Современная наука и инновации.
2023. № 3 (43). С. 126-140.
Modern Science and Innovations.
2023; 3(43):126-140.

ТЕХНОЛОГИЯ ПРОДОВОЛЬСТВЕННЫХ ПРОДУКТОВ /
TECHNOLOGY OF FOOD PRODUCTS

Обзорная статья / Review article

УДК 637.041 : 637.637.051
https://doi.org/10.37493/2307-910X.2023.3.12

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Состав и свойства козьего молока как сырья для производства функциональных продуктов

The goat milk composition and properties as a raw material for functional foods manufacturing

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Аннотация*. В данной статье приведены исследования состава и свойства козьего молока как сырья для производства функциональных продуктов питания. Основное внимание уделяется анализу химического состава, который включает в себя содержание белков, жиров, углеводов, витаминов и микроэлементов. Белковая фракция козьего молока имеет более низкие уровни as1-казеина, которые приводят к образованию более крупных казеиновых мицелл с более увлажненными порами, в результате снижается аллергенный потенциал козьего молока, по сравнению с казеиновыми мицеллами коровьего молока. Общее содержание незаменимых аминокислот в козьем молоке, даже, в несколько выше, чем в женском молоке, и составляет (в среднем) соответственно 45% и 39,2% от общего количества аминокислот. Углеводная фракция козьего молока помимо основного компонента – лактозы, содержит олигосахариды, состав которых приближен к женскому молоку. Характерный «козий» запах частично обусловлен жирными кислотами со средней и короткой цепью. Они также важны для легкости переваривания и всасывания молочного жира, так как эффективность фермента липазы на коротких цепях выше, чем на длинноцепочечных жирных кислотах. Диапазон размеров жировых шариков составляет около 1–10 мкм, а соотношение жировых шариков менее пяти мкм составляет более 80%. Как в любом молоке, в козьем молоке присутствуют витамины, содержание большинства из которых B1, B2, B6, D, E сопоставимо с уровнем витаминов в коровьем молоке, при этом в козьем молоке концентрация витамина C несколько выше. По содержанию минералов, козье молоко вполне сопоставим с коровьим молоком по содержанию Na, Zn и Fe, но содержит в 2 раза больше Cu, в 3 раза больше Mn, в 1,5 раза больше Mo, которые участвуют*

в кроветворении, регулируют метаболические процессы. В нашей стране растёт число козьих ферм, постепенно развивается промышленное производство – это новый тренд в отечественном козоводстве, при этом российские фермеры активно изучают зарубежный опыт по производству и переработке козьего молока на ферментированные молочные продукты. На основе полученных данных предлагается использовать козье молоко в качестве основного компонента при разработке функциональных пищевых продуктов. Считается, что использование козьего молока может способствовать улучшению здоровья и качества жизни людей, особенно тех, кто нуждается в дополнительных питательных веществах или имеет специфические диетические потребности. Однако для реализации этого предложения необходимо провести дополнительные исследования, чтобы определить оптимальные способы использования козьего молока и разработать эффективные функциональные продукты на его основе.

Ключевые слова: козье молоко, функциональное питание, медицина, пищевая промышленность, исследования

Для цитирования: *Лодыгин А. Д., Куликова И. К., Михайлов И. Ю. Состав и свойства козьего молока как сырья для производства функциональных продуктов // Современная наука и инновации. 2023. № 3 (43). С. 126-140. https://doi.org/10.37493/2307-910X.2023.3.12*

Abstract. *This article presents studies of the composition and properties of goat's milk as a raw material for the production of functional food products. The main attention is paid to the analysis of the chemical composition, which includes the content of proteins, fats, carbohydrates, vitamins and trace elements. The protein fraction of goat's milk has lower levels of as1-casein, which lead to the formation of larger casein micelles with more moistened pores, as a result, the allergenic potential of goat's milk decreases, compared with casein micelles of cow's milk. The total content of essential amino acids in goat's milk is even slightly higher than in women's milk, and is (on average) 45% and 39.2% of the total number of amino acids, respectively. The carbohydrate fraction of goat's milk, in addition to the main component – lactose, contains oligosaccharides, the composition of which is close to women's milk. The characteristic "goat" smell is partly due to fatty acids with medium and short chain. They are also important for the ease of digestion and absorption of milk fat, since the efficiency of the lipase enzyme on short chains is higher than on long-chain fatty acids. The size range of fat globules is about 1-10 microns, and the ratio of fat globules less than five microns is more than 80%. As in any milk, goat's milk contains vitamins, the content of most of which B1, B2, B6, D, E is comparable to the level of vitamins in cow's milk, while in goat's milk the concentration of vitamin C is slightly higher. In terms of mineral content, goat's milk is quite comparable to cow's milk in terms of Na, Zn and Fe, but it contains 2 times more Cu, 3 times more Mn, 1.5 times more Mo, which are involved in hematopoiesis, regulate metabolic processes. The number of goat farms is growing in our country, industrial production is gradually developing – this is a new trend in domestic goat breeding, while Russian farmers are actively studying foreign experience in the production and processing of goat milk for fermented dairy products. Based on the data obtained, it is proposed to use goat's milk as the main component in the development of functional food products. It is believed that the use of goat's milk can contribute to improving the health and quality of life of people, especially those who need additional nutrients or have specific dietary needs. However, in order to implement this proposal, additional research is needed to determine the optimal ways to use goat's milk and develop effective functional products based on it.*

