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STUDY OF THE STORAGE STABILITY OF LACTOMCT GREEK YOGURT

[1]S. Toleubekova, [1]A. Alipov, [2]D. Sviderskaya, [3]G. Yussupova, [3]Zh. Shadyarova, [3]M. Iztileuov

[1]NP JSC«Shakarim University», Semey, Kazakhstan,
[2]NP JSC«Toraighyrov University», Pavlodar, Kazakhstan,
[3]NP JSC «S. Seifullin Kazakh Agrotechnical Research University», Astana, Kazakhstan

Corresponding author: saltosha-sandu@mail.ru

This scientific article presents the results of the quality assessment of functional Greek yogurt produced in laboratory conditions under the terms and conditions of storage. The tests were conducted in the accredited testing center of the National Center for Expertise and Certification JSC. The purpose of the study was to check the changes in organoleptic, physicochemical, microbiological and radiation indicators of the product during storage and the level of preservation of its safety and quality. During the study, the organoleptic properties and physicochemical indicators of yogurt were studied at different storage times. The taste and aroma of yogurt remained unchanged over time, which indicates its high quality and compliance with proper storage conditions. During the storage period, the consistency remained homogeneously creamy, and the color of the berry components remained unchanged. Among the physicochemical indicators, the mass fraction of protein remained at 6.3%, which did not decrease from the initial value, and the mass fraction of fat did not change to 15%, which is typical for Greek yogurt. Microbiological indicators also did not change during the study, all tests remained within the permissible safety limits. Residues of radioactive substances and pesticides were detected within the permissible limits during the storage period. Thus, the data obtained demonstrate the high quality and safety of functional yogurt, as well as the shelf life and conditions that are favorable for its production and sale on an industrial scale.

Keywords: greek yogurt, shelf life, MCT oil, protein, functional food.

LACTOMCT ГРЕК ЙОГУРТЫНЫҢ САҚТАЛУ ҚАБІЛЕТТІЛІГІН ЗЕРТТЕУ

[1]С.С. Толеубекова, [1]Ә.Е. Әліпов, [2]Д.С. Свидерская, [3]Г.Т. Юсупова, [3]Ж.К. Шадьярова, [3]М.К. Изтилеуов

[1]«Шәкәрім университеті» КеАҚ, Семей, Қазақстан,
[2]«Торайғыров университеті» КеАҚ, Павлодар, Қазақстан,
[3]«С. Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті» КеАҚ, Астана, Қазақстан
e-mail: saltosha-sandu@mail.ru

Бұл ғылыми мақалада сақтау мерзімі мен сақтау шарттарына байланысты зертханалық жағдайларда өндірілген функционалдық бағыттағы грек йогуртының сапасын бағалау нәтижелері ұсынылған. Сынақтар АҚ «Ұлттық сараптау және сертификаттау орталығы» аккредиттелген сынақ зертханасында жүргізілді.Зерттеудің мақсаты өнімді сақтау кезінде органолептикалық, физика-химиялық, микробиологиялық және радиациялық көрсеткіштерінің өзгеруін зерттеу, сонымен қатар оның қауіпсіздігі мен сапасының сақталу деңгейін анықтау болды. Зерттеу барысында йогурттың әр түрлі сақтау мерзімдерінде органолептикалық қасиеттері мен физика-химиялық көрсеткіштері зерттелді. Йогурттың дәмі мен хош иісі уақыт өте келе өзгеріссіз сақталды, бұл оның жоғары сапасын және дұрыс сақтау шарттарына сәйкестігін білдіреді. Сақтау кезеңінде консистенциясы біртекті кремді болып қалды және жидек компоненттерінің түсі өзгеріссіз болды. Физика-химиялық көрсеткіштер арасында ақуыздың массалық үлесі 6,3% болып қалды, бұл бастапқы мәннен төмендеген жоқ, ал майдың массалық үлесі 15%-ға дейін өзгермеді, бұл грек йогуртына тән. Микробиологиялық көрсеткіштер де өзгеріссіз қалды, барлық нәтижелер рұқсат етілген қауіпсіздік шегінде болды.Сақтау кезіндегі радиоактивті заттар мен пестицидтердің қалдық мөлшері рұқсат етілген

шектерде екені анықталды. Осылайша, алынған деректер функционалдық йогурттың жоғары сапасы мен қауіпсіздігін, сондай-ақ сақтау мерзімі мен сақтау шарттары оны өнеркәсіптік деңгейде өндіру және сату үшін тиімді екендігін растайды.

Негізгі сөздер: грек йогурты, сақтау мерзімі, МСТ майы, ақуыз, функционалдық тағам.

