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A. Mustafayeva*, B. Leonidova[1], G. Sharikbaeva[1], V. Akhmetova[1], A. Utegenova[2]
[1]S. Seifullin Kazakh Agro Technical Research University,
010011, Republic of Kazakhstan Astana, Zhenis avenue, 62.
[2]Shakarim University, 071412, Republic of Kazakhstan, Semey, 20 A, Glinki str.
e-mail: ayaulym.mustafa@mail.ru

IMPROVEMENT OF THE TECHNOLOGY FOR PRODUCING A FERMENTED MILK BEVERAGE BASED ON GOAT'S MILK

Abstract: *The present study was aimed at improving the formulation and production technology of goat milk yogurt through the replacement of refined sugar with natural sweeteners. Four formulations were prepared: a control sample containing sucrose and experimental samples containing Jerusalem artichoke extract, erythritol, or stevia extract. Yogurt was produced by a controlled fermentation process, and its organoleptic and physicochemical characteristics were evaluated. The experimental samples showed physicochemical properties comparable with those of the control. Total solids ranged from 15.4 to 15.7%, titratable acidity from 93 to 106 °T, pH from 4.5 to 4.7, fat from 4.0 to 4.3%, lactose from 4.5 to 4.8%, and protein from 3.3 to 3.5%. The addition of natural sweeteners affected sensory characteristics without adversely affecting fermentation or the main quality indicators. The Jerusalem artichoke sample had a caramel-like flavour and brownish colour, the erythritol sample had a refreshing sweet taste, and the stevia sample had a sweet taste with slight sourness. The results demonstrate that refined sugar can be replaced with selected natural sweeteners in goat milk yogurt while maintaining the required physicochemical and organoleptic characteristics. The developed formulations may be used as a basis for producing fermented dairy products with reduced added sucrose and improved sensory diversity.*

Key words: *goat milk, yogurt, natural sweeteners, stevia, erythritol, Jerusalem artichoke.*

Introduction

The safety and quality of food products represent a cornerstone of public health, making the study of food safety a topic of ongoing relevance. In recent years, several critical dietary challenges have emerged in our country, including excessive salt consumption, high levels of trans fats in processed foods, and the rapid increase in the intake of sugar and sugar-containing products. Addressing these issues effectively requires a thorough understanding of their underlying mechanisms, causes, and potential health implications.

One of the most pressing concerns is overconsumption of sugar, which is especially prevalent among school-aged children. Current statistics indicate that nearly half of this population regularly consumes sugar-containing foods and beverages [1]. Excessive sugar intake is associated with numerous health risks, including weight gain, diabetes, elevated cardiovascular risk, and a range of metabolic complications. Beyond these chronic conditions, high sugar consumption also contributes to overstimulation of the nervous system, resulting in increased restlessness and behavioral disturbances among children.

Given these risks, it is essential to explore strategies aimed at reducing sugar consumption. The World Health Organization recommends that adults limit their daily intake of pure sucrose to no more than 25 grams, with children advised to consume even less [2]. One promising approach involves replacing refined sugar with fruits or naturally derived sweeteners, which can provide sweetness while reducing negative metabolic impacts.

Not all natural sweeteners are equivalent in terms of caloric content; however, stevia was selected for this study due to its low glycemic index and its ability to provide sweetness without causing significant blood glucose spikes. This investigation therefore focuses on the production of fermented milk beverages using stevia as a natural sweetener. Such beverages not only deliver essential nutrients but also contain phytochemicals that support cardiovascular health, modulate blood sugar and insulin levels, and promote overall well-being. Plant-based components contribute dietary fiber, minerals, and antioxidants, while dairy ingredients supply high-quality proteins and calcium, creating a product that is both nutritionally rich and functionally beneficial [3].

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Among functional dairy products, yogurt prepared from goat milk with natural sweeteners presents notable advantages. Goat milk is known for its digestibility and high nutrient bioavailability, making it particularly suitable for populations with sensitive digestive systems [4]. The consumption of goat milk yogurt offers several health benefits:

- Probiotic cultures enhance gastrointestinal function, supporting healthy digestion.
- It is an appropriate alternative for individuals with cow's milk intolerance.
- Rich in calcium and phosphorus, it strengthens bones and supports hair, nail, and dental health.
- It is beneficial for pregnant women and children prone to diathesis.
- The probiotic content makes it suitable for children with atopic dermatitis.
- Its low caloric content allows inclusion in weight management diets.