Keywords: goat's milk, functional nutrition, medicine, food industry, research

For citation: *Lodygin AD, Kulikova IK, Mikhailov IYu. The goat milk composition and properties as a raw material for functional foods manufacturing. Modern Science and Innovations. 2023;3(43):126-140. https://doi.org/10.37493/2307-910X.2023.3.12*

Introduction. To correct deficiencies in the diet of modern man, traditional products must be supplemented with specialized food products containing biologically active complexes that deliver vitamins, minerals, microelements, antioxidants and other necessary substances to the body that ordinary nutrition cannot provide in sufficient quantities. Therefore, the development of functional foods has become an important component of the concept of optimal nutrition. Functional foods are a wide range of fortified foods: carriers of natural organic substances and dietary fiber (prebiotics); probiotic dairy products containing acido-, lacto- and bifidobacteria; products enriched with vitamins, minerals, bioflavonoids and others. There is no doubt that traditional foods supplemented with essential micronutrients and functional foods should occupy a special place in the structure of human nutrition [9].

Materials and research methods. The nutritional properties of goat's milk and its lower allergenicity compared to cow's milk are of great interest and are currently one of the reasons for its active use in the production of healthy food products. The component composition of goat's milk is generally similar to that of cow's (Table 1) [1,2]. Nevertheless, there are a number of significant differences that make goat milk an attractive raw material for healthy food products.

Let's look at the protein fraction of goat's milk. The main proteins that are present in goat milk are casein fractions, β-lactoglobulin, α-lactoalbulin, serum albumin, immunoglobulins and proteose peptones. In addition to these proteins, milk contains β2-microglobulin, lactoferrin, ceruplasmin, and fat globule membrane proteins, which have not yet been fully identified [22].

Table 1. Average composition indicators of goat, cow and human milk

Indicators	Goat milk	Cow's milk	Human milk
Mass fraction of total protein, %	3, 3	3, 4	0, 9
αs_2-casein, % of total protein	16	27	4
αs_1 - casein, % of total protein	-	34	30
β-casein, % of total protein	51	9	8
κ-casein, % of total protein	8	16	-
β-lactoglobulin, % of total protein	17	16	-
α-lactalbumin, % of total protein	6	4	25
Mass fraction of lactose, %	4, 1	4, 5	6, 5
Mass fraction of oligosaccharides, %	0.3	0.06	12
Mass fraction of fat, %	3, 5	3.0	3, 4
Calcium content, mg/100 ml	121	87	26
Phosphorus content, mg/100 ml	104	76	16
Vitamin A content, IU/100 g	185.00	126.00	190.00
Vitamin D content, IU/100	2.30	2.00	1.40
$_{B2}$ content, mg/100 g	0.21	0.16	0.02
Niacin content, mg/100 g	0.27	0.08	0.17

Goat milk casein is represented by fractions of as1-casein, as2-casein, β-casein, κ-casein. The as1-casein molecule (as1-Cn) consists of one polypeptide chain containing 199 amino acid residues with a molecular weight of 23.6 kDa. According to domestic and foreign researchers, the content of the as1 fraction relative to total casein in goat milk is about 10-33%. as2-casein (as2-Cn): molecular weight is 25.2 kDa. The as2-casein molecule consists of 207 amino acid residues. The content of as2-casein in goat milk from total casein varies widely from 5 to 41%. β-casein (β-Cn) is one of the main casein fractions in goat milk, the content of which is 37-76% relative to total casein. The β-casein molecule consists of one polypeptide chain with a molecular weight of 24 kDa and contains 209 amino acid residues. κ-casein (κ-Cn) has a molecular weight of 19 kDa and consists of 169 amino acid residues. In goat milk, the content of this fraction of total casein is 5-20% [4, 9, 22].