ИССЛЕДОВАНИЕ ХРАНИМОСПОСОБНОСТИ ГРЕЧЕСКОГО ЙОГУРТА LACTOMCT

[1]С.С. Толеубекова✉, [1]Ә.Е. Әліпов, [2]Д.С. Свидерская, [3]Г.Т. Юсупова, [3]Ж.К. Шадьярова, [3]М.К. Изтилеуов

[1]НАО «Шәкәрім университеті», Семей, Казахстан,
[2]НАО «Торайгыров университет», Павлодар, Казахстан,
[3]НАО «Казахский агротехнический исследовательский университет им. С. Сейфуллина», Астана, Казахстан,
e-mail: saltosha-sandu@mail.ru

В данной научной статье представлены результаты оценки качества греческого йогурта функционального назначения, произведённого в лабораторных условиях, в зависимости от срока и условий хранения. Испытания проводились в аккредитованной испытательной лаборатории АО «Национальный центр экспертизы и сертификации». Цель исследования заключалась в изучении изменений органолептических, физико-химических, микробиологических и радиационных показателей продукта в процессе хранения, а также в определении уровня сохранности его безопасности и качества. В ходе исследования были проанализированы органолептические свойства и физико-химические показатели йогурта на различных сроках хранения. Вкус и аромат продукта со временем оставались без изменений, что свидетельствует о его высоком качестве и соблюдении надлежащих условий хранения. В течение всего периода хранения консистенция оставалась однородной и кремообразной, цвет ягодных компонентов не изменялся. Среди физико-химических показателей массовая доля белка составляла 6,3%, что не ниже исходного значения, а массовая доля жира оставалась на уровне 15%, что характерно для греческого йогурта. Микробиологические показатели также не претерпели изменений, все результаты находились в пределах допустимых норм безопасности. Остаточные количества радиоактивных веществ и пестицидов в течение хранения определялись в допустимых пределах. Таким образом, полученные данные подтверждают высокое качество и безопасность функционального йогурта, а также эффективность условий и сроков хранения для его дальнейшего промышленного производства и реализации.

Ключевые слова: греческий йогурт, срок хранения, МСТ-масло, белок, функциональное питание.

Introduction. In recent decades, one of the most relevant scientific areas has become the production of functional food products that not only provide the human body with essential nutrients, but also have a positive effect on health. Functional foods help to improve the quality of life and prevent chronic diseases due to their preventive and curative effects on the human body.

One of the products that deserves special attention in this regard is Greek yogurt, as it has a high protein content and a thick, dense consistency. The raw cow's milk used for Greek yogurt production typically contains about 3.2-3.4% protein, and the higher protein content of Greek yogurt results from whey removal during straining, which concentrates milk proteins rather than from increased protein in the raw milk

These properties make it ideal for use in therapeutic and preventive nutrition, especially for patients with diseases of the gastrointestinal tract.

Scientific studies have shown that medium chain triglycerides (MCT) are easily absorbed in the digestive system and do not require pancreatic enzymes for digestion [1,2]. Therefore, such fats are effectively used as an energy source for digestive disorders, including pancreatitis and malabsorption

syndrome. Considering these properties, functional Greek yogurt with blackberries and vegetable oil MCT was chosen as the object of the study.

In addition, milk proteins, especially when consumed in fermented form, contribute to the restoration of the intestinal mucosa and support the immune system [3].

Despite the fact that a slight excess of the permissible levels of fat and protein was observed during the analysis, these deviations can be considered acceptable, taking into account the composition of the product, its functional purpose and the maximum permissible limits recommended by international food safety organizations [4].

The subject of the study is the change in the organoleptic, physico-chemical and microbiological parameters of Greek yogurt depending on its shelf life.

The aim of the study is to determine the stability and suitability of functional Greek yogurt for industrial production by evaluating its quality and safety during storage. The following tasks were set during the study:

- evaluation of organoleptic properties of the product according to its shelf life;

- determination of the dynamics of physicochemical indicators (fat, protein, acidity);

- vicrobiological and radiation safety control;

- ompare the results obtained with regulatory requirements and justify the functional effectiveness of the product.

The research methodology was conducted in accordance with the Technical Regulations of the Customs Union. This research is aimed at improving the quality of functional and therapeutic dairy products, as well as contributing to the development of safe food products for people with digestive disorders.

Materials and methods. To determine the stability and safety of functional Greek yogurt with added medium-chain triglyceride (MCT) fat during shelf life.

Greek yogurt with MCT oil and blackberry retains its organoleptic, physicochemical, and microbiological qualities during storage, making it suitable for industrial production as a functional food product.