Despite its relatively high fat content, goat milk does not significantly contribute to fat accumulation. Its combination of macro- and micronutrients, vitamins, and minerals helps prevent deficiencies and mitigates complications associated with excessive body weight [5].

Natural sweeteners are typically derived from sugar-containing plants through various processing methods, providing energy while being metabolized slowly, thus preventing rapid fluctuations in blood glucose. In contrast, excessive consumption of refined sugar can lead to abrupt changes in blood glucose levels, disrupting neuronal activity, triggering false hunger, and promoting overeating. Lipid metabolism may also be impaired, cholesterol levels can increase, vascular permeability may change, and the risk of atherosclerosis and cardiovascular disorders rises [6].

Refined sugar is a primary contributor to digestive disturbances, hypoglycemia, and metabolic dysfunction, while artificial sweeteners such as aspartame, saccharin, and sucralose, despite their low caloric value, can still contribute to weight gain and fail to provide essential micronutrients. Against this backdrop, the present study emphasizes the development of goat milk yogurt formulations using natural sweeteners, offering a promising approach to producing nutritionally and biologically valuable dairy products with reduced sugar content.

Materials and methods. Yogurt is produced using the thermostatic method according to GOST 31812-2013 "Yogurts. General technical specifications." The quality indicators of the finished yogurt product made from goat milk with added natural sweeteners were studied in the laboratory of the pilot production workshop for dairy processing. Protein content was determined according to GOST 25176, carbohydrate content according to GOST 3628, and acidity according to GOST 3624-92 «Milk and dairy products. Titrimetric methods for determining acidity» [7, 8].

The material used in the study was goat milk, a type of milk commonly consumed by humans. Goat milk is highly nutritious and contains more beneficial substances compared to cow's milk.

Literature review. Goat milk is known for its higher content of proteins, fats, calcium, and vitamins A and D when compared to cow's milk. Despite its relatively higher fat content, consumption of goat milk does not lead to increased body fat accumulation. Additionally, goat milk provides a diverse range of microelements, macroelements, minerals, and vitamins, which can help prevent deficiencies and support nutritional balance, particularly during weight management programs.

Stevia, a natural zero-calorie sweetener, has long been utilized both as a sugar substitute and as a flavor enhancer. Historically, it has served as a bio-sweetener and traditional remedy for diabetes, with scientific studies confirming its ability to regulate blood glucose levels. Beyond its sweetening properties, stevia demonstrates anti-inflammatory, antioxidant, anticancer, and antibacterial effects. The recommended daily intake for stevia is approximately 40 g [9], and research highlights its potential benefits for individuals seeking weight reduction, diabetic patients, and children.

The stevia plant is native to South America, where local populations first employed its leaves to sweeten beverages or chewed them for their natural sweetness roughly 200 years ago. Commonly referred to as the "sweet herb," stevia leaves were traditionally dried and used to enhance the flavor of teas, medicinal preparations, or consumed as a natural sweet snack. Commercial stevia extracts were first introduced in Japan during the 1970s and have remained popular there. Today, stevia is also cultivated in countries such as China, the United States, Paraguay, Kenya, Vietnam, Brazil, India, and Colombia.

The sweet taste of stevia is attributed to naturally occurring steviol glycosides present in the leaves. Over 11 types of glycosides are found in stevia, with rebaudioside A and stevioside being the most abundant. Purified stevia extracts may contain one or several glycosides and can be

approximately 200-250 times sweeter than sucrose [10]. More than 100 phytochemicals have been identified in stevia, including apigenin, austroulin, beta-sitosterol, cosmosin, humic acids, luteolin, stigmasterol, and xanthophylls. The slightly acidic taste present in fresh or dried leaves is eliminated in processed dry or liquid extracts. Importantly, stevia and its metabolites do not accumulate in the human body, and its caloric contribution is negligible, allowing purified extracts to be considered effectively zero-calorie.

Erythritol is another natural, non-caloric sugar substitute that does not affect blood glucose levels. It naturally occurs in grains, corn, mushrooms, berries, and fruits. Numerous studies, numbering around 2,000, have demonstrated that erythritol has favorable dietary properties compared to sugar and fructose. It does not disrupt the intestinal microbiota because approximately 90% is absorbed before reaching the colon, with the remainder being excreted through the kidneys. Erythritol has a zero glycemic index and, unlike conventional sugar, does not promote oral bacterial growth, thereby reducing the risk of dental caries [11].

