Biotechnology for the development of a functional fermented milk product using vegetable raw materials

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Abstract. This article discusses the possibility of using flour from pomegranate waste and persimmon waste as a biologically active additive in yogurt formulations. To assess the effect of the additive used, the dynamics of titrated acidity during sample storage was studied, and dynamic viscosity was considered. Since the main indicators of product quality for the consumer are its organoleptic properties, the taste, smell, color and consistency of the developed samples of low-fat yogurt were evaluated. It was determined that in the formulation of low-fat yogurt, the optimal use of flour from pomegranate waste in an amount of 2.0%. The introduction of a fruit additive from persimmon flour into the prototypes was 1, 3, 6, 9% by weight. The results of the degree of syneresis and viscosity indicate a positive effect of the additive on the formation of a milk clot. In low-fat yogurt without the addition of flour from pomegranate waste, the texture of the milk clot was not oily, loose and less viscous, and with an increase in the mass of the added additive, the smell and taste became more pronounced, the color of the yogurt turned pink. Studies show that adding persimmons to yogurt can increase the content of antioxidants, in particular lycopene, which exhibits the strongest antioxidant properties among carotenoids, vitamins and minerals. The nutrients contained in persimmons, combined with probiotics from yogurt, can have beneficial effects on digestion, strengthen the immune system and promote overall health.

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1 Introduction

Today, the main tasks of the food industry are the development and development of appropriate methods of processing agri-food waste in order to obtain products that meet international standards. This trend is due to the fact that agricultural waste is a source of natural bioactive substances – polyphenolic compounds, dietary fibers and flavonoids, which can be used in the production of functional foods. Thus, through the use of agricultural by-products, it is possible to give products antioxidant properties and increase shelf life due to antimicrobial actions [1, 2].

Currently, the relationship between nutrition and healthcare is determined by a new strategy based on adherence to proper nutrition in order to counteract alimentary-dependent diseases such as diabetes mellitus, obesity and others. This innovative concept makes it possible to consciously approach the choice of food. In this regard, in order to maintain the health of the population, innovative products are being searched and developed, including fruit and vegetable processing products. The state policy of the Russian Federation regulates current trends in biotechnology related to the development of lactic acid products containing vitamins and nutrients.

One of the widely known and popular fruits is pomegranate. Its value all over the world is associated with a pleasant taste, as well as nutritional and medicinal properties. Pomegranate fruits, due to their high content of phenolic compounds, tannins, flavonoids and complex polysaccharides, are used in the production of juices and soft drinks. However, the technological process generates a large amount of waste consisting of peel and seeds. In a number of studies [3, 4], the biological activity of these wastes has been proven, which gives grounds for using them as food additives or as functional ingredients. Thus, pomegranate waste has antioxidant and antimicrobial activity, is a source of soluble and insoluble dietary fibers, unsaturated fatty acids, pectins, macro- and micronutrients (K, Cu, Mn and Zn), vitamins (C, K and B groups) [5]. In addition, ongoing research on pomegranate pectin [6] indicates its gelling properties, which determines the possibility of its use in the food industry as a natural emulsifier.

In the south of Russia, the cultivation of persimmons on a production scale is gaining momentum. This is due to favorable climatic conditions, as well as the unpretentiousness of these fruit plants, since they do not require chemical treatment to control pests and diseases. Among the most popular varieties are "Rossiyanka", "Korolek", "Velvety" and "Honey" [7].

The chemical composition of persimmon fruits is represented by a high content of polyphenolic compounds – catechin, epicatechin, epigallocatechin, p-coumaric acid and proanthocyanidins. Consequently, the systematic inclusion of persimmon fruits in the human diet ensures the prevention of certain diseases, since polyphenolic compounds play an important role in protecting against free radicals [8]. In addition to polyphenolic compounds, persimmon fruits, depending on the variety, contain about 14% sugars (glucose and fructose), up to 0.7% protein, 0.1% organic acids and 1.2 mg/100 g of β-carotene. Also, the bright orange color of persimmon fruits is formed due to the high content of lycopene, which exhibits the strongest antioxidant properties among carotenoids [9].