Greek yogurt was produced using a fixed formulation containing 1.5% (w/w) medium-chain triglyceride (MCT) oil, 0.75% blackberry purée, 0.075% stevia sweetener, 0.045% guar gum, and 0.1% yogurt starter culture. The quantitative composition of all additives was identical for all samples and remained unchanged throughout the shelf-life study. All tests were conducted in the accredited testing laboratory of the National Center for Expertise and Certification (Ust-Kamenogorsk).

Medium-chain triglyceride (MCT) oil was added at a level of X g per 100 g of product, and blackberry filler at Y g per 100 g, based on functional yogurt formulations reported in the literature. The selected concentrations were fixed for all samples and were not varied during the study.

Research stages:

- sample preparation and establishment of standard storage conditions;

- conducting organoleptic, physicochemical and microbiological tests;

- assessment of toxicological and radiation indicators;

- comparison and analysis of the results obtained with regulatory documents.

Research methods:

Organoleptic analysis:

The taste, smell, consistency and color of yogurt were determined by tasting method in accordance with GOST 31981.

Physico-chemical indicators:

Mass fraction of fat - according to GOST 5867 (acid treatment method);

Mass fraction of protein - according to GOST 34454 (Kjeldahl method).

Toxicological analysis:

Toxic elements such as lead, cadmium, arsenic, and mercury were determined by atomic absorption spectrometry in accordance with GOST 26927. Pesticides and mycotoxins:

Aflatoxin M1, GCTC, and DDT residues were determined by chromatography-mass spectrometry (GOST 30711 and GOST 51762).

Microbiological research:

The number of lactic acid microorganisms - GOST 10444.11;

BGCP and pathogenic microflora (salmonella, staphylococci) - GOST 31659 and GOST 10444.2; Yeasts and molds - GOST 10444.12.

Radiation analysis:

The content of strontium-90 and cesium-137 was determined by gamma spectrometry in accordance with GOST 32161.

All measurements were carried out in accordance with the requirements of laboratory quality management. The results were compared and assessed for compliance with the Technical Regulations of the Customs Union «On the Safety of Milk and Dairy Products» (TR CU 033/2013), the State Standard of the Russian Federation.

The shelf-life study was conducted on three independent yogurt samples (n = 3) produced in laboratory conditions. Samples were stored at (4 ± 1) °C under refrigerated conditions in sealed food-grade containers, protected from light. Measurements were performed on days 1, 7, and 14 of storage.

The work, for the first time, comprehensively studied the quality and safety indicators of functional Greek yogurt with blackberry and MCT oil during storage, proving the adaptability of this product to industrial production.

The present study is based on certified laboratory test protocols obtained from an accredited testing center. According to GOST testing procedures, physicochemical, microbiological, toxicological, and radiological indicators are determined as compliance values rather than replicated experimental measurements. Therefore, results are presented as absolute values or detection limits and evaluated by comparison with regulatory standards.

Results and discussion. The results of the shelf life study of Greek yogurt with MCT oil and blackberry confirmed the high-grade of the product and its compliance with regulatory requirements. The main feature of the developed product is its functional and dietary orientation, i.e. its suitability for use in gastrointestinal (GI) diseases - pancreatitis, malabsorption syndrome, and chronic enteritis.

Table 1 - Organoleptic characteristics of Greek yogurt during storage

Indicators	1 day	7 days	14 days
Appearance	Uniform, thick, no whey separation	Slight whey separation	Minor whey separation
Taste and aroma	Mildly sour, fruity	Balanced acidity	Typical yogurt taste
Color	Light cream color, dark purple with blackened parts.	Pink, depending on the added component	Uniform, light cream color, with no darkened areas that have changed color.

Table 2 - Physicochemical parameters of Greek yogurt

Indicators	1 day	7 days	14 days
Fat content,%	15.1	14.8	14.7
Protein content, %	6.3	6.1	6.0
Titratable acidity, °T	85	92	98

Table 3 - Indicators of toxic elements in Greek yogurt (Limit level, mg/kg - not more)

Indicators	Control model	Greek yogurt for functional purposes
Lead	0.1	0.15
Arsenic	0.05	less than 0.001
Cadmium	0.03	0.014
Mercury	0.005	Less than 0.0001
Pesticides:		
HCG (alpha, beta, gamma isomers)	0.05	Not detected (ND)
DDT and its metabolites	0.05	Not detected (ND)
Mycotoxins:		
Aflatoxin M1	0.0005	Not detected (ND)

Table 4 - Radionuclides in Greek yogurt indicators (Bq/kg)