Jerusalem artichoke, or topinambur, is a highly nutritious vegetable crop. Its primary constituents are inulin and fructose, which account for roughly 80% of the plant's dry matter. Inulin is unique as a natural polysaccharide composed solely of fructose units. Jerusalem artichoke also provides higher levels of vitamins B1, B2, B3, and C compared to potatoes, and three times more than carrots or beets. Notably, the tubers of Jerusalem artichoke contain about 3.2% protein, comprising eight essential and non-essential amino acids, including arginine, valine, histidine, isoleucine, leucine, lysine, methionine, threonine, tryptophan, and phenylalanine [12].

A comparative analysis of the natural sweeteners examined in this study is presented in Table 1.

Table 1 – Comparative analysis of natural sweeteners

Component	Erythritol	Stevioside	Jerusalem Artichoke
Additive code	E968	E960	HS Code 1702608000
Raw material	Sugar alcohol	Stevia leaves	Tubers or seeds
Form	Crystalline powder	Powder, tablets, liquid extract	Powder, pulp, juice
Taste	Sweet, cool sensation	Slightly bittersweet	Pleasant, sweet, nutty
Composition	High starch content, traces of fat and alcohol	Minerals, vitamins, flavonoids	Proteins, minerals, inulin, fructose, vitamins
Caloric value (per 100 g)	20 kcal	18 kcal	267 kcal
Glycemic index	0	0	13-15
Sweetness coefficient	70% of sugar	200-250 times sweeter than sugar	2 times sweeter than sugar
Absorbability	Good	Good	Good
Drawbacks	Requires high consumption for effect	Can taste bitter if added in excess	High in fructose, thus relatively caloric

Natural sweeteners provide the desired sweetness in foods without contributing additional calories or causing significant increases in blood glucose levels.

In the present study, a standard yogurt formulation containing 6% sugar was prepared. Yogurt produced from goat milk combines the nutritional benefits of the milk itself with the functional properties of lactic acid bacteria, resulting in a product that is both healthy and nutrient-rich. Its composition includes water, proteins, fats, carbohydrates, and essential minerals (Table 2).

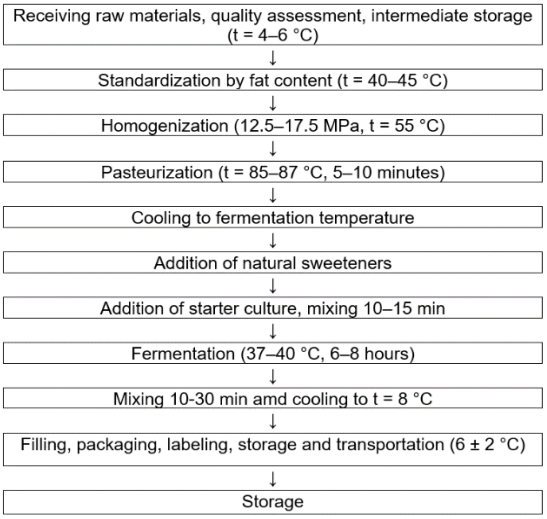
Table 2 – Formulation of traditional yogurt and yogurt with natural sweeteners

Yogurt	№ 1 (Control)	№ 2	№ 3	№ 4
Goat milk	1000 L	1000 L	1000 L	1000 L
Yogurt starter	3 kg	3 kg	3 kg	3 kg
Stevia extract	-	-	-	0.24 L
Erythirtol powder	-	-	85 kg	-
Jerusalem artichoke extract	-	30 L	-	-
Sugar	60 kg	-	-	-
Total	1063 kg	1033 kg	1088 kg	1003.24 kg

Following a comprehensive evaluation of available sugar substitutes, three natural sweeteners were selected to replace conventional sugar in the yogurt formulation: erythritol powder, Jerusalem artichoke (topinambur) extract, and stevia extract. These ingredients were chosen for their ability to maintain the sensory quality of the yogurt while providing additional nutritional or functional benefits.

Based on the use of natural sweeteners, a specific formulation and production technology for goat milk yogurt were established. The experimental work was carried out at the pilot dairy processing workshop of the Department of “Food and Processing Industry Technology” at S. Seifullin Kazakh Agro-Technical Research University.