Today, persimmon fruits are processed to produce juices, jams and other products. This industrialization contributes to the appearance of large amounts of waste – peel and pulp. These wastes can be used to produce a biologically active additive in the form of powder (flour). The results of the physico-chemical, technical-functional and physico-functional properties of stable persimmon powder [10,11] indicate the possibility of using this additive in dairy production technology, due to the high content of dietary fibers, as well as the manifestation of hydration and emulsifying properties.

Marketing research conducted in the Rostov region in 2021-2022 has shown that the dairy industry plays an important role in solving the problem of improving the health of the nation, occupying a special place among other branches of the food industry.

Among the wide range of products of animal and vegetable origin, milk and dairy products, in particular yogurt, are the most popular. The peculiarity of this type of products is their rich and balanced composition, with high digestibility of all food substances. At the same time, their leading place in the diet of the population is due to their social significance and affordability [12,13].

The value of this category of products is determined by a rich and balanced composition with high digestibility of all food substances. To achieve the necessary consistency of low-fat yogurt, manufacturers often use corn starch as thickeners, since this additive does not increase the cost of the product. However, this component is high in calories and it is not recommended to use it in functional products [14,15].

Yogurt is a dairy product that has a fermented milk taste and aroma. It has a milky white or due to the color of the introduced components, as well as a homogeneous structure. The traditional yogurt recipe includes milk and sourdough, which ensure the fermentation process and enrich the product with beneficial microorganisms. It has been established that this product contains all the substances necessary for the vital activity of the body: proteins, fats, carbohydrates, minerals, vitamins (balanced among themselves).

In the production of fermented milk products, there are two main methods for producing yoghurts: thermostatic and reservoir. To give the product a long shelf life, heat treatment of the clot after fermentation, known as thermization, is often used. The most common and effective production method is the reservoir method, which is widely used for the production of drinking yogurt.

In this regard, the purpose of this work is to study the effect of pomegranate waste powder on the physico-chemical properties of low-fat yogurt and to develop a recipe for functional yogurt using persimmon powder.

2 Materials and methods

The object of research is low-fat yogurt with the addition of flour from pomegranate waste. Skimmed cow's milk, a direct-applied bacterial starter culture containing pure cultures of Streptococcus thermophilus and Lactobacteriumbulgaricum were used to prepare the prototypes. Due to the low fat content, to obtain an oily structure and high organoleptic parameters, a fruit filler was used – flour from pomegranate waste and yogurt with the addition of flour from persimmon waste with a mass fraction of 2.5% fat. For the preparation of prototypes, cow's milk was used as the main raw material, fruit filler – flour from persimmon waste and a bacterial starter culture of direct application containing pure cultures of Streptococcus thermophilus, Lactobacillusdelbrueckiissp.bulgaricus, Lactobacillusacidophilus and Bifidobacteriumanimalis. The process of formation of a fermented milk clot was carried out in a thermostat at a temperature of 40 ° C. The final point of fermentation was to achieve an acidity of 80 ° T.

The process of obtaining powder from pomegranate waste consisted in drying them at 50 ° C for 24 hours and grinding them in a mill to obtain fine flour with a particle fraction of less than 0.3 mm. To introduce the powder into the formulation of low-fat yogurt, the flour swelling stage was previously performed in warm skimmed milk in a ratio of 1:3 at a temperature of 70-80 ° C for 20 minutes.

The yogurt formulation without additives was used as a control sample. Yogurt preparation was carried out according to the recipe indicated in Table 1.

Table 1. Formulation of the studied samples

Component	Designed sample formulation				
	Control sample	Sample №1	Sample №2	Sample №3	Sample №4
Skimmed milk	100,0	99,0	98,5	98,0	97,5
Sourdough	0,01	0,01	0,01	0,01	0,01
Fruit filling	-	1,0	1,5	2,0	2,5
Total	100,0	100,0	100,0	100,0	100,0

When determining the organoleptic assessment, GOST 31981-2013 was used, titrated acidity was determined by titration according to GOST 3624-92, the dynamic viscosity of the milk clot was determined on a BrookfieldDV-II+Pro rotary viscometer according to the method of A.P. Patria, V.P. Aristova.

To obtain the powder, waste persimmons of the Rossiyanka variety were used. The drying process was carried out at 45 ° C for 24 hours. The dehydrated samples were milled to obtain fine flour with a particle fraction of less than 0.3 mm.The yogurt formulation without additives was used as a control sample.

The following yogurt samples were used to perform the research:

- Control sample – without adding flour from persimmon waste;
- Sample No. 1 – with the addition of 1 % flour from persimmon waste;
- Sample No. 2 – with the addition of 3 % flour from persimmon waste;
- Sample No. 3 – with the addition of 6 % flour from persimmon waste;
- Sample No. 4 – with the addition of 9% flour from persimmon waste.

The organoleptic evaluation of the obtained samples was carried out visually and characterized in accordance with GOST 31981-2013.

The titrated acidity was determined by titration according to GOST 3624-92. The viscosity of the milk clot was determined on a BrookfieldDV-II+Pro rotary viscometer according to the method of A.P. Batch, V.P. Aristova. The degree of syneresis was determined by the method of V.P. Shidlovskaya.

The addition of flour from persimmon waste to yogurt production technology had an impact on the rate of milk clot formation and the achievement of acidity of 80 ° T. So, for the control sample, the fermentation time was 8 hours, for sample No. 1 – 6 hours 30 minutes, for sample No. 2 – 6 hours, for sample No. 3 – 5 hours 10 minutes, for sample No. 4 – 4 hours 40 minutes. Presumably, the reduction in fermentation time is due to the chemical composition of the vegetable additive, which contains about 30% of dietary fibers, including easily digestible ones, which are an additional substrate for microorganisms.

The main physico-chemical parameters of yogurt are the degree of syneresis and viscosity, since it is important for the consumer to purchase a product with the "correct" texture of the clot. Therefore, it is necessary to assess the effect of the flour used from persimmon waste on these yogurt indicators. The results are presented in table 2.

Table 2. Physical and chemical parameters of the samples

Indicator	Yogurt samples				
	Control	Experienced №1	Experienced №2	Experienced №3	Experienced №4
Degree of syneresis, %	43,5±2,45	41,4±2,25	38,6±1,75	34,4±1,65	29,5±1,79
Viscosity, Pa/sec	54,4±1,45	64,4±1,85	74,4±2,13	77,8±2,75	79,4±2,86

3 Results

Since the flour from pomegranate waste contains soluble and insoluble dietary fibers and pectins [4], the introduction of this non-traditional vegetable raw material into the fermented milk product affects the fermentation process. The results of titrated acidity dynamics are shown in Figure 1.

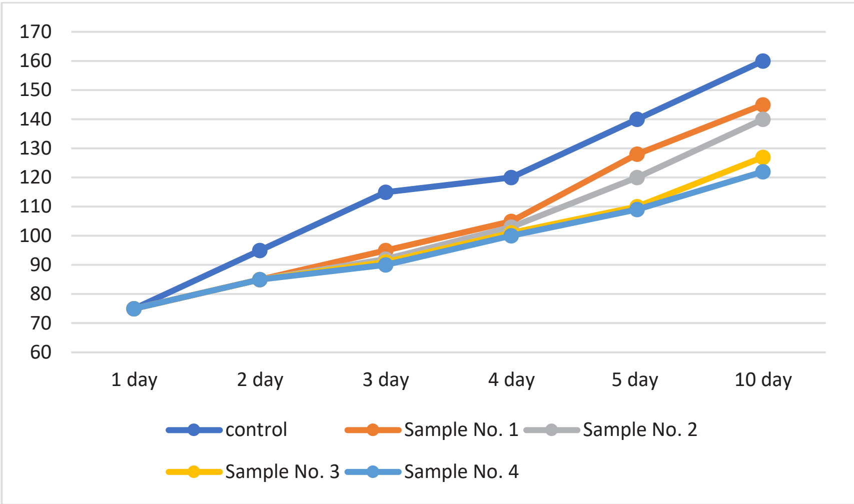

Fig. 1. Dynamics of acidity of experimental samples, °T

An assessment of the change in acidity in the experimental samples during storage (Figure 2) indicates the positive effect of the fruit additive used. So, probably, due to the additional content of dietary fiber (soluble fiber) in low-fat yogurt, the shelf life of the product increases to 10 days. At the same time, with an increase in the dose of the additive, the titrated acidity in the samples decreased for 10 days.

The results of experiments on the study of the dynamic viscosity of low-fat yoghurts are shown in Figure 2.

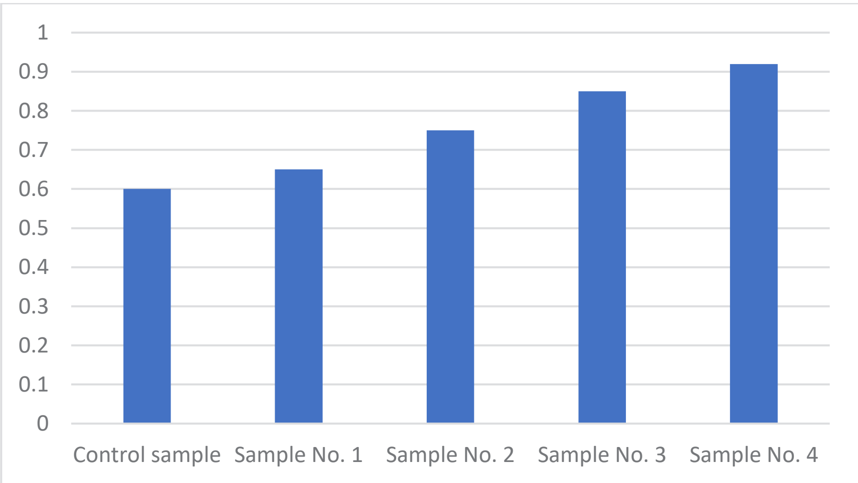

Fig. 2. Dynamic viscosity of experimental samples, Pa•s

4 Discussion of the results

Thus, when using flour from pomegranate waste, the dynamic viscosity increases, while the highest value is noted in sample No. 4, which contains 2.5% fruit filler. Perhaps this is due to the properties of pomegranate pectin to form bonds between themselves and milk components due to the presence of negatively charged OH- or COOH-radicals[5].As a result, the liquid phase binds in the form of a gel, a strong protein-carbohydrate space is formed throughout the entire volume of the system, which forms the necessary viscosity and stability during storage.

Since the main indicators of product quality for the consumer are its organoleptic properties, the taste, smell, color and consistency of the developed samples of low-fat yogurt were evaluated (Figure 3).

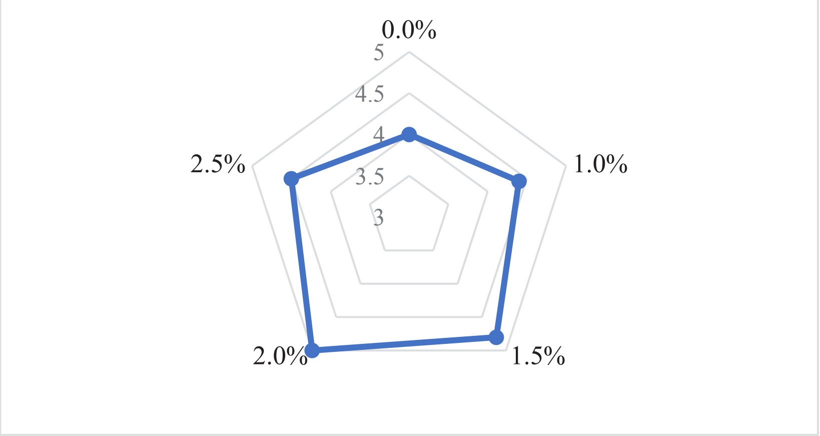

Fig. 3. Organoleptic characteristics of experimental samples

So, in low-fat yogurt without the addition of flour from pomegranate waste, the texture of the milk clot was not oily, loose and less viscous, and with an increase in the mass of the added additive, the smell and taste became more pronounced, the color of the yogurt acquired a pink color. However, in sample No. 4 with a 2.5% content of pomegranate waste flour, the consistency of low-fat yogurt was too thick.

So, in the control sample, the degree of syneresis is 2.1 – 14.0% lower than in samples with the addition of flour from persimmon waste. Among the experimental samples, moisture retention improves with an increase in the dose of the additive: the lowest degree of syneresis is observed in sample No. 1 – 41.4% (persimmon flour content of 1%), the highest degree of syneresis in sample No. 4 – 29.5% (persimmon flour content of 9%).

The fruit additive used also affects the viscosity of fermented milk products. A thicker clot with a higher viscosity is noted in sample No. 4, which is 25 Pa/sec higher than the viscosity of the control sample. Therefore, when using persimmon flour, yogurt will exhibit better storage abilities.

An organoleptic evaluation of the developed samples was performed, the results of which are shown in Figure 4.

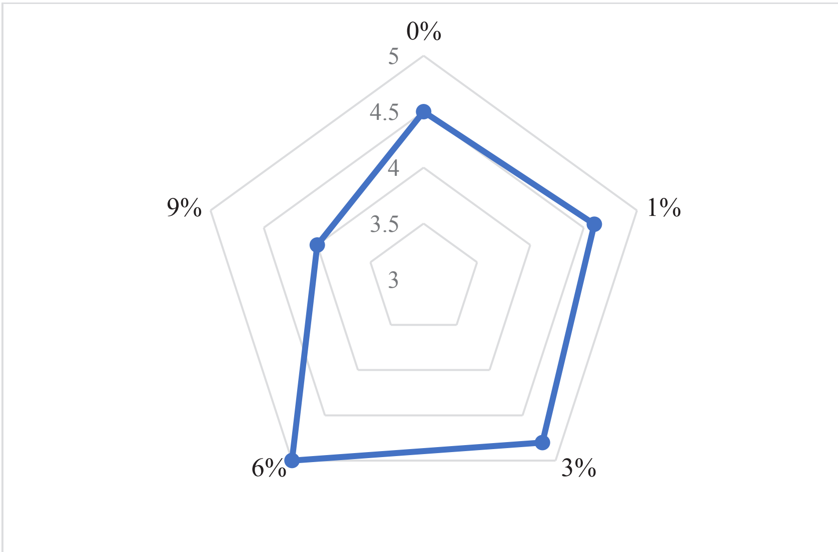

Fig. 4. Organoleptic characteristics of the studied samples

Thus, with an increase in the weight of the added fruit additive, the smell and taste become more pronounced, and the color of the yogurt turns orange due to the high content of lycopene. However, in sample No. 4 with a flour content of 9%, the consistency of yogurt is too thick, and the taste acquires a distinct tartness. Since yogurt belongs to the category of "drinking", the excessive thick consistency is unattractive to the consumer.

5 Conclusions

Thus, the results of experimental studies indicate the expediency of using agri-food waste, in particular peel and seed pomegranate, in the technology of lactic acid products. It was determined that in the formulation of low-fat yogurt, the optimal use of flour from pomegranate waste in an amount of 2.0%. Therefore, according to the conducted physico-chemical and organoleptic studies, it is optimal to use flour from persimmon waste in an amount of 6% (sample No. 3). At the same time, studies show that adding persimmons to yogurt can increase the content of antioxidants, in particular lycopene, which exhibits the strongest antioxidant properties among carotenoids, vitamins and minerals. The nutrients contained in persimmons, combined with probiotics from yogurt, can have beneficial effects on digestion, strengthen the immune system and promote overall health.

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