ISSN 1817-7204 (Print)
ISSN 1817-7239 (Online)

ПЕРАПРАЦОЎКА І ЗАХАВАННЕ СЕЛЬСКАГАСПАДАРЧАЙ ПРАДУКЦЫІ

PROCESSING AND STORAGE OF AGRICULTURAL PRODUCTS

UDC 637.3.056
https://doi.org/10.29235/1817-7204-2026-64-4-342-352

Поступила в редакцию 29.01.2026
Received 29.01.2026

Ksenia A. Andreychikova[1], Oksana V. Anistratova[1, 2], Marina N. Alshevskaya[2], Dmitry L. Alshevsky[2]

[1]Western Branch of the Russian Presidential Academy of National Economy and Public Administration, Kaliningrad, Russian Federation
[2]Kaliningrad State Technical University, Kaliningrad, Russian Federation

STUDY OF QUALITY INDICATORS OF SOFT CHEESE DURING STORAGE AND JUSTIFICATION OF ITS SHELF LIFE

Abstract. In connection with the emerging trend towards healthy eating, the development of soft cheeses with a probiotic focus, produced using biocompatible consortia of microorganisms and possessing increased nutritional and biological value due to the inclusion of plant-based ingredients, is relevant. The scientific significance of the study lies in the theoretical and experimental substantiation of the synergistic interaction of probiotic bacterial strains and non-traditional plant raw materials in the dairy product matrix. The results of a study substantiating the shelf life of soft cheeses with probiotic cultures enriched with a plant filler are presented. A consortium of microorganisms consisting of *S. salivarius* sp. *thermophilus*, *L. delbrueckii* sp. *bulgaricus*, *P. freudenreichii* subsp. *P. shermanii* KM-186 is used as the probiotic component. A plant component used to enrich soft cheese is tiger nut (*Cyperus esculentus* L.). To comprehensively evaluate quality indicators, the produced soft cheese samples were subjected to refrigeration storage (at a temperature of (4 ± 2) °C) using polymer packaging and a modified atmosphere (MAP). During refrigeration storage of trial batches of soft cheeses, changes in their organoleptic and physico-chemical characteristics were assessed. Microbiological indicators of the samples, including spoilage indicators, as well as the dynamics of probiotic microflora development (lactic acid and propionic acid microorganisms) during storage in two packaging options were determined. Based on the data obtained, the shelf life of the trial batches of soft cheeses was established: 10 days for polymer packaging and 15 days when using a modified atmosphere. The obtained results can be applied in the dairy industry to expand the range of functional food products, as well as in the development of technical documentation for the production of new types of fortified cheeses.

Keywords: soft cheese, shelf life, storage, organoleptic indicators, physico-chemical indicators, microbiological indicators, probiotic, modified atmosphere

For citation: Andreychikova K. A., Anistratova O. V., Alshevskaya M. N., Alshevsky D. L. Study of quality indicators of soft cheese during storage and justification of its shelf life. *Vestsi Natsyyanal'nai akademii navuk Belarusi. Seryya agrarnykh navuk = Proceedings of the National Academy of Sciences of Belarus. Agrarian series*, 2026, vol. 64, no. 4, pp. 342–352. https://doi.org/10.29235/1817-7204-2026-64-4-342-352

К. А. Андрейчикова[1], О. В. Анистратова[1, 2], М. Н. Альшевская[2], Д. Л. Альшевский[2]

[1]Западный филиал Российской академии народного хозяйства и государственной службы при Президенте Российской Федерации, Калининград, Российская Федерация
[2]Калининградский государственный технический университет, Калининград, Российская Федерация

ИССЛЕДОВАНИЕ ПОКАЗАТЕЛЕЙ КАЧЕСТВА МЯГКОГО СЫРА В ПРОЦЕССЕ ХРАНЕНИЯ И ОБОСНОВАНИЕ ЕГО СРОКА ГОДНОСТИ

Аннотация. В связи с тенденцией к здоровому питанию актуальной является разработка мягких сыров пробиотической направленности, произведенных с помощью биосовместимых консорциумов микроорганизмов и обладающих повышенной пищевой и биологической ценностью за счет включения в состав растительных компонентов. Научная значимость работы заключается в теоретическом и экспериментальном обосновании синергетического взаимодействия пробиотических штаммов бактерий и нетрадиционного растительного сырья в матрице молочного продукта. Приводятся результаты исследования по обоснованию срока годности мягких сыров с пробиотическими

культурами, обогащенных растительным наполнителем. В качестве пробиотической составляющей рассмотрен консорциум микроорганизмов, состоящий из *S. salivarius* sp. *thermophilus*, *L. delbrueckii* sp. *bulgaricus*, *P. freudenreichii* subsp. *P. shermanii* KM-186. Растительный компонент, используемый для обогащения мягкого сыра, – сыть съедобная луговая (*Cyperus esculentus* L.). Для комплексной оценки показателей качества произведенные образцы мягких сыров были подвергнуты холодильному хранению (при температуре (4 ± 2) °С) с использованием полимерной упаковки и модифицированной газовой среды (МГС). В процессе холодильного хранения опытных партий мягких сыров оценивались изменения их органолептических и физико-химических характеристик. Установлены микробиологические показатели образцов, включая показатели порчи, а также динамика развития пробиотической микрофлоры (молочнокислых и пропионовокислых микроорганизмов) в процессе хранения в двух вариантах упаковочных решений. На основании полученных данных установлены сроки годности опытных партий мягких сыров, которые составили 10 сут для полимерной упаковки и 15 сут при использовании МГС. Полученные результаты могут быть применены на предприятиях молочной промышленности для расширения ассортимента функциональных продуктов питания, а также при разработке технической документации на производство новых видов обогащенных сыров.

Ключевые слова: мягкий сыр, срок годности, хранение, органолептические показатели, физико-химические показатели, микробиологические показатели, пробиотик, модифицированная газовая среда

Для цитирования: Исследование показателей качества мягкого сыра в процессе хранения и обоснование его срока годности / К. А. Андрейчикова, О. В. Анистратова, М. Н. Альшевская, Д. Л. Альшевский // Весці Нацыянальнай акадэміі навук Беларусі. Серыя аграрных навук. – 2026. – Т. 64, № 4. – С. 342–352. https://doi.org/10.29235/1817-7204-2026-64-4-342-352

Introduction. Currently, the government is paying close attention to healthy nutrition for the population. This can be achieved through improving both traditional food production technologies and creating new fortified products, including probiotic ones.