Serum β-lactoglobulin, like its bovine homologue, consists of a polypeptide chain of 162 amino acid residues, but differs from bovine β-lactoglobulin in six positions. Whey α-lactalbumin does not coagulate in milk at the isoelectric point due to its high hydration, does not coagulate under the influence of rennet, and is thermostable [5].

Concentrations of as1-casein in goat milk are highly dependent on genetic polymorphisms, contributing up to 25% of the total protein in the milk of goats with A, B or C alleles, whereas goats with O or N alleles do not have as1-casein [6677. In contrast, as1-casein in cow's milk tends to be more consistent at an average of 25% of the total protein.

Lower levels of as1-casein in goat milk lead to the formation of larger casein micelles with more hydrated pores, and also reduces, to a certain extent, the allergenic potential of goat milk [8] 7casein micelles in cow's milk [3]. As a result, goat yogurt and cheese have a less dense gel structure than their counterparts made from cow's milk. The formation and secretion of casein micelles are also impaired when as1-casein is low or absent in goat milk 9, 22].

Research results and their discussion. The total content of essential amino acids in goat's milk is even slightly higher than in women's milk, and amounts (on average) to 45% and 39.2% of the total amino acids, respectively (Table 2). Goat milk proteins are characterized by a high content of essential amino acids - threonine, valine, isoleucine, as well as some non-essential amino acids such as alanine, proline. Goat's milk has a relatively lower content of the essential amino acid lysine, but a higher level of the essential amino acid histidine, as well as the sulfur-containing amino acid cysteine (compared to cow's milk), capable of binding heavy metals and being one of the powerful antioxidants. Goat milk contains more protein-free nitrogen. Non-protein nitrogenous compounds are proteose peptones and low molecular weight nitrogen-containing substances - peptides representing fragments of milk proteins, metabolic products of mammary gland cells, free amino acids and over 60 other substances, the physiological role of which has not yet been sufficiently studied. The content of free amino acids in goat milk is 3 times higher than in cow milk [2].

Table 2. Average amino acid composition of goat, cow and human milk proteins (as a percentage of the total amount of amino acids)

Amino acid	Goat milk, %	Cow's milk, %	Human milk, %
Essential amino acids			
Threonine	7.0	4.6	4.2
Valin	7.8	5.1	1.4
Methionine	2.3	3.0	1.9
Leucine	5.9	14.9	15.3
Isoleucine	9.7	5.1	5.0
Phenylalanine	6.3	5.4	5.1
Lysine	6.0	6.1	6.3
Nonessential amino acids			
Aspartic	4.3	5.1	7.7
Glutamine	15.4	20.6	15.3
Serin	5.9	4.9	3.6
Glycine	1.9	no data	no data
Alanin	7.3	2.4	2.3
Arginine	1.9	3.9	4.5
Proline	10.7	7.4	5.3
Cysteine	1.1	0.8	2.7
Histidine	4.5	1.9	1.7
Tyrosine	2.3	5.2	5.1

From the point of view of nutrition, organoleptic and physical qualities, the fat content is considered far from the most variable, both qualitatively and quantitatively. As a rule, fat content is influenced by factors such as seasonality, food supply, breed and stage of lactation. Goat milk contains smaller fatty acid globules and higher titers of short-chain fatty acids, the composition of which is significantly different from other milk, this is an important feature that determines the excellent digestibility of goat milk [2121.

The characteristic "goat" odor is due in part to medium- and short-chain fatty acids. They are also important for the ease of digestion and absorption of milk fat, since the efficiency of the

lipase enzyme on short chain fatty acids is higher than on long chain fatty acids. The size range of fat globules is about 1–10 μm, and the ratio of fat globules less than five μm is more than 80% [1].

Medium chain fatty acids found in goat milk, such as caprylic, capric and caproic acids, make up 15% to 18% of total fatty acids, help lower cholesterol levels by limiting cholesterol deposition and increasing its mobilization in tissues. Short-chain fatty acids typically account for 15% to 18% of the fatty acids in goat milk. The various fat components and their composition present in goat milk are given in (Table 3) [9]. Long chain triglycerides make up 30 to 33% of the fatty acids in goat milk. The amount of total readily available energy substrates in goat milk is 53.95%. Therefore, it is believed that goat milk is digested faster to create energy due to its high concentration [19].