The technological process for producing goat milk yogurt incorporating natural sweeteners is illustrated in Figure 1, providing a clear overview of the steps involved in fermentation, ingredient integration, and product maturation.



Figire 1 – Technological scheme for Yogurt preparation

Overall, the inclusion of natural sweeteners enhances the organoleptic qualities of yogurt, particularly its taste and aroma. However, achieving a flavor and texture profile that closely resembles the natural product requires careful selection of an appropriate and balanced quantity of additives.

Results and Discussion

Stevia and erythritol exhibit excellent solubility in water, remain stable during heat treatment, and do not interfere with the fermentation process. These characteristics make them highly suitable for use in food production. Additionally, stevia possesses biologically active properties that contribute to the regulation of multiple physiological functions, support immune system performance, and assist in lowering blood pressure [13].

The primary constituents of goat milk yogurt include water, proteins, fats, carbohydrates, and minerals. Water represents the largest proportion of the product, while proteins play a key role in tissue growth and repair. Fats facilitate the absorption of fat-soluble vitamins and serve as a source of energy. Carbohydrates, mainly lactose, provide additional energy, and minerals are essential for the maintenance of healthy bones and teeth. Furthermore, yogurt positively impacts digestive health and supports a balanced gut microbiota. The presence of live cultures and probiotics strengthens the immune system and contributes to overall health. A detailed chemical composition of the yogurt is provided in Table 3.

Table 3 – Chemical composition of yogurt

Component	№ 1 (Control)	№ 2	№ 3	№ 4
Energy value, kcal/ kJ	68,2 / 286,4	68,2 / 286,4	68,6/288,1	66/277,2
Protein, g	3,3	3,3	3,4	3,5
Fat, g	4,2	4,3	4,2	4,0
Carbohydrate, g	4,3	4,3	4,3	4,0
Water, g	87,58	87,58	87,55	87,5
Ash, g	0,82	0,83	0,85	0,80

The organoleptic properties of yogurt are assessed based on its type, composition, aroma, consistency, taste and color, i.e., evaluated using the sense of smell and taste. The orgabolpetic properties of goat milk yogurt are presented in Table 4.

Table 4 – Organoleptic properties of goat milk yogurt

№	Sample	Consistency	Aroma and Taste	Color
1	MEST standard sample	Homogeneous, moderately viscous. With stabilizer, resembles jelly or cream.	Sour milk, no other taste or aroma.	Milk-white, evenly distributed components
2	Control sample	Homogeneous, moderately viscous	Clean sour milk, slightly sweet	Milk-white
3	Sample with Jerusalem artichoke	Homogeneous, creamy, slightly viscous	Sweet caramel taste	Brownish, depending on additive
4	Sample with erythritol	Homogeneous, thick liquid	Sweet, refreshing taste	Milk-white
5	Sample with stevia	Homogeneous, moderately viscous	Sweet with slight sourness	Light milk-white

The table shows the organoleptic properties of yoguert made from goat milk with different natural sweeteners. The yogurt had typicsl properties: sweet, without foreign tastes or odors, characteristic of fermented milk products.

Table 5 presents the physicochemical properties of yogurt made from goat milk with natural sweeteners (stevia, erythritol, Jerusalem artichoke) and with sugar.

Table 5 – Physicochemical properties of goat milk yogurt with natural sweeteners

Product	Total Solids (TS)	Acidity (°T)	pH	Fat (%)	Lactose (%)	Protein (%)
Control sample	15.7	94°T	4.5-4.7	4.0-4.3	4.8	3.3-3.5
Sample with Jerusalem Artichoke	15.6	93°T	4.5-4.7	4.0-4.3	4.8	3.3-3.5
Sample with Erythritol	15.5	93°T	4.5-4.7	4.0-4.3	4.5	3.3-3.5
Sample with stevia	15.4	95°T	4.5-4.7	4.0-4.3	4.5	3.3-3.5

The density, acidity, pH, fat content, lactose, and non-fat milk solids (NFMS) of yogurt made from goat milk with added natural sweeteners (stevia, erythritol, Jerusalem artichoke) and sugar are shown. From the table, the composition of yogurt with natural sweeteners does not differ significantly from the control sample. Figure 2 shows samples of yogurt made from hoat milk with natural sweeteners.