The modern cheese-making market is undergoing significant changes. Changes are observed in market segmentation, particularly in the growth of soft cheese production, which requires lower raw material and energy costs and is in high demand among various population groups [1]. Soft cheeses available on the Russian and Belarusian markets are mainly produced industrially using the rennet and acid-rennet methods. The production of soft cheeses using the fermented milk (lactic acid) method is limited and is used mainly in small cheese factories, which is associated with the technological features of their production, organoleptic and physico-chemical characteristics (high moisture content, absence or low salt content) [2].

The development of technology for soft acid cheeses enriched with biocompatible microbial consortia, including propionibacteria, is promising for expanding the range of dairy products [3, 4]. Propionibacteria strengthen the human immune system, possess antimutagenic properties, and form a number of compounds important for the body during their vital activity, including vitamin B_{12} [5, 6].

Research conducted by scientists is aimed at developing functional food products using domestic plant-based raw materials with therapeutic and prophylactic properties and a rich vitamin and mineral composition [7, 8].

Scientists from Moscow State University of Food Sciences and Technology (MGUPP) have presented a technology for producing soft cream cheese with fish collagen hydrolysates [9]. To regulate the biological value, namely the amino acid, lipid, carbohydrate, mineral and vitamin compositions, recipes for soft cheeses with a dietary and therapeutic-prophylactic focus have been developed [10–14]. Cheeses enriched with probiotics have been presented: *Bifidobacterium longum MS-42*, *Lactobacillus plantarum 8PA-3* and dietary fiber “Citri-Fi” [11]. A functional cheese with the addition of rose hips, honeysuckle, and black currant has been developed. The feasibility of their use in the technology of soft cheese production has been substantiated [10, 12]. At the Altai State Technical University named after I. I. Polzunov, a patent was developed describing a method for the production of soft cheese using pure cultures of lactic acid and bifidobacteria BB-12S [13]. At the Omsk State Agrarian University named after P. A. Stolypin, in the production of soft cheeses, researchers substantiated the method of introducing a starter culture consisting of lactic acid microorganisms and buckwheat or oat bran in an amount of 4.0 % of the mass of the normalized mixture [14]. The Institute of Meat and Dairy Industry (part of the National Academy of Sciences of Belarus) and related organizations are also conducting research on technologies for soft and functional cheeses, including the use of new strains of starter cultures and various functional ingredients [15, 16].

The analysis conducted within the framework of patent research and scientific literature revealed that the primary research conducted by scientists aimed at producing functional products enriched with probiotic cultures is based on the use of monocultures of lactic acid bacteria, bifidobacteria, propionic acid bacteria, or their consortia.

Various methods for producing these cheeses, such as rennet, acid-rennet, and melting, are also being explored. However, despite the wide range of technological solutions presented, the technology for producing probiotic soft cheeses obtained by the acid method requires further study and detailed development.

A crucial aspect is not only the production of enriched and functional dairy products but also the reduction of losses during logistics, maintaining quality and safety throughout the entire shelf life under specified conditions, using modern technological packaging solutions [17].

Research Objectives and Tasks. The aim of the study was to experimentally determine and scientifically substantiate the shelf life of soft cheeses containing probiotic cultures (*Streptococcus salivarius* sp. *thermophilus*, *Lactobacillus delbrueckii* sp. *bulgaricus*, *Propionibacterium freudenreichii* subsp. *shermanii* KM-186) and a plant-based filler (*Cyperus esculentus* L.).

To achieve this goal, the following tasks have been set:

1) to study the organoleptic and physico-chemical properties of soft cheeses during storage;

2) to study the microbiological properties of soft cheeses during storage in aerobic and anaerobic environments;

3) to substantiate the shelf life of soft cheeses using various packaging solutions.

Materials and Methods. The raw materials and auxiliary components used for the experiment are presented in Table 1. All raw materials used complied with regulatory requirements.

T a b l e 1. **Raw materials and auxiliary components**

Component Name	Manufacturer	Regulatory Documentation
Raw cow's milk	Gusevmoloko LLC, Russian Federation	National state standard R 52054-2023, TR CU 033/2013
Direct inoculation starter	Genesis Laboratories, Bulgaria	TR CU 033/2013
Concentrated liquid inoculation starter	Propionics LLC, Russian Federation	Technical specifications 9229-007-02069473-2005, TR CU 033/2013
Edible tiger nut tubers	IP Rynkovoy A. P., Russian Federation	Organization standard 2044340097-001-2021, TR CU 021/2011

Pilot batches of soft cheeses were produced according to the process flow chart shown in Figure 1.

During the acceptance and preparation of raw materials, milk is accepted based on its weight and quality, as determined by the company's quality control department (laboratory). If necessary, milk may be stored until use at a temperature of (4 ± 2) °C, but for no more than 12 hours.

The milk is normalized by adding skim milk to whole milk until the mass fraction of fat in the mixture reaches 2.5 %. The milk is cleaned using centrifugal milk cleaners, then the normalized mixture is heated in a heat exchanger to a temperature of 60–65 °C and sent for homogenization. Homogenization is carried out at a pressure of (6.0 ± 0.5) MPa. The normalized mixture is pasteurized at a temperature of (95 ± 2) °C with a holding time of 3–5 seconds. After holding, the mixture is cooled to a fermentation temperature of (37 ± 2) °C.

The mixture is fermented using an activated consortium of starter microorganisms consisting of (*Streptococcus salivarius* sp. *thermophilus*, *Lactobacillus delbrueckii* sp. *bulgaricus*) and two parts of propionic acid microorganisms (*Propionibacterium freudenreichii* subsp. *shermanii* KM-186) in tanks with a cooling jacket equipped with special agitators that ensure uniform and thorough mixing of the mixture with the starter. To ensure better mixing of the mixture with the starter, the tank is filled with the mixture while the agitator is running. Mixing is completed 20 minutes after the tank is filled. Fermentation is carried out at a temperature of (37 ± 2) °C. The end of fermentation is determined by the formation of a milk curd with an acidity of 75–80 °T. The fermentation duration is 4–6 hours.