Table 3. Average indicators of fatty acid composition of goat, cow and human milk

Fatty acid, % of their total	Goat milk	Cow's milk	Human milk
Oil C4:0, %	2.18	2.78	0.6
Nylon C6:0, %	2.39	1.81	0.07
Caprylic C8:0, %	2.73	1.13	0.21
Capric C10:0,%	9.97	2.55	1.22
Lauric C12:0,%	4.99	2.98	5.60
Myristic C14:0,%	9.81	10.16	5.68
Myristoleic C14:1,%	0.18	0.86	-
Palmitic C16:0,%	28	29	20.46
Palmitoleic C16:1,%	1.59	1.73	-
Stearic C18:0,%	8.88	11.04	6.04
Oleic C18:1,%	19.3	26.32	32.02
Linoleic C18:2,%	3.19	3.23	20.67
Linolenic C18:3n3,%	0.42	0.61	0.98
Arachine C20:0,%	0.3	0.21	-
Behenovaya C22:0,%	0.1	0.08	-
Minor fatty acids,%	3.19	4.2	-

The carbohydrate fraction of goat milk, in addition to the main component - lactose, contains oligosaccharides, the composition of which is closer to human milk. The functions of goat's milk oligosaccharides are related to biological and antibacterial properties, and the fact that the majority of human milk oligosaccharides (>95%) are resistant to digestion suggests that their primary biological purpose is to protect the infant's gastrointestinal tract. Goat's milk contains from 250 to 300 mg/l of oligosaccharides, which is 4-5 times higher than in cow's milk. The oligosaccharide profile of goat's milk is most similar to human milk compared to cow's milk, making goat's milk a very attractive natural source of oligosaccharides for use in breastfeeding formula formulas [11].

As in any milk, goat milk contains vitamins, the content of most of which B_1, B_2, B_6, D, E is comparable to the level of vitamins in cow's milk, while the concentration of vitamin C in goat's milk is slightly higher. One of the features of the goat body is that all beta-carotene that comes from food is converted into vitamin A, so goat milk is whiter than cow milk and the vitamin A content is many times higher. However, goat milk contains 5 times less folic acid and 4 times less vitamin B12, which are necessary for normal hematopoiesis, which is probably associated with the development of megaloblastic anemia in some children [7].

In terms of mineral content, goat's milk is quite comparable to cow's milk in terms of Na, Zn and Fe content, but contains 2 times more Cu, 3 times more Mn, 1.5 times more Mo, which are involved in hematopoiesis as they are a component of a number of enzymes One of these enzymes involved in the formation of red blood cells is ceruloplasmin, which is involved in the metabolism of iron and promotes its transport in the body. However, some studies indicate a lower iron content in goat milk, which is associated with the large genetic variability of dairy goat breeds, climatic and geographical zones of pastures, and differences in the composition of feed. Several

studies have reported that goat's milk has higher bioavailability of magnesium, calcium, copper, iron and phosphorus than cow's milk [12,15**Ошибка! Источник ссылки не найден.**].

Research by foreign and domestic scientists claims [9] that the use of goat's milk in the daily diet of a modern person will replenish the balance of missing micronutrients. Summarizing the above, we can confidently say that the development and introduction of functional food products from goat milk into everyday life is a promising direction for the development of the Russian dairy market.

In our country, the number of goat farms is growing, industrial production is gradually developing – this is a new trend in domestic goat breeding, while Russian farmers are actively studying foreign experience in the production and processing of goat milk into fermented dairy products.

Considering that goats produce small volumes of milk of 2-3 liters per day, in order to organize industrial processing, especially the production of dry products based on goat milk, farms must be large enough, for example, in France and Belgium, farms on average contain 400-600 milk goats, and in Holland this figure is close to 1000. The largest complex operates in Saudi Arabia, where 15 thousand goats are kept. Among the modern vectors of development of the Russian dairy industry, goat breeding is significant, which corresponds to global trends in the state and dynamics of the goat population and goat milk production. At the moment, the largest goat farm in Russia is located in the Republic of Mari El; the farm contains 2 thousand heads.

The composition and properties of goat milk and its effect on dairy products, including functional nutrition, continue to be actively studied both in Russia and abroad (Table 4).

In Spain, the dynamics of the content of vitamins A and E in cheeses made from goat's, sheep's and cow's milk during their ripening period was studied. Italian scientists studied the fatty acid composition of goat's milk and the content of conjugated linoleic acid in goat's milk cheeses to determine their biological value. For the same purpose, the influence of the starter on the chemical composition, taste and microbiological characteristics of the traditional Marzolino cheese was determined [54].