Figure 2 – Samples of yogurt

The findings of this study indicate that goat milk yogurt enriched with erythritol, stevia, and Jerusalem artichoke exctract meets standard requirements for both physicochemical and organoleptic properties. This formulation is particularly beneficial for individuals managing excess weight or diabetes, and it supports gastrointenstinal health due to the presence of beneficial microorganisms and non-digestable carbohydrates that exhibit synergistic effects.

Conclusion

Yogurt produced from goat milk with the addition of natural sweeteners – stevia, erythritol, and Jerusalem artichoke – exhibited characteristics comparable to conventional yogurt containing sugar. Utilizing goat milk instead of cow's milk offers multiple advantages, including lower lactose content and higher concentrations of essential nutrients. For the production process, the thermostatic

(tank) fermentation method was selected, as it is economically efficient and allows for uniform incorporation of sweeteners with the starter culture, reducing overall production costs.

From an organoleptic perspective, the yogurt demonstrated a smooth, dense, and uniform texture. The addition of natural sweeteners increased the mixture's viscosity, while the color reflected the light brown tint imparted by Jerusalem artichoke. The flavor profile was moderately sweet, with a noticeable caramel-like note.

Over a 10-day observation period, the yogurt maintained stable organoleptic properties, showing no significant deviations in taste, color, aroma, or consistency compared to the control sample. The product preserved a uniform texture, free from sedimentation or discoloration, and retained a clean taste and pleasant aroma without off-flavors, indicating high-quality standards. Acidity was monitored during storage, remaining within 94-106 °T, confirming the product's suitability for consumption.

Overall, yogurt with natural sweeteners exhibited high quality, long shel life, a delicate consistency, and a favorable taste. Measured parameters included a pH of 4.5-4.7, non-fat milk solids (NFMS) of 15.6%, and a density of 1.040 g/cm³.

These results provide valuable guidance for the industrial-scale production of goat milk yogurt with natural sweeteners. The study highlights the potential for developing new products and enhancing existing formulations.

In summary, incorporating Jerusalem artichoke, erythritol, and stevia as natural sweeteners enables the production of goat milk yogurt that maintains its physicochemical properties, delivers health benefits, offers preventive and restorative effects, remains economically viable, and results in a fermented milk product with a pleasant taste that effectively masks the distinctive flavor of goat milk.

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А.К. Мустафаева[*], Б.Л. Леонидова[1], Г.Ж. Шарикбаева[1], В.Ш. Ахметова[1], А.О. Утегенова[2]
[1]Казахский агротехнический исследовательский университет имени Сакена Сейфуллина, Казахстан, 010011, Астана, пр. Женис 62
[2]Шәкәрім университет, 071412, Республика Казахстан, г. Семей, ул. Глинки, 20 А
e-mail: ayaulym.mustafa@mail.ru

СОВЕРШЕНСТВОВАНИЕ ТЕХНОЛОГИИ ПРОИЗВОДСТВА КИСЛОМОЛОЧНОГО НАПИТКА НА ОСНОВЕ КОЗЬЕГО МОЛОКА

Целью данного исследования было совершенствование рецептуры и технологии производства йогурта из козьего молока путем замены рафинированного сахара натуральными подсластителями. Были подготовлены четыре варианта продукта: контрольный образец, содержащий сахарозу, и опытные образцы с добавлением экстракта топинамбура, эритрита или

экстракта стевии. Йогурт изготавливали методом контролируемой ферментации, после чего оценивали его органолептические и физико-химические показатели. Физико-химические свойства опытных образцов оказались сопоставимы с показателями контрольного образца. Содержание сухих веществ варьировалось от 15,4 до 15,7%, титруемая кислотность – от 93 до 106°Т, pH – от 4,5 до 4,7, массовая доля жира – от 4,0 до 4,3%, лактозы – от 4,5 до 4,8%, белка – от 3,3 до 3,5%. Использование натуральных подсластителей повлияло на органолептические свойства, не оказывая при этом негативного воздействия на процесс ферментации или основные показатели качества. Образец с топинамбуром отличался карамельным привкусом и коричневатым оттенком, образец с эритритом имел освежающий сладкий вкус, а образец со стевией – сладкий вкус с легкой кислинкой. Результаты исследования подтверждают возможность замены рафинированного сахара на выбранные натуральные подсластители при производстве йогурта из козьего молока с сохранением требуемых физико-химических и органолептических характеристик. Разработанные рецептуры могут служить основой для производства кисломолочных продуктов с пониженным содержанием добавленной сахарозы и более разнообразными органолептическими свойствами.