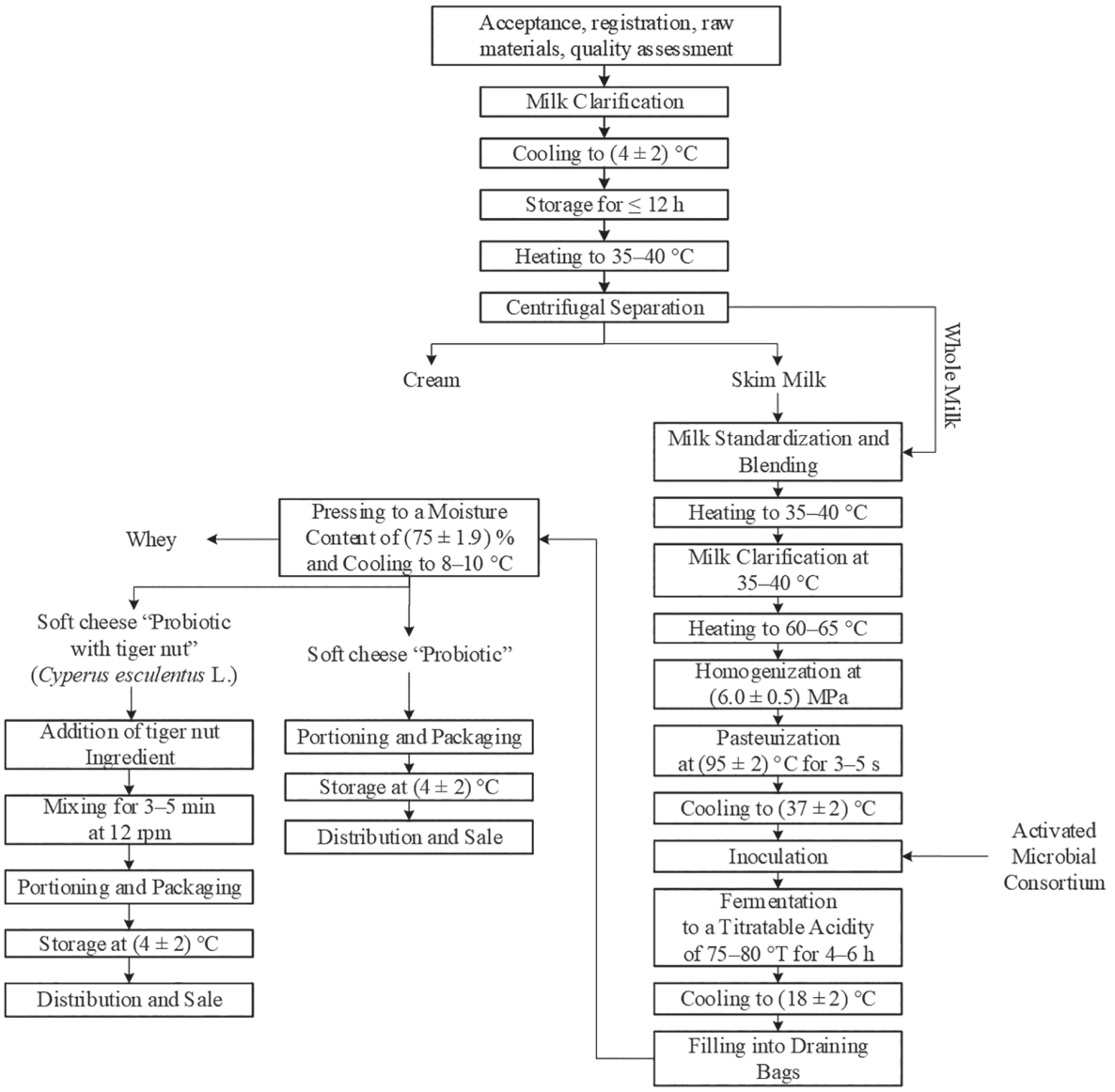


Figure 1. Production scheme for experimental samples

After the curdling process is complete, the resulting curd is cooled to a temperature of (18 ± 2) °C, poured into lavsan bags, and sent to a unit for separating the whey from the curd and cooling (Mitrofanov cooler). The temperature of the finished cheese after cooling is 8–10 °C; the process duration is 1.5–2.0 hours, until the moisture content in the product reaches (75.0 ± 1.9) %.

When producing soft cheese with a filler, the pressed mass is mixed with a filler from aseptic packaging (cleaned, dried tiger nut, particle size 3–5 mm) in a paddle mixer for 3–5 minutes (shaft rotation speed 12–15 rpm) to ensure even distribution of the components.

The resulting product is packaged in airtight consumer packaging, placed in transport packaging, and sent to a refrigeration chamber. In the refrigeration chamber, the finished product is cooled to a temperature of (4 ± 2) °C.

According to the developed program for setting the shelf life of soft cheeses "Probiotic" and "Probiotic with tiger nut", the produced batches were stored in refrigerated storage at a temperature of (4 ± 2) °C: the cheeses were stored in hermetically sealed polystyrene cups and studied on days 0, 5, 10, and 13; the second experimental batch was stored in bags made of polypropylene (60 microns) with a modified atmosphere (MAP 70 % N_2 + 30 % CO_2) and tested on the 0th, 5th, 10th, 13th, 15th, and 20th days of cold storage.

During the storage process, the organoleptic, physico-chemical, and microbiological characteristics of the soft cheese samples were evaluated.

The produced batches of soft cheeses had the characteristics presented in Table 2.

T a b l e 2. **Characteristics of cheese samples [18]**

Indicator Name	Product Name	
	"Probiotic"	"Probiotic with tiger nuts"
Lactic acid microorganism count at end of expiration date, CFU/g, minimum	$1 \cdot 10^7$	$1 \cdot 10^7$
Propionibacterium count at end of expiration date, CFU/g, minimum	$1 \cdot 10^6$	$1 \cdot 10^6$
Moisture content, maximum, %	75.00 ± 0.20	70.00 ± 0.20
Protein content, minimum, %	13.00 ± 0.50	11.00 ± 0.50
Fat content, maximum, %	10.00 ± 0.80	12.00 ± 0.80
Fat content in dry matter, maximum, %	40.00 ± 1.1	40.00 ± 1.1
Total ash content, %	1.059 ± 0.009	1.064 ± 0.009
Carbohydrate content, %	2.00 ± 0.50	7.00 ± 0.50
Calcium content, mg/100 g	680.32 ± 75.49	668.56 ± 75.49
Phosphorus content, mg/100 g	182.00 ± 11.00	181.00 ± 11.00
Vitamin B_{12} content, μg/100 g	1.88 ± 0.16	1.62 ± 0.16
Vitamin B_9 content, μg/100 g	40.00 ± 4.00	36.40 ± 3.64
Total tocopherol content, mg/100 g	0.20 ± 0.04	3.01 ± 0.11

The sample scores were distributed as follows: taste and aroma – 20 points, texture – 15 points, colour – 5 points, appearance – 5 points, packaging and labeling – 5 points.