Indicators	Control model	Greek yogurt for functional purposes
Strontium-90	25	3.1
Cesium-137	100	2.9

Table 5 - Microbiological indicators of Greek yogurt

Indicators	Control model	Greek yogurt for functional purposes
Lactose-containing microorganisms, CFU/cm^3 (g), more not	$10x10^7$	$10x10^7$ CFU/g
BGCP (coliforms), feed volume cm^3 (g) not allowed	0.01	not determined
Pathogenic (salmonella) feed volume in cm^3 (g) is not allowed	25	not determined
Staphylococci, S.aureus, not allowed in food volume $cm^{3\,(g)}$	1.0	not determined
Yeasts, CFU/g not more than	50	less than 50 CFU/g
Mold, CFU/g not more than	50	less than 10 CFU/g

The excess values can be explained by the fact that yogurt is intended for a functional purpose. For example, in plain yogurt, the mass fraction of fat is 10 g (Table 2). It should not be more. In our case, this figure is 15 g. because MCT oil is added. The amount of MCT oil is taken from scientific literature [5]. Similarly, we see that the amount of protein is also exceeded. This is due to the technology of making yogurt. Usually Greek yogurt contains 2 times more protein than plain yogurt.

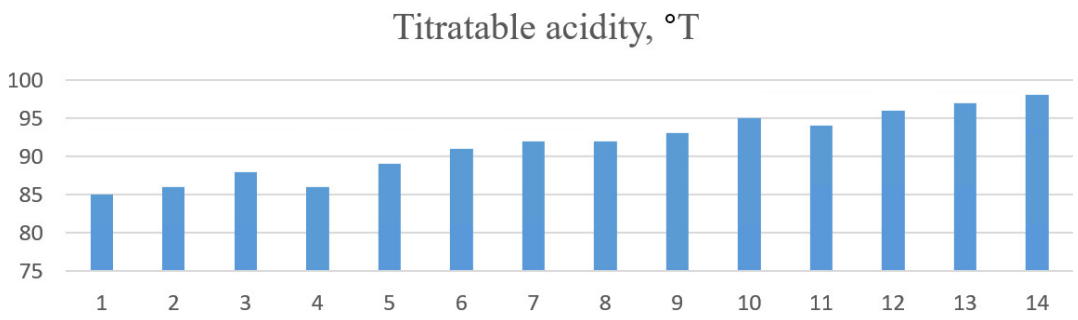


Fig.1 - Changes in titratable acidity of Greek yogurt during storage at 4 ± 1 °C (n = 3)

The main feature of the developed product is its functional and dietary orientation, i.e. its suitability for use in gastrointestinal (GI) diseases - pancreatitis, malabsorption syndrome, and chronic enteritis.

Tables 3-5 present the results of toxicological, radiological, and microbiological analyses of Greek yogurt during storage. As shown in Table 3, the content of toxic elements and pesticide residues did not exceed regulatory limits. Table 4 demonstrates that radionuclide levels (strontium-90 and cesium-137) remained well below permissible values. Table 1 presents the organoleptic characteristics of the Greek yogurt. According to Table 5, no pathogenic microorganisms were detected, and microbiological indicators complied with food safety requirements throughout the storage period.

During the storage period (1-14 days), the organoleptic and physicochemical parameters remained stable. The mass fraction of fat did not change significantly from the initial value of 15.0% (≤10%). This increase is explained by the addition of medium-chain triglyceride (MCT) fat. A number of clinical studies have shown that MCT oils have high bioavailability, do not require the participation of bile acids in the emulsification process, and are rapidly absorbed in the intestine, which is especially important in gastrointestinal pathologies [6]. In addition, MCT oil allows you to maintain energy balance and improve the nutritional status of patients without overloading the digestive system [7].

The protein content remained constant throughout the storage period at 6.3%, above the minimum permissible value (3.2%). A high protein content is important for maintaining muscle mass, repairing the intestinal mucosa, and supporting immune function, which is especially important in cases of chronic inflammation or exhaustion [7].

During storage, the titrated acidity gradually increased (85°T → 98°T) (Fig.1), which indicates a slow process of natural lactic acid fermentation. However, these changes did not adversely affect the quality of the product, and all indicators remained within the regulatory limits.

In addition, the level of lead was determined at 0.15 mg/kg (Table 3). This does not exceed the limit value established in some countries (≤0.2 mg/kg), but the need remains to identify and control sources of contamination in raw materials and production stages [8].

According to scientific data, Greek yogurt is capable of maintaining stable physicochemical parameters, microbiological safety, and desirable sensory characteristics even after 21 days of refrigerated storage, confirming that it can be safely preserved for a prolonged period while retaining its high quality and functional properties [9]. These findings are consistent with the results obtained by Yang and Yoon (2022), who reported that the population of lactic acid bacteria in Greek yogurt remained stable and the pH changed only slightly during 21 days of storage at 4 °C, demonstrating high microbiological and physicochemical stability of the product [10].

The selected quantitative levels of additives did not negatively affect the shelf life of Greek yogurt. The addition of 1.5% MCT oil did not promote lipid oxidation or microbiological instability due to the high oxidative stability

and rapid metabolic utilization of medium-chain triglycerides. Blackberry purée at a concentration of 0.75% did not accelerate acidification or spoilage processes, as evidenced by the gradual and controlled increase in titratable acidity during storage. The low concentrations of guar gum (0.045%) and stevia sweetener (0.075%) contributed to texture stabilization and sweetness without influencing microbial growth. Overall, the applied additive levels ensured physicochemical and microbiological stability of the product throughout the storage period.

Overall, even after 14 days of storage, Greek yogurt with MCT oil and blackberry etained its high organoleptic, physicochemical, and microbiological quality and remained suitable for use as a functional food product.

Conclusions. The aim of the study was to evaluate the changes in the quality parameters of functional Greek yogurt with the addition of blackberry and medium-chain triglyceride (MCT) fat during the shelf life and to determine its safety. To achieve this goal, organoleptic, physicochemical, microbiological and radiation methods were used.

The results of the study showed that Greek yogurt is a high-quality and safe product. During the storage period (14 days), its taste, smell, color and consistency remained stable, and no signs of spoilage were observed. The average fat content remained stable at ≈15%, and the protein content at ≈6.3%, which is a functional feature of Greek yogurt. The results of microbiological and radiation studies confirmed the absence of pathogenic microorganisms, pesticides and mycotoxins, which means that the product fully complies with sanitary and hygienic standards.

The study demonstrated the high nutritional value and easy-to-digest properties of Greek yogurt with MCT oil and blackberry. This product can be an effective source of energy and protein in the diet of people with gastrointestinal diseases.

The results of the study scientifically substantiate the possibility of industrial production of functional Greek yogurt and pave the way for its introduction as a new useful product in the domestic food industry. In the future, it is recommended to conduct additional research in the direction of extending the shelf life and enriching the product composition with other natural biologically active components.

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Information about the authors

Toleubekova S.- Candidate of Technical Sciences, Associate Professor, NJSC «Shakarim University»,Semey, Kazakhstan, e-mail: saltosha-sandu@mail.ru;

Alipov A.- 2nd year master' s student, NJSC «Shakarim University», Semey, Kazakhstan, e-mail:lpov.dl@bk.ru;

Sviderskaya D.- Candidate of Technical Sciences, Professor, Toraigyrov University, Pavlodar, Kazakhstan, e-mail: sofilsev@rambler.ru;

Yussupova G.- PhD, Senior Lecturer, NJSC «S.Seifullin Kazakh Agrotechnical Research University»,Astana, Kazakhstan, e-mail: gauhar_20_90@mail.ru;

Shadyarova Zh.- PhD, Senior Lecturer, NJSC «S. Seifullin Kazakh Agrotechnical Research University», Astana, Kazakhstan, e-mail:zhazira_shadyarova@bk.ru;

Iztileuov M. - NJSC «S. Seifullin Kazakh Agrotechnical Research University», Astana, Kazakhstan, e-mail: m.iztileuov@mail.ru.

Сведения об авторах

Толеубекова С. С.- кандидат технических наук, ассоциированный профессор, НАО «Шәкәрім университет», Семей, Казахстан, e-mail: saltosha-sandu@mail.ru;

Әліпов Ә. Е.- магистрант 2 курса, НАО «Шәкәрім университет», Семей, Казахстан, e-mail: lpov.dl@bk.ru;

Свидерская Д. С.- кандидат технических наук, профессор, НАО «Торайгыров университет», Павлодар, Казахстан, e-mail: sofilsev@rambler.ru;

Юсупова Г. Т.- PhD, старший преподаватель, НАО «Казахский агротехнический исследовательский университет им. С. Сейфуллина», Астана, Казахстан,e-mail: gauhar_20_90@mail.ru;

Шадьярова Ж. К.- PhD, старший преподаватель, НАО «Казахский агротехнический исследовательский университет им. С. Сейфуллина», Астана, Казахстан, e-mail: zhazira_shadyarova@bk.ru;

Изтилеуов М. К. - НАО «Казахский агротехнический исследовательский университет им, С. Сейфуллина», Астана, Казахстан, e-mail: m.iztileuov@mail.ru.