by the alginate introduced into the composition of the aqueous extraction.

Next, the syneresis indicator was evaluated, that is, this spontaneous separation of serum from the clot. It is worth noting that the isolation of whey is a consequence of the unsatisfactory quality of raw materials, deviations from the normal regime of homogenization and pasteurization of milk.

The largest amount of serum isolated in 1.5 hours was observed in sample 3 yogurt prepared on the basis of milk of 0.05 % fat content with the addition of sodium alginate extract №. 1. The lowest synuresis index in 1.5 hours was detected in sample 1 yogurt prepared on the basis of milk of 3.5 % fat content with the addition of sodium alginate extract №. 1. Judging by the data, the degree of synthesis of all samples increases over time.

Studies of the viscosity of yogurt samples were carried out using a vibroviscosimeter, model SV-10. High viscosity is observed in sample 6 of yogurt obtained on the basis of milk of 0.05 % fat content with the addition of sodium alginate extract №. 2 and is 1811 mpa.s. A low viscosity index was detected in sample 1. The viscosity of the clots formed during fermentation using sodium alginate extract is slightly higher compared to the control sample, which correlates with data from previous studies. These changes in viscosity may be due to the fact that different extracts and different fat concentrations have different effects on the formation of the protein mesh structure of yogurt.

One of the important consumer properties of yogurt based on lactose-free milk with the addition of aqueous extracts of sodium alginate is the accumulation of BAS exopolysaccharide (EPS) kefiran in it. It is a water-soluble exopoly-

Table 1

Physico-chemical parameters of yogurt samples

Name of the ample	pH	Titratable acidity	Degree of syneresis			Viscosity/mpa·s
			0.5 h/ml	1 hour/ml	1.5 hours/ml	
Sample 1	4.1	190	13	18.5	21	75.1
Sample 2	4.1	202	18	24	27	61.5
Sample 3	4.2	184	22	29.5	30	157
Sample 4	4.2	192	14	21	24	74.3
Sample 5	4.1	180	17	22.5	25	1330
Sample 6	4.1	186	22	27.5	29	1811
Control 1	3.9	191	17	22	24.5	142
Control 2	4	173	19	24	26	163
Control 3	4.1	187	20	26.5	27.5	188

saccharide produced by Lactobacillus kefiranofaciens, L. kefirgranum, L. parakefir, L. kefir and L. delbrueckii subsp. bulgaricus. It has antitumor, immunomodulatory, anti-inflammatory, anti-asthmatic wound healing effect. The results of the study of the mass fraction of EPS kefiran on the example of yogurt samples with the addition of aqueous extract of sodium alginate №. 1 are presented in Table 2.

Table 2

The content of EPS kefiran in yogurt samples

Name of the sample	EPS kefiran content/μg	Ccontent of EPS kefiran in 1 g
Sample 1	69.81	174.52
Sample 2	69.53	174.46
Sample 3	69.37	173.41
Control 1	68.79	179.47
Control 2	68.77	167.93
Control 3	68.51	173.77

With an increase in the fat content of milk used for the preparation of yogurt samples, an increase in the content of EPS kefiran is observed. The highest content of EPS kefiran was found in sample 1 yogurt prepared based on milk of 3.5 % fat content with the addition of sodium alginate extract № 1. The content in 1 g of yogurt (sample 1) EPS kefiran is 174.52 g. The increase in kefiran was similar to control samples [2, 4, 6, 10].

Conclusions based on the results of the work

Thus, the results of the study suggest the possibility of obtaining yogurt based on lactose-free milk with the addition of aqueous extracts of sodium alginate with an increased content of EPS kefiran. All the prepared samples had an undisturbed clot, and a slight separation of serum was found on the surface. This technology and formulation are promising for the formation of a new yogurt to ensure the health of the population.

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