In Slovenia, to increase the nutritional value of hard cheeses, studies were carried out on the influence of the starting culture, the type of milk (cow, goat, sheep), and heat treatment of raw milk on the composition and number of aromatic compounds.

Table 4. Advances in Goat Milk Research

Year of publication of the study	Field of study	Proceedings
1	2	3
1902	First published work on goat milk	[51]
1914	Use of goat milk in infant nutrition	[52]
1921	Goat milk fat globule size studies	[53]
1932-1934	The first papers on fat metabolism in dairy goats were published in the Journal of Dairy Science. Dairy goats are used in research as cow replacements to save costs.	[24, 25]
1937	The first publication on the composition of goat colostrum.	[26]
1940	First preliminary analysis of goat milk (355 goats from 21 herds).	[27]
1953	Related publications examine the effects of mineral supplementation on folic acid and vitamin B12 in bovine and goat colostrum and milk.	[28]
1965	First insight into the synthesis of butyric acid and milk fat using cow's and goat's milk.	[29]
1968	First report of lysozyme, lipase and ribonuclease in milk of 5 species.	[30]
1968	Data shows that goat's milk is nutritionally similar to cow's milk, but is an insufficient source of vitamins B6, B12 and folic acid compared to cow's milk for infant formula. Research is underway to identify the adulteration of goat milk with cow milk.	[31, 32]
1971	Goat's milk fat globules resemble cow's milk fat globules, but with a higher proportion of small fat globules and no agglutinin.	[33]
1978	Caution is advised when using goats as a model species in lactation studies due to significant differences from cows.	[34]

1980	The first report indicated that the 5 major proteins of goat milk (αs1-casein, αs2-casein, β-casein, β-lactoglobulin and α-lactalbumin) are very similar to cow's milk proteins. αs1-casein has been suggested to play a role in milk allergenicity.	[35]
1982	A formal assessment of lipid distribution in goat milk has been published. First study to report differences in lipoprotein lipase between cattle and goats and the effect on the taste of goat milk.	[36, 37]
1986	The number of bacteria does not explain the higher somatic cell content in goat's milk than in cow's milk.	[38]
1989	Evidence suggests that adulteration of goat and sheep cheese occurs throughout the world.	[39]
1991	Early evidence suggests that goat milk can be classified into low, medium and high αs1-casein producing groups; It is suggested that different genetic variants may influence the αs1-casein-expressing phenotype. Branched-chain FAs, including 4-ethyl octanoic (goat or "goat") and 4-methyl octanoic (lamb) acids from goat and sheep milk, have been shown to impart their characteristic flavor to varietal cheeses.	[40]
1993	Initial studies also characterize the genotypic variability of caprin-κ-casein. The overall fatty acid profile of bovine and goat colostrum was quantified and significant differences were found between species.	[41, 42]
2006	Transgenic goats are used to express human lysozyme to monitor the antimicrobial properties of goat milk. Genetic studies indicate that at least 16 alleles determine the rate of αs1-casein synthesis in goats.	[43]
2011	It has been shown that the allergenicity of goat milk depends on the genetic polymorphism of αs1-casein. Different genotypes of goat milk αs1-casein can serve as a source of protein for hypoallergenic formulas.	[44]
2014	Goat milk products have been found to be unsuitable for patients with cow's milk allergy due to cross-reactivity of goat IgE antibodies with cow's milk caseins.	[45]
2016	Proteomics is used to evaluate the adulteration of goat milk by cow's milk.	[46]
2017	Nutrition and Health Profile of Goat Products: Focus on the Health Benefits of Goat Milk	[47]
2019	Current status of global dairy goat production: an overview	[48]
2020	Effect of heat treatment on the microstructure and functional properties of whey protein from goat milk	[49]
2021	Extraction and quantitation of goat milk oligosaccharides: composition, variation, associations and 2'-FL variability	[50]

In Greece, the possibility of using gamma-glutamine transferase and xanthine oxidase activities as indicators of various pasteurization regimes of raw cow, sheep, goat milk and cream was studied. Scientists from the Czech Republic and Poland determined the kinetics and degree of influence of *Staphylococcus aureus* on the safety of rennet cheeses made from goat milk, including unpasteurized cheese [7].

In Altai, studies have been conducted on the effect of probiotic preparations based on lactobacilli, propionic acid bacteria and enterococci on the physicