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Исследование возможности применения биологически активных компонентов в технологии йогурта

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Аннотация. Обоснована актуальность использования функциональных ингредиентов в технологии йогурта. Исследованы физико-химические и органолептические показатели образцов йогурта с добавлением витамина С и рутина. Для оптимизации рецептуры йогурта экспериментально обоснован выбор вкусо-ароматических наполнителей. Получены органолептические профили опытных образцов йогурта с добавлением наполнителей. В результате всех проведенных экспериментов для создания трехслойного молочного десерта был выбран образец йогурта с внесением 5 % закваски, функциональным наполнителем в количестве витамин С и рутин 50:50. Для улучшения органолептических свойств и дальнейшего сочетания в десерте были выбраны смесь подсластителей в количестве 3 % и вкусо-ароматический наполнитель «Банан» – 0,3 %. Результаты исследований подтвердили возможность использования йогурта, обогащенного витамином С и рутином, для изготовления трехслойного молочного десерта.
Ключевые слова: биойогурт, аскорбиновая кислота, рутин, заквасочная культура, биологически активная добавка, кисломолочный продукт с функциональными свойствами.
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Research article

Study of the possibility of using biologically active components in yogurt technology

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Abstract. The relevance of using functional ingredients in yogurt technology is substantiated. The physicochemical and organoleptic properties of yogurt samples with added vitamin C and rutin were studied. To optimize the yogurt recipe, the choice of flavor fillers was experimentally substantiated. Organoleptic profiles of experimental yogurt samples with the addition of fillers were obtained. Based on all the experiments, a yogurt sample with a 5% starter culture and a functional filler in the amount of vitamin C and rutin in a 50:50 ratio was selected for the creation of a three-layer milk dessert. A mixture of sweeteners at a level of 3% and a flavor filler "Banana" at 0.3% were selected to improve the organoleptic properties and further combination in the dessert. Results of research proved the feasibility of using yogurt enriched with vitamin C and rutin for the production of a three-layer dairy dessert.
Keywords: bioyogurt, ascorbic acid, rutin, starter culture, dietary supplement, fermented milk product with functional properties.
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Introduction. Our modern understanding of nutrition and the establishment of physiological norms for energy and nutrient intake are the result of the comprehensive work of specialists from numerous disciplines, including nutritionists, biochemists, microbiologists, and technologists. Furthermore, new scientific fields such as nutrigenomics, nutrigenetics, nutrimetabolomics, and proteomics are rapidly developing, exploring the molecular mechanisms of food component transformation at the gene level. A modern, balanced diet ensures normal growth and development of children, promotes disease prevention, prolongs life, and creates conditions for enhancing the body's ability to withstand adverse environmental influences.

Experts emphasize the particular importance of enriching food products with antioxidants, vitamin and mineral premixes, and food sources rich in biologically and physiologically active substances, the deficiency of which leads to a disruption of nutritional status, and insufficient consumption of vitamins and vitamin-like substances reduces a person’s adaptive potential and is a risk factor for the development of many alimentary-dependent diseases.

Among the huge variety of food products, the most valuable in nutritional and biological terms are milk and dairy products, the value of which is determined by the rich and balanced composition of its components and the high digestibility of all nutrients [4, 7, 8].

Fermented milk products, including yogurts, occupy a leading position in dietary and therapeutic nutrition due to their functional properties. They contain all the components of milk in a more digestible form. The Russian yogurt market is constantly growing, with consumer interest in fortified and functional yogurts growing [9].

Today, yogurt is far from being the end product it was 10-15 years ago. It has become the foundation, the starting point of a world of possibilities.

Yogurt is produced as a delicious fruit-flavored product, a carbonated drink, and a healthy breakfast containing muesli and vitamins. It's also used to make ice cream, and even yogurt butter has emerged. Not only is the number of yogurt products increasing, but their quality is also improving.

To enhance the nutritional value and functional properties of yogurts, various fillers and additives are added to their composition, particularly those that enhance their therapeutic and prophylactic effects. The use of fiber-rich food additives and fillers, such as pectins, microcrystalline cellulose (MCC), plant gums, and vegetable and fruit additives, helps impart additional functional properties to yogurts [3].

To enhance the functional properties of yogurts, various components are added to enhance their preventative effects [5]. The use of food additives containing vitamins, bioflavonoids, and antioxidants allows yogurts to acquire additional functional properties.

The modern diversity of functional components used in yogurt production offers vast opportunities for creating a wide range of yogurts with balanced compositions, as well as products with targeted functional uses. The food ingredients industry has opened up virtually unlimited opportunities for dairy product manufacturers with new consumer properties—nutrition value, balanced composition, taste, aroma, texture, shelf life, and therapeutic and dietary properties.

In recent years, interest in functional foods enriched with biologically active components capable of positively impacting human health has grown significantly. Fermented milk products, particularly yogurt, occupy a special place in this category. Due to its probiotic properties and high nutritional value, yogurt serves as an ideal base for the introduction of additional functional ingredients [2, 6].

Developing new types of probiotic fermented milk products with enhanced functional properties is a pressing issue, given their significant share of the healthy food market. One promising area is the incorporation of biologically active substances, such as antioxidants, into formulas, which not only support the microbiome but also promote overall health. The use of ascorbic acid (vitamin C) and rutin (vitamin P) allows for the creation of fortified fermented milk drinks that can meet the daily requirement for these vitamins and impart additional beneficial properties, including pronounced antioxidant activity.

Materials and methods. Cow's milk with a fat content of 2.5% and yogurt starter were used to produce the yogurt. Functional filler:

- Ascorbic acid, powder. A non-enzymatic antioxidant, it activates the biosynthesis of corticoid hormones responsible for the body's adaptive responses, providing an anti-stress effect. It inhibits lipid peroxidation, which is associated with its membrane-stabilizing effect. It also strengthens capillaries, which is realized through the fact that vitamin C significantly influences the formation of collagen fibers in blood vessels, skin, bone tissue, and teeth. It promotes iron absorption and normalizes hematopoiesis, participates in oxidation-reduction reactions, and supports the functioning of the immune system. The recommended daily intake for adults is 100 mg. The recommended daily intake for children is 30 to 90 mg.
- Rutin powder. Rutin, like other bioflavonoids, strengthens capillary walls (increases resistance) and reduces capillary permeability. Its antioxidant properties play a significant role in its mechanism of action, particularly its ability to inhibit free-radical lipid peroxidation, which helps reduce the risk of cardiovascular disease and cancer, as well as its radioprotective properties.

Bioflavonoids potentiate and enhance the effects of vitamin C. The combined effect of rutin and vitamin C enhances the capillary-strengthening effect.

The adequate intake level of flavonols and their glycosides for adults is 30 mg calculated as rutin. The upper tolerable level of flavonols and their glycosides for adults is 100 mg per day calculated as rutin.

The following research methods were used during the experiments:

- Determination of titratable acidity according to GOST 3624–92.
- Determination of active acidity according to GOST 32892-2014.
- Determination of density according to GOST R 54758-2011.
- Method for determination of lactic acid microorganisms according to GOST 32901-2014.
- Organoleptic assessment according to GOST R ISO 22935-2-2011 and GOST R ISO 22935-3-2011.
- TermoHaake EN 29001 falling ball viscometer with a type "C" falling ball. The kinematic viscosity was converted to dynamic viscosity using the formula h=k p1-p2)t; where k=individual ball constant (mPa cm^3/g), p1=ball density g/cm^3 , p2=sample density at the measurement temperature g/cm^3 , t = ball fall time in second.

Results and discussion. As part of the study, samples of a fermented milk product enriched with an ascorbic acid complex and rutin were prepared. The yogurt production method consists of several stages: in the first stage, samples of pasteurized milk with a fat content of 2.5% were mixed with a complex starter culture (*Streptococcus thermophilus, Lactobacillus delbruecki subsp. Bulgaricus, Lactobacillus casei*). Then, biologically active substances were introduced into the system: ascorbic acid and rutin in the following ratios: 25:25, 50:50, and 100:100 mg. Samples of the fermented milk product were placed in a thermostat at a temperature of 42 ±2°C.

After the fermentation process was complete, the resulting fermented milk product samples were analyzed for their physicochemical properties and their organoleptic characteristics. After fermentation, the samples were held at 6–8°C for 24 hours, after which their physicochemical properties were determined (Table 1).

Table 1. Physicochemical and organoleptic properties of yogurt samples with added vitamin C and rutin

Sample number	Amount of vitamin C and rutin mg: mg	Titratable acidity, °T	pH	Density, ρ, g/cm^3	Dynamic viscosity, η, MPa×s	Organoleptic properties
Control	-	93±1	5,6 ±0.5	1,065 ±0.05	67,23 ±0.5	The smell is sour milk, the color is white, the consistency is viscous, the taste is extremely sour
1	25:25	97±1	5,3 ±0.5	1,065 ±0,05	67,41 ±0.5	The smell is sour milk, the color is white, the consistency is dense and stretchy, the taste is extremely sour
2	50:50	105±1	5,2 ±0.5	1,070 ±0,05	76,78 ±0.5	The smell is sour milk, the color is white, the consistency is dense and stretchy, the taste is extremely sour
3	100:100	107±1	4,8 ±0.5	1,070 ±0,05	76,91 ±0.5	The smell is sour milk, the color is white, the consistency is dense and stretchy, the taste is extremely sour

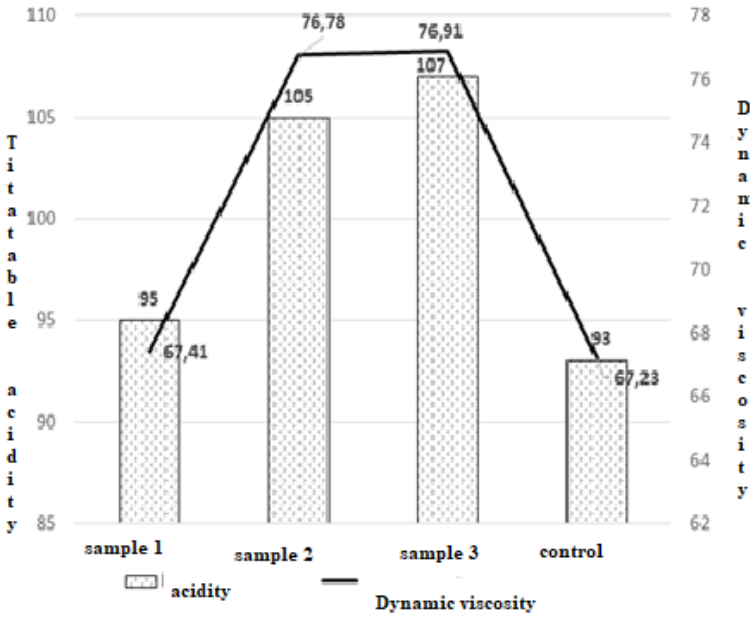

Figure 1. Dependence of titratable acidity and dynamic viscosity of yogurt samples on the dose of introduced functional components: vitamin C and rutin

In light of the implementation of healthy eating principles, the production of biologically complete products with functional properties requires active development. One of humanity's problems has become sucrose consumption, which has doubled over the past half-century, leading to a rapidly increasing incidence of coronary heart disease, obesity, and diabetes.

This problem has affected all segments of the population, regardless of social and professional status, age, lifestyle, location, and gender. Diabetes is a chronic disease that develops when the pancreas does not produce enough insulin, or when the body cannot effectively utilize the insulin it produces. Diet therapy is one of the main treatment methods for any type of disease. Its primary goal is to reduce hyperglycemia and maintain blood sugar levels within healthy limits. For these purposes, sugar substitutes - low-calorie plant-based sweeteners such as stevioside, isomalt, and Jerusalem artichoke syrup - are used in food production.

Thus, as part of the strategy to provide the population with food products that have a beneficial effect on human health, and given the global problem of excess sugar consumption, the development of food products, including drinking yoghurts, based on natural sugar substitutes is particularly relevant.

The experiment was conducted using pasteurized milk with a fat content of 2.5%. Yogurt starter (5%) was added for fermentation, and vitamin C and rutin were added as functional components in a ratio of 50:50 mg.

A mixture of inulin, erythritol, and sucralose was used as sweeteners in amounts ranging from 2 to 5% of the product volume. Table 2 presents the scores for the fermented milk product samples using these sweeteners.

Table 2. Organoleptic rating of samples using sweeteners

Indicator	Sample 1 – 2%	Sample 2 – 2.5%	Sample 3 – 3%	Sample 4 – 4%	Sample 5 – 5%
Color	5	5	5	5	5
Taste	2	3	5	2	2
Smell	5	5	5	5	5
Consistency	5	5	5	5	5
Aftertaste	2	3	5	3	2

Based on the data in the table, a taste profile of the samples was constructed (Figure 2).

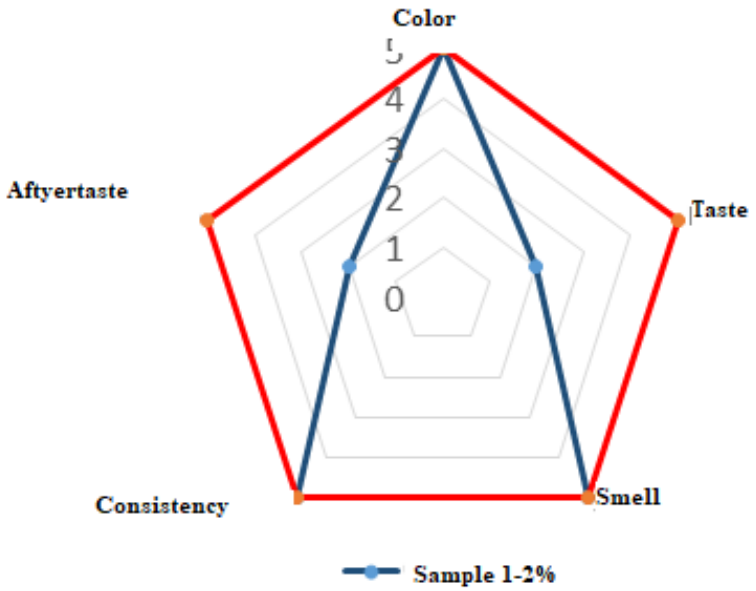

Figure 2. Taste profile of the samples

The data obtained showed that adding more than 3% sweetener made the product excessively sweet, while reducing the dose, on the contrary, did not produce the desired sweetness. We opted for a sample with 3% sweetener. The added flavor components did not significantly affect the product's physicochemical properties. The fermentation process was rapid, with acidity reaching its optimum within 4 hours, and a good curd formed.

The increase in yogurt consumption is explained by the growing popularity of fruit and/or flavored yogurts. Currently, many ingredients are used in yogurt production that alter the taste, color, and texture, such as fruit fillings, natural and/or artificial flavors, and colorings.

There are many fruit flavors that are always in high demand. Among the most popular are strawberry, banana, citrus, and berry flavors. Unusual flavors like caramel and nut have also recently gained popularity.

In order to optimize the organoleptic characteristics of the fermented milk product, the next stage involved studying the influence of flavoring agents on the performance of yogurt with vitamin C and rutin.

Pasteurized milk with a fat content of 2.5% was used for the study. Yogurt starter (5%) was added for fermentation, and vitamin C and rutin in a 50:50 mg ratio were added as functional components, along with a 3% sweetener mixture.

To optimize the yogurt recipe, the flavoring fillers “Orange”, “Caramel” and “Banana” were used in an amount of 0.3% of the product volume.

The results of the experiment using flavoring agents are shown in Table 3.

Table 3. Characteristics of yoghurts with the use of flavoring fillers

Indicator	Samples with sweeteners		
	Sample 1 "Orange"	Sample 2 "Caramel"	Sample 3 "Banana"
Color	Light orange	Cream	Light yellow
Taste	Citrusy, bright,	Sweet, not pronounced	Banana
Smell	Citrus	Not expressed	Banana
Consistency	Homogeneous, moderately viscous	Homogeneous, moderately viscous	Homogeneous, moderately viscous
Aftertaste	Citrus	cloying	Light banana flavor

Table 4 presents the point rating of samples using flavoring agents.

Table 4 – Organoleptic score evaluation of samples using flavoring agents

Indicator	Sample 1 "Orange"	Sample 2 "Caramel"	Sample 3 "Banana"
Color	4	3	5
Taste	3	3	5
Smell	5	5	5
Consistency	4	4	5
Aftertaste	4	4	5

Based on the table data, an organoleptic profile of the samples was constructed (Figure 3).

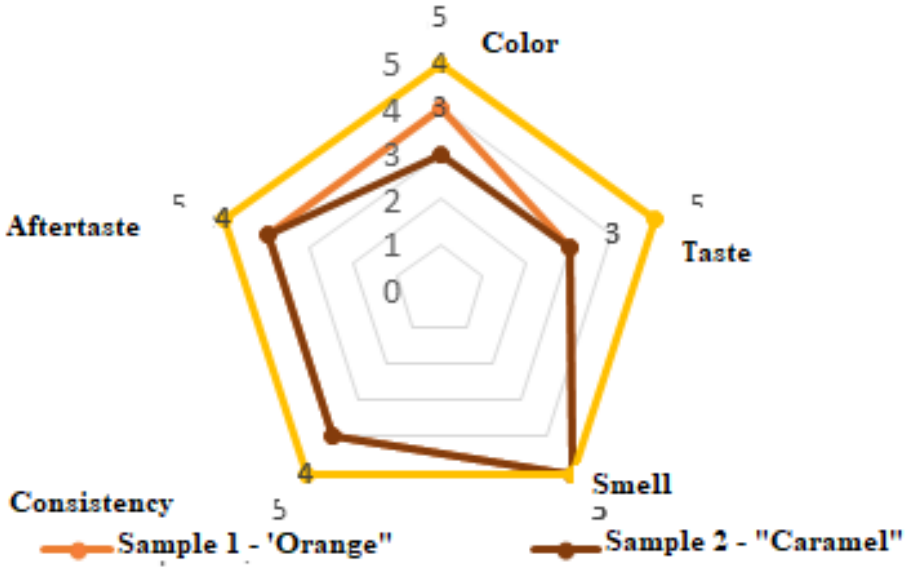

Figure 3. Organoleptic evaluation of yogurt samples with flavoring agents

Conclusion. The study found that all samples exhibited vigorous acidification, with the product fermenting within 4 hours and forming a curd. According to the organoleptic evaluation, the sample with the "Banana" filling received the highest scores. The sample's flavor was mild, moderately sweet, left no unpleasant aftertaste, and complemented the fermented milk flavor of the yogurt itself.

Following all the experiments conducted, a yogurt sample containing 5% starter culture and a functional filler in a 50:50 ratio of vitamin C and rutin was selected for the creation of a three-layer milk dessert. To improve the organoleptic properties and further complement the dessert, a sweetener blend at 3% and a "Banana" flavoring filler at 0.3% were selected.

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