Ключевые слова: *козье молоко, йогурт, натуральные подсластители, стевия, эритрит, топинамбур.*

А.К. Мустафаева[*], Б.Л. Леонидова[1], Г.Ж. Шарикбаева[1], В.Ш. Ахметова[1], А.О. Утегенова[2]
[1]Сәкен Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті,
Қазақстан Республикасы, 010011, Астана қаласы, Жеңіс даңғылы 62
[2]Шәкәрім университеті, Қазақстан Республикасы, 071412, Семей қ., Глинка к-сі, 20 А
*e-mail: ayaulym.mustafa@mail.ru

ЕШКІ СҮТ НЕГІЗІНДЕГІ СҮТҚЫШҚЫЛДЫ СУСЫН ӨНДІРУ ТЕХНОЛОГИЯСЫН ЖЕТІЛДІРУ

Ұсынылып отырған зерттеу жұмысы йогуртқа қосылатын табиғи қантты табиғи тәттілендіргіштермен алмастыру арқылы ешкі сүтінен әзірленген йогурттың рецептурасын және өндіру технологиясын жетілдіруге арналған. Зерттеу барысында өнімнің төрт үлгісі дайындалып алынды: қант қосылған йогурттың бақылау үлгісі, топинамбур сығындысы, эритрит ұнтағы және стевия сығындысы қосылған үлгілер дайындалды. Йогуртты ұйытындыны бақылау әдісімен өндірілді, содан кейін дайын өнімнің органолептикалық және физика-химиялық көрсеткіштері бағаланды. Табиғи тәттілендіргіш қосылған йогурттардың көрсеткіштері бақылау үлгісіне сәйкес болды. Құрғақ заттардың мөлшері 15,4-тен 15,7% -ға дейін, титрленетін қышқылдығы 93-тен 106 °Т-ге дейін, pH 4,5-тен 4,7-ге дейін, майдың массалық үлесі 4,0-ден 4,3% -ға дейін, лактоза 4,5-тен 4,8% -ға дейін, ақуыз 3,3-тен 3,5% -ға дейін өзгерді. Табиғи тәттілендіргіштерді қолдану йогуртты ұйыту процесіне немесе негізгі сапа параметрлеріне кері әсер етпестен органолептикалық қасиеттерін жақсартты. Топинамбур қосылған үлгі карамельді дәм мен қоңыр реңкті, эритрит қосылған үлгі сергітетін тәтті дәмді, ал стевия қосылған үлгі тәтті жеңіл қышқыл дәмі тәтті өнім болып табылды. Зерттеу нәтижелері ешкі сүтінен жасалған йогурт өндірісінде қажетті физика-химиялық және органолептикалық сипаттамаларды сақтай отырып, ақ қантты табиғи тәттілендіргіштермен алмастыру мүмкіндігін растайды. Зерттеу нәтижесінде ешкі сүті негізінде табиғи тәттілендіргіштер стевия, эритритол және топинамбур қосылған сүтқылды сусынның құрамындағы қанттың мөлшері аз және органолептикалық көрсеткіштері әртүрлә болатын сүтқышқылды өнімдер өндіруге негіз бола алады.

Түйін сөздер: *ешкі сүті, йогурт, табиғи тәттілендіргіш, стевия, эритритол, эритрит, топинамбур.*

Авторлар туралы мәлімет

Аяулым Какеновна Мустафаева* – техника ғылымдарының кандидаты, «Тамақ және қайта өңдеу өндірістерінің технологиясы» кафедрасының қауымдастырылған профессоры, Сәкен Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Астана қаласы, Қазақстан Республикасы; e-mail: ayaulym.mustafa@mail.ru. ORCID: https://orcid.org/0000-0002-9627-7543.

Балқаш Леонидқызы Леонидова – техника ғылымдарының кандидаты, «Тамақ және қайта өңдеу өндірістерінің технологиясы» кафедрасының аға оқытушысы; Сәкен Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Астана қаласы, Қазақстан Республикасы; e-mail: b.leonidova@kazatu.edu.kz. ORCID https://orcid.org/ 0009-0009-2752-8300.