A 50-point scale developed by the authors was used to evaluate the organoleptic characteristics. The physico-chemical and microbiological properties of the samples were assessed according to the methods presented in Table 3.

T a b l e 3. **Methods for determining the indicators of soft cheeses during storage**

Name of the indicator to be determined	Regulatory documentation for the test procedure
Titratable acidity	National state standard R 54669
Active acidity (pH)	National state standard 32892
Water activity	National state standard 21807
Microbiological indicators:	
Probiotic microorganisms	National state standard R 56139
Lactic acid microorganisms	National state standard 33951
Coliforms	National state standard 9225
Pathogenic bacteria, including Salmonella	National state standard ISO 6785
Staphylococcus aureus	National state standard 30347
Listeria monocytogenes	National state standard 32031
Yeasts, molds	National state standard 33566

During refrigerated storage of the samples in polymer packaging with a modified atmosphere, the composition of the packaging was assessed using a Gaspace Advance analyzer.

The studies were conducted at the Department of Food Technology of the Federal State Budgetary Educational Institution of Higher Education KSTU, in the Atlantic branch of the All-Russian Research Institute of Fisheries and Oceanography (AtlantNIRO) in the Russian Federation in 3–5 replicates in accordance with the methods presented in Table 3. Data processing was carried out using Microsoft Office 2024 software.

Results and Discussion. Fresh soft cheeses without salt or maturation are characterized by a delicate texture and high moisture content, but they have a limited shelf life. For this group of products, the shelf life is established by the manufacturer, taking into account its safety, which has been confirmed by laboratory tests. According to regulatory documentation, the shelf life for this group of products is 5 to 10 days at a storage temperature of (4 ± 2) °C.

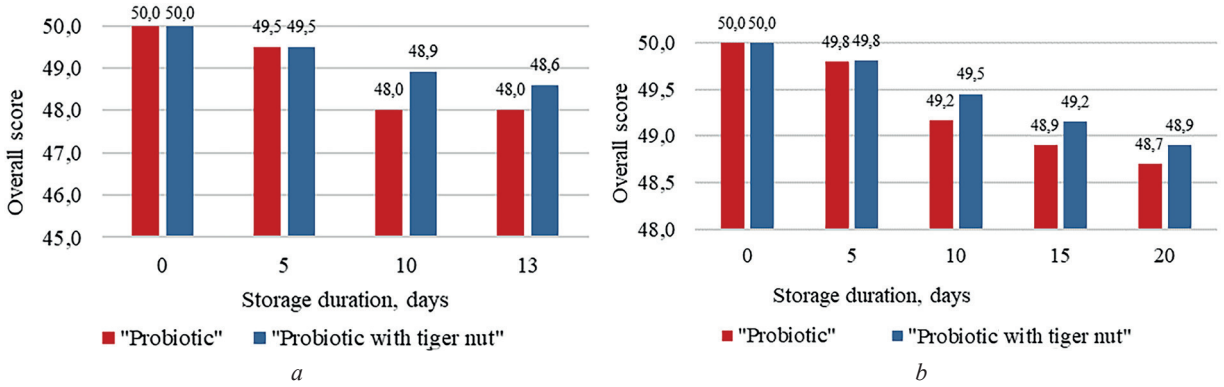


Figure 2. Changes in organoleptic characteristics of cheeses during storage:
a – in polymer packaging; *b* – in polymer packaging with MAP

Due to the emerging trend towards resource conservation, as well as the not always rapid "producer to customer" supply chain, there is a need to extend the shelf life of soft cheeses. This can be achieved in various ways: by changing the parameters of the refrigeration chain, by using preservatives (which contradicts the concept of healthy eating), and also by using new-generation packaging materials and storing products in a modified atmosphere.

The tasting committee conducted an organoleptic evaluation of the samples based on the following criteria: appearance, color, aroma, taste, consistency, packaging, and labeling. The change in the overall score of the samples depending on storage time and packaging method is shown in Figure 2.

At the initial stage of the research, the experimental batches of cheese had a homogeneous, uniform mass with a plastic, spreadable consistency; the colour was white with a uniform creamy hue. In the samples of soft cheese with tiger nut, the filler particles were evenly distributed throughout the mass. The taste of the cheeses was clean and characteristic of fermented milk products; in the samples with a vegetable filler, tasters noted slightly sweet notes.

Figure 2, *a* shows the changes in the overall organoleptic assessment of both cheese samples in polymer packaging over a period of 13 days for samples with and without a filler. The appearance of the studied samples of soft cheese without a plant-based filler ("Probiotic") was that of a homogeneous mass with a smooth surface; on the 10th day of storage, a single instance of surface cracking was observed, which led to a decrease in the value of this indicator to 4.6 points. The colour of the cheese was white and uniform throughout the mass; it did not change during the shelf life. The packaging and labeling of all samples were correct, complete, and clear throughout the storage period. The taste of the samples was clean, delicate, and fermented, but on the 10th day, slightly perceptible foreign sour notes appeared, which led to a rating reduction to 13.9 points. The consistency of the samples was uniform, soft, and slightly spreadable; only by the 13th day was there a slight thickening of the consistency (14.7 points).

The "Probiotic with tiger nut" cheese was a uniform mass with a smooth surface. The cheese had a white color with grey-beige inclusions of the tiger nut filler, evenly distributed throughout the mass; this color did not change during the storage period. The packaging and labeling of all samples were correct, complete, and clear throughout the storage period. The appearance of the studied samples was a homogeneous mass with a smooth surface; on the 10th day of storage, isolated cracking of the surface around the filler inclusions was observed, and the appearance score was 4.7 points. The taste of the samples was clean, delicate, and slightly sweet; however, on the 10th day, slightly perceptible foreign sour notes appeared, which led to a decrease in the score to 14.6 points by the 13th day. The consistency of the samples was uniform, soft, and slightly spreadable; only by the 13th day did the consistency became less spreadable, and swelling of the plant component particles was observed (14.6 points).