Гульмира Жексеновна Шарикбаева – «Тамақ және қайта өңдеу өндірістерінің технологиясы» кафедрасының оқытушысы, Сәкен Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Астана қаласы, Қазақстан Республикасы; e-mail: gsharikbaeva@mail.ru. ORCID ID https://orcid.org/0009-0006-1786-3250.

Венера Шаймуратовна Ахметова – техника ғылымдарының магистры, «Инжиниринг және азық-түлік технологиялар» институтытың аға оқытушысы, С. Сейфуллин атындағы Қазақ агротехникалық зерттеу университеті, Қазақстан Республикасы; e-mail: v.akhmetova@kazatu.edu.kz. ORCID: https://orcid.org/0009-0001-5456-2872.

Асия Оразбековна Утегенова – PhD, «Тамақ технологиясы» кафедрасының қауымдастырылған профессор м.а., Шәкәрім атындағы университеті, Қазақстан; e-mail: asia_aksu@mail.ru. ORCID: https://orcid.org/0000-0003-3378-6815.

Сведения об авторах

Аяулым Какеновна Мустафаева* – кандидат технических наук, ассоциированный профессор кафедры «Технология пищевых и перерабатывающих производств», Казахский агротехнический исследовательский университет имени С. Сейфуллина, город Астана, Республика Казахстан; e-mail: ayaulym.mustafa@mail.ru. ORCID: https://orcid.org/0000-0002-9627-7543.

Балкаш Леонидовна Леонидова – кандидат технических наук, старший преподаватель кафедры «Технология пищевых и перерабатывающих производств», Казахский агротехнический исследовательский университет имени С. Сейфуллина, город Астана, Республика Казахстан; e-mail: b.leonidova@kazatu.edu.kz. ORCID https://orcid.org/ 0009-0009-2752-8300.

Гульмира Жексеновна Шарикбаева – преподаватель кафедры «Технология пищевых и перерабатывающих производств», Казахский агротехнический исследовательский университет им. Сакена Сейфуллина, Астана, Казахстан; e-mail: gsharikbaeva@mail.ru. ORCID: https://orcid.org/0009-0006-1786-3250.

Венера Шаймуратовна Ахметова – магистр технических наук, старший преподаватель института «Инжиниринга и пищевых технологий», Казахский агротехнический исследовательский университет имени С. Сейфуллина, Республика Казахстан; e-mail: v.akhmetova@kazatu.edu.kz. ORCID: https://orcid.org/0009-0001-5456-2872.

Асия Оразбековна Утегенова – PhD, и.о. ассоциированного профессора кафедры «Технология пищевых продуктов», Шәкәрім университет, Казахстан; e-mail: asia_aksu@mail.ru. ORCID: https://orcid.org/0000-0003-3378-6815.

Information about the authors

Ayaulym Kakenovna Mustafayeva* – Candidate of Technical Sciences, Senior lecturer of the Department «Technology of Food and Processing Industries», Kazakh Agrotechnical Research University named after S.Seifullin, Astana city, Republic of Kazakhstan; e-mail: ayaulym.mustafa@mail.ru. ORCID: https://orcid.org/0000-0002-9627-7543.

Balkash Leonidovna Leonidova – Candidate of Technical Sciences, Senior lecturer of the Department «Technology of Food and Processing Industries», Kazakh Agrotechnical Research University named after S.Seifullin, Astana city, Republic of Kazakhstan; e-mail: b.leonidova@kazatu.edu.kz. ORCID https://orcid.org/ 0009-0009-2752-8300.

Gulmira Zheksenovna Sharikbaeva – Lecturer of the Department of Food Technology and Processing Products; Saken Seifullin Kazakh Agrotechnical Research University, Astana, Kazakhstan; e-mail: gsharikbaeva@mail.ru. ORCID: https://orcid.org/0009-0006-1786-3250.

Venera Shaimuratovna Akhmetova – Master of Technical Sciences, Senior Lecturer at the Institute of Engineering and Food Technologies; Kazakh Agrotechnical Research University named after S. Seifullin; Republic of Kazakhstan; e-mail:v.akhmetova@kazatu.edu.kz. ORCID: https://orcid.org/0009-0001-5456-2872.

Assiya Orazbekovna Utegenova – PhD, Acting Associate Professor of the Department of «Food Technology», Shakarim University of Semey, Kazakhstan; e-mail: asia_aksu@mail.ru. ORCID: https://orcid.org/0000-0003-3378-6815.

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