According to the tasting panel's assessment, by the 5th day of storage, the overall organoleptic evaluation of the samples deteriorated only slightly. At the third monitoring point (10th day), the total score decreased to 48.0 for "Probiotic" cheese and 48.9 for "Probiotic with tiger nut" cheese; by the end of the storage period, the scores were 48.0 and 48.6, respectively.

Figure 2, *b* shows the change in the total score of the samples stored in MAP.

The "Probiotic" cheese was a homogeneous mass with a smooth surface. The cheese's color was white, uniform throughout the mass, and did not change during the shelf life. The packaging and labeling of all samples were correct, complete, and clear throughout the storage period. The appearance of the studied samples was a homogeneous mass with a smooth surface; on the 15th day of storage, a process of isolated surface cracking was observed, which led to a decrease in the indicator value to 4.8 points. The taste of the samples was clean, delicate, and fermented, but on the 10th day, slightly perceptible foreign sour notes appeared, which resulted in a reduction of the score to 14.8 points. The consistency of the samples was uniform, soft, and slightly spreadable; only by the 15th day was a slight thickening of the consistency observed (14.6 points).

The "Probiotic with tiger nut" cheese was a uniform mass with a smooth surface. The cheese had a white color with grey-beige specks of tiger nut, uniform throughout the mass, and this did not change during the shelf life. The packaging and labeling of all samples were correct, complete, and clear throughout the storage period. The appearance of the samples under study was a homogeneous mass with a smooth surface; on the 10th day of storage, isolated cracking of the surface around the filler inclusions was observed, and the appearance score was 4.9 points; by the 20th day of storage, the appearance score was 4.8 points.

The taste of the samples was clean, delicate, and slightly sweet; however, on the 10th day, slightly noticeable foreign sour notes appeared, which led to a decrease in the score to 14.8 points by the 20th day. The consistency of the samples was uniform, soft, and slightly spreadable; only by the 15th day did the consistency become less spreadable and slightly firm, with swelling of the plant component particles observed (14.6 points).

According to the tasting panel's assessment, by the 5th day of storage, the organoleptic characteristics of the samples generally remained stable. At the third control point (day 10), the total score for the organoleptic assessment decreased and amounted to 49.2 for the "Probiotic" cheese and 49.5 for the "Probiotic with tiger nut" cheese. By the end of the storage period, the final score was 48.7 and 48.9, respectively.

As physico-chemical indicator reflecting the changes in cheese samples during storage in various packaging options, the active acidity was selected (Figure 3).

During storage, a slight decrease in this indicator was observed in the samples, which can be explained by the fact that slight lactic acid fermentation occurs in the cheese, resulting in a decrease in active acidity, which reflects the dynamics of changes in the total scores of organoleptic indicators.

During the study, the changes in gas composition inside the packaging were determined during storage of the cheese samples (Table 4).

Oxygen is a key factor for the growth of molds and yeasts, as well as for the oxidation of fats. CO_2 suppresses part of the microflora (aerobic) and slows down spoilage; N_2 is an inert gas that helps prevent the packaging from collapsing. Table 4 shows the composition of the gaseous environment in experimental batches of soft cheese.

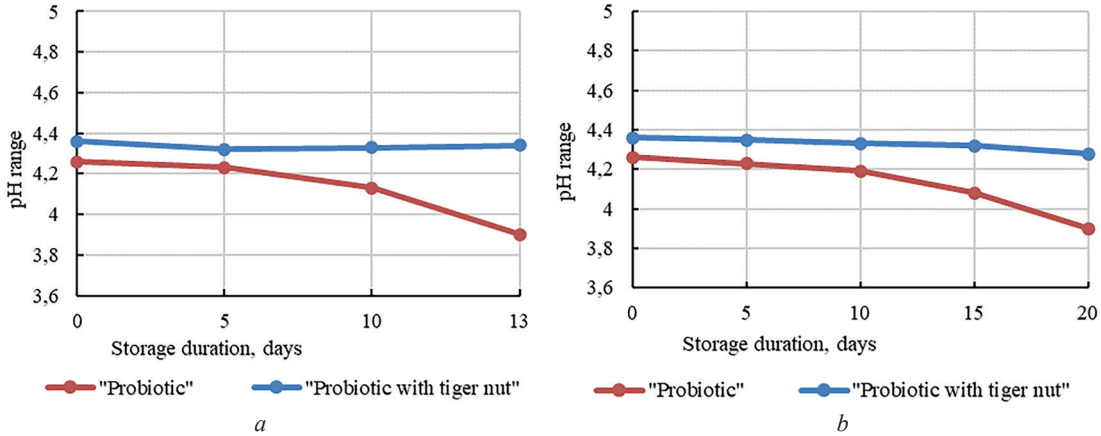


Figure 3. Changes in active acidity of soft cheese samples: *a* – in polymer packaging; *b* – in polymer packaging with modified atmosphere

T a b l e 4. **Changes in the gas composition of the packaging**

Gas content in packaging, %	Storage life				
	Background (Day 0)	(Day 5)	(Day 10)	(Day 15)	(Day 20)
O_2	0.23	0.34	0.34	1.06	1.45
CO_2	27.8	22.8	21.5	22.90	21.5
N_2	71.9	76.9	78.2	76.0	77.0

Changes in the gas composition inside the packaging of a product with a modified atmosphere indicate the rate of microbiological spoilage, the integrity of the packaging, and serve as an indicator of spoilage. Inside the packaging, gases change due to the activity of microflora (including yeasts, molds, and bacteria) and the biochemical processes of the product itself. Monitoring O_2 helps to understand when conditions become conducive to mold growth and deterioration of taste. The rise in CO_2 is often correlated with the onset of undesirable processes before off-odours and flavour defects become clearly perceptible.

The data presented in Table 4 reflect the following changes by the end of the 20th day of storage: a slight increase in the volume fraction of oxygen from 0.23 % to 1.45 %, indicating the permeability of the polymer film; the accumulation of nitrogen-containing substances, which led to a slight increase in the nitrogen content by 7.1 % and a decrease in the carbon dioxide content by 22.6 %.

The air modification inside the packaging material is probably due to biochemical reactions, namely the conversion of carbohydrates to form carbon dioxide and the parallel process of its partial dissolution in water to form carbonic acid. The latter is confirmed by the results of organoleptic assessment on the 20th day of storage, which indicate the appearance of acidic notes that were previously not characteristic of the samples, as well as a decrease in active acidity by the end of storage.

To determine the shelf life of food products, microbiological studies are carried out, covering both probiotic microflora and spoilage microflora, as well as pathogenic microflora, the absence of which indicates the safety of cheeses throughout the entire storage period. The change in the number of lactic acid and propionic acid microorganisms in soft cheeses is shown in Figure 4.

Figure 4, *a*, *b* show the change in the number of microorganisms in the samples stored in polymer packaging. For these samples, the maximum number of lactic acid bacteria cells was reached by day 10 and, decreasing thereafter, reached 7.2×10^9 CFU/g for soft cheese without a filler (“Probiotic”) and 6.9×10^9 CFU/g for cheese with a plant-based filler (“Probiotic with tiger nut”) (Figure 4, *a*), respectively, at the final storage point (day 13). The number of propionic acid bacteria was recorded at its maximum on the 5th day of storage and then decreased slightly, within the same order of magnitude, in all samples by the end of the storage period (Figure 4, *b*).

Figure 4, *c*, *d* show the changes in the microflora in samples packaged with MAP. Thus, the number of lactic acid microorganisms decreased from the beginning of storage due to the lack of oxygen and by the 20th day reached 5.6×10^9 CFU/g for soft cheese without a filler (“Probiotic”) and 5.2×10^9 CFU/g for cheese with a plant-based filler (“Probiotic with tiger nut”) (Figure 4, *c*). The number of propionibacteria in these samples was maximum on the 5th day of storage, subsequently decreasing to 1.1×10^9 CFU/g (Probiotic cheese) and 1.2×10^9 CFU/g (“Probiotic with tiger nut”) by the 20th day of refrigerated storage (Figure 4, *d*).

During refrigerated storage, no pathogenic or conditionally pathogenic microflora (Salmonella, *Staphylococcus aureus*, *L. monocytogenes*, Coliform bacteria) were detected in the experimental batches of soft cheeses.

Colonies of molds were not identified in the tested batches of soft cheeses. The number of yeast cells in soft cheeses is not governed by applicable regulatory standards; however, their twofold increase in the product can be used to assess the degree of its spoilage.

In the studied batches of cheese stored both in polymer packaging and in modified atmosphere packaging, isolated yeast cells were detected at the end of the storage period; no increase exceeding twofold compared to the initially detected level was observed.

Summarizing the above experimental data, it can be concluded that soft cheeses stored in polymer packaging for 13 days, as well as samples stored in MAP for up to 20 days, showed no signs of spoilage and maintained high organoleptic, physico-chemical, and microbiological quality and safety indicators.

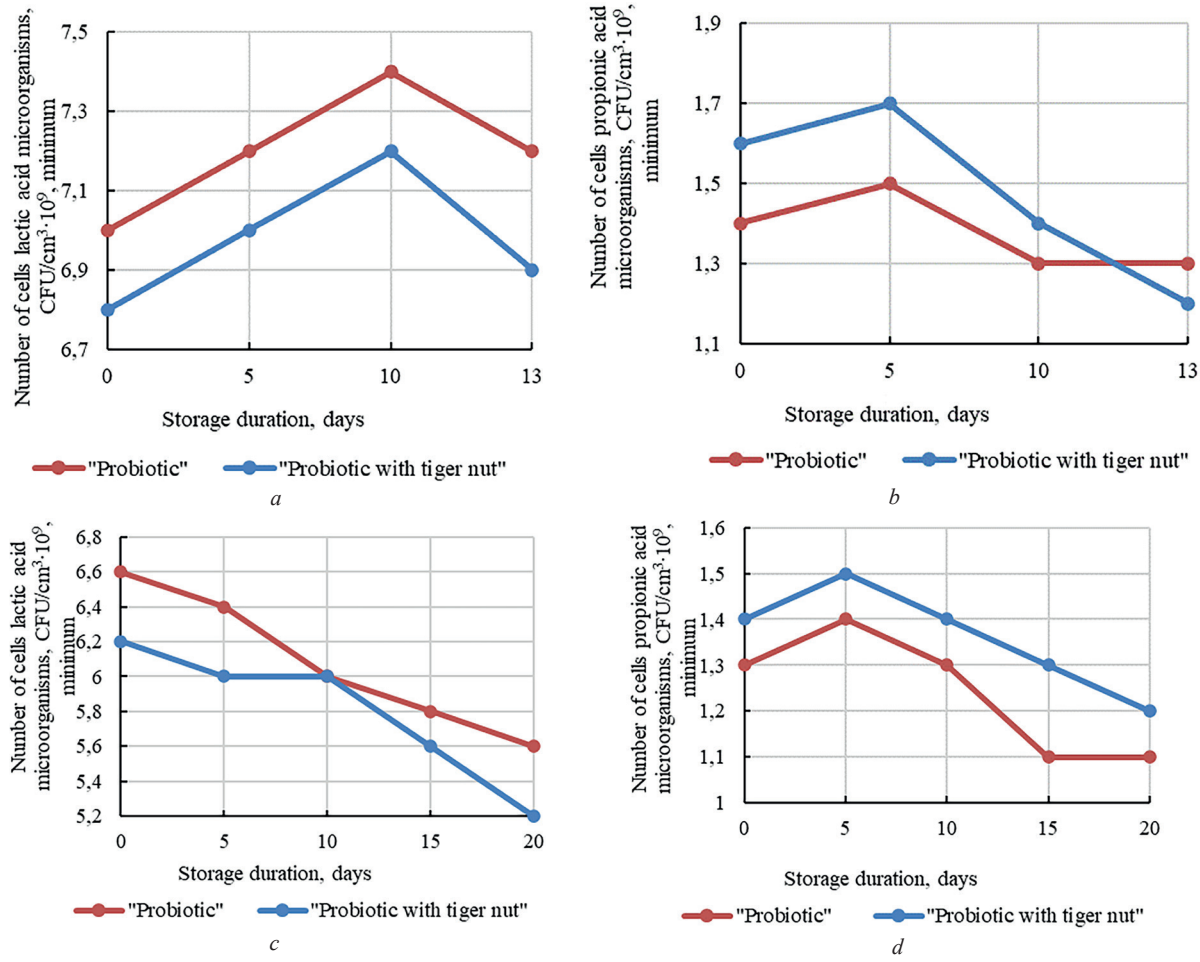


Figure 4. Changes in the number of microorganisms in soft cheeses during storage under different storage conditions: *a* – lactic acid microorganisms in polymer packaging; *b* – propionic acid microorganisms in polymer packaging; *c* – lactic acid microorganisms in polymer packaging with modified atmosphere; *d* – propionic acid microorganisms in polymer packaging with modified atmosphere

Taking into account the specified reserve factor, the shelf life of "Probiotic" and "Probiotic with tiger nut" soft cheeses was 10 days in sealed polymer packaging and 15 days in a modified atmosphere.

Conclusions. Modern packaging solutions enhance the efficiency and safety of storing dairy products, including soft cheeses. Regulating the gas composition inside the packaging helps slow down oxidation processes and the development of pathogenic microflora, yeast, and molds.

The studies conducted revealed that the organoleptic characteristics of soft cheeses stored in polymer packaging deteriorated by the 10th day of refrigerated storage. At the end of the studies, this indicator for samples in polymer packaging was 45.3 and 45.4 points, respectively. When storing the samples in a modified atmosphere, the final score for organoleptic characteristics reached 48.5 and 48.7 points, respectively. The changes in the organoleptic characteristics of soft cheeses during storage are primarily associated with the appearance of a sour taste and a denser texture. For the cheese with added filler, swelling of plant particles was observed.

A slight change in the active acidity index of all samples during storage under various conditions was noted. In samples without a filler, this indicator by the end of storage amounted to (3.90 ± 0.08) units, while in samples of soft cheese with a vegetable filler it was (4.34 ± 0.08) units and (4.28 ± 0.08) units, respectively.

It was established that by the end of the storage period (13 days), the number of lactic acid and propionic acid microorganisms in soft cheeses in polymer packaging was 7.2 CFU/g · 10^9 and 1.3 CFU/g · 10^9 ("Probiotic"); 6.9 CFU/g · 10^9 and 1.2 CFU/g · 10^9 ("Probiotic with tiger nut").

In the samples stored under MAP conditions: 5.6 CFU/g · 10^9 and 1.1 CFU/g · 10^9 ("Probiotic"), and 5.2 CFU/g · 10^9 and 1.2 CFU/g · 10^9 ("Probiotic with tiger nut") respectively. Storing products containing probiotic microorganisms in modified atmosphere does not affect their viability and does not change the order of magnitude of their count. Throughout the entire period of refrigerated storage, the number of pathogenic or opportunistic microflora in all experimental samples of soft cheese did not exceed the standard values.

Thus, taking into account the reserve factor of 1.3, the shelf life of soft cheeses was 10 days in sealed polymer packaging and 15 days in polymer packaging with modified atmosphere.

References

1. Analysis of the brine and soft cheeses market in Russia: current situation and forecasts for 2026–2030. *ACG: Alto Consulting Group*. Available at: https://alto-group.ru/otchot/rossija/5769-rynok-rassolnyh-i-mjagkih-syrov-v-rossii-tekuschaja-situacija-i-prognoz-2022-2026-gg.html (accessed 2 June 2026) (in Russian).

2. Kholobova K. A., Anistratova O. V. Quality characteristics of milk curds for the production of soft cheese with probiotic properties. *Molochnaya promyshlennost' = Dairy Industry*, 2021, no. 5, pp. 32–34 (in Russian). https://doi.org/10.31515/1019-8946-2021-05-32-34

3. Kholobova K. A., Anistratova O. V., Kochina A. A. Marketing analysis of the regional market and consumer preferences of soft cheeses in the Kaliningrad region. *Tekhnologiya i tovarovedenie innovatsionnykh pishchevykh produktov = Technology and Merchandising of the Innovative Foodstuff*, 2023, no. 1 (78), pp. 71–75 (in Russian). https://doi.org/10.33979/2219-8466-2023-78-6-108-113

4. Khamagaeva I. S., Kachanina L. M., Tumurova S. M. *Biotechnology of starter cultures of propionic acid bacteria*. Ulan-Ude, East Siberian State Technological University Publishing House, 2006. 172 p. (in Russian).

5. Boyarineva I. V. *Theoretical and practical aspects of creating innovative functional bioproducts using propionic acid bacteria*. Ulan-Ude, 2020. 36 p. (in Russian).

6. Kholobova K. A., Anistratova O. V., Vinokur M. L., Rynkovoy A. P. Analysis of biopotential of the tiger nut tubers (*Cyperus esculentus* L.) produced in the Krasnodar region and the prospects for its use in food technology. *Nauchnyi zhurnal NIU ITMO. Seriya: Protsessy i apparaty pishchevykh proizvodstv = Processes and Food Production Equipment*, 2022, vol. 52, no. 3, pp. 3–11 (in Russian). https://doi.org/10.17586/2310-1164-2022-15-3-3-11

7. Mishra S., Tripathi A., Tripathi D. K., Chauhan D. K. Role of sedges (*Cyperaceae*) in wetlands, environmental cleaning and as food material: possibilities and future perspectives. *Plant-environment interaction: responses and approaches to mitigate stress*. Hoboken, 2016, pp. 327–338. https://doi.org/10.1002/9781119081005.ch18

8. Shchetinina E. M., Gavrilova N. B., Chernopolskaya N. L., Shchetinin M. P. Soft cheese based on goat's milk for specialized nutrition. *Khranenie i pererabotka sel'khozsyr'ya = Storage and Processing of Farm Products*, 2022, no. 3, pp. 134–146 (in Russian). https://doi.org/10.36107/spfp.2021.360

9. Martynova E. R. Soft cream cheese "Philadelphia" with hydrolyzed fish collagen. *Nauchno-prakticheskie issledovaniya* [Scientific and Practical Research], 2019, no. 8-3, pp. 141–147 (in Russian).

10. Gavrilova N. B., Dunchenko N. I. Biotechnology of production of soft cheeses from a mixture of cow's and goat's milk with functional ingredients. *Syrodelie i maslodelie = Cheese- and Buttermaking*, 2023, no. 4, pp. 40–43 (in Russian). https://doi.org/10.21603/2073-4018-2023-4-1

11. Eliseeva L. I., Stepanov K. M., Egorova V. R. The use of wild berries in soft cheese technology. *Syrodelie i maslodelie = Cheese- and Buttermaking*, 2023, no. 4, pp. 44–46 (in Russian). https://doi.org/10.21603/2073-4018-2023-4-12

12. Fedorova O. S., Klyuchko N. Yu. Study on the improvement of the recipe for soft cheese with increased biological value and osteotropic orientation. *Izvestiya KGTU = KSTU News*, 2025, no. 76, pp. 74–87 (in Russian). https://doi.org/10.46845/1997-3071-2025-76-74-87

13. Mazalevskij V. B., Volonchuk S. K., Chekryga G. P., Stankevich S. V. Method of production of soft cheese with carrotpowder of functional orientation. *Polzunovskiy vestnik*, 2023, no. 3, pp. 107–114 (in Russian). https://doi.org/10.25712/ASTU.2072-8921.2023.03.014

14. Gudkov A. V. *Cheese making: technological, biological and physico-chemical foundations*. Moscow, DeLi print Publ., 2003. 799 p. (in Russian).

15. Siderko I. A., Furik N. N., Zhabnos N. K., Biruk E. N. Evaluation of the impact of *Lactobacillus delbrueckii* subsp. *Lactis* and *Lactobacillus casei* subsp. *Casei* as part of a bacterial consortium for cheese on the rate of acid formation. *Aktual'nye voprosy pererabotki myasnogo i molochnogo syr'ya: sbornik nauchnykh trudov = Topical issues of processing of meat and milk raw materials: collection of research papers*. Minsk, 2022, iss. 17, pp. 101–106 (in Russian).

16. Pavlovskaya V. V. Development of production technology for soft cheese with plant components. *Sovremennye tekhnologii sel'skokhozyaistvennogo proizvodstva: agronomiya, zashchita rastenii, tekhnologiya khraneniya i pererabotki sel'skokhozyaistvennoi produktsii: sbornik nauchnykh statei po materialam XXIV Mezhdunarodnoi nauchno-prakticheskoi konferentsii (Grodno, 23 marta, 14 maya 2021 g.)* [Modern technologies of agricultural production: agronomy, plant protection, agricultural storage and processing technology: collection of scientific articles based on the materials of the XXIV International Scientific and Practical Conference (Grodno, March 23, May 14, 2021)]. Grodno, 2021, pp. 384–385 (in Russian).

17. Gorbatova K. K., Gun'kova P. I. *Biochemistry of milk and dairy products*. 4th ed. St. Petersburg, GIORD Publ., 2010. 329 p. (in Russian).

18. Bykova M. V., Kholobova K. A., Anistratova O. V. Expansion of the range of probiotic fermented milk products through the use of raw materials of plant origin. *Nauchnoe obespechenie tekhnologicheskogo razvitiya i povysheniya konkurentosposobnosti v pishchevoi i pererabatyvayushchei promyshlennosti: sbornik materialov 3-i Mezhdunarodnoi nauchno-prakticheskoi konferentsii, 28–29 noyabrya 2023g., Krasnodar* [Scientific support for technological development and enhancement of competitiveness in the food and processing industry: proceedings of the 3rd International Scientific and Practical Conference, November 28–29, 2023, Krasnodar]. Krasnodar, 2023, pp. 326–330 (in Russian).

Information about the authors

Ksenia A. Andreychikova – Lecturer, Western Branch of the Russian Presidential Academy of National Economy and Public Administration (62, Artillery Str., 236038, Kaliningrad, Russian Federation). https://orcid.org/0009-0001-4404-0640. E-mail: xaandreychikova@mail.ru

Oksana V. Anistratova – Lecturer, Western Branch of the Russian Presidential Academy of National Economy and Public Administration (62, Artillery Str., 236038, Kaliningrad, Russian Federation); Ph. D. (Engineering), Associate Professor, Associate Professor of the Department of Food Technology, Kaliningrad State Technical University (1, Sovetsky Ave., 236022, Kaliningrad, Russian Federation). https://orcid.org/0000-0002-6278-0861. E-mail: oksana.anistratova@klgtu.ru

Marina N. Alshevskaya – Ph. D. (Engineering), Associate Professor of the Department of Food Technology, Kaliningrad State Technical University (1, Sovetsky Ave., 236022, Kaliningrad, Russian Federation). https://orcid.org/0000-0002-0632-9013. E-mail: marina.alshevskaya@klgtu.ru

Dmitry L. Alshevsky – Ph. D. (Engineering), Associate Professor of the Department of Food Technology, Kaliningrad State Technical University (1, Sovetsky Ave., 236022, Kaliningrad, Russian Federation). https://orcid.org/0000-0003-4809-2998. E-mail: alshevsky@klgtu.ru

Информация об авторах

Андрейчикова Ксения Александровна – преподаватель, Западный филиал Российской академии народного хозяйства и государственной службы при Президенте Российской Федерации (ул. Артиллерийская, 62, 236038, Калининград, Российская Федерация). https://orcid.org/0009-0001-4404-0640. E-mail: xaandreychikova@mail.ru

Анистратова Оксана Вячеславовна – преподаватель, Западный филиал Российской академии народного хозяйства и государственной службы при Президенте Российской Федерации (ул. Артиллерийская, 62, 236038, Калининград, Российская Федерация); кандидат технических наук, доцент, доцент кафедры технологии продуктов питания, Калининградский государственный технический университет (Советский пр., 1, 236038, Калининград, Российская Федерация). https://orcid.org/0000-0002-6278-0861. E-mail: oksana.anistratova@klgtu.ru

Альшевская Марина Николаевна – кандидат технических наук, доцент кафедры технологии продуктов питания, Калининградский государственный технический университет (Советский пр., 1, 236038, Калининград, Российская Федерация). https://orcid.org/0000-0002-0632-9013. E-mail: marina.alshevskaya@klgtu.ru

Альшевский Дмитрий Леонидович – кандидат технических наук, доцент кафедры технологии продуктов питания, Калининградский государственный технический университет (Советский пр., 1, 236038, Калининград, Российская Федерация). https://orcid.org/0000-0003-4809-2998. E-mail: alshevsky@klgtu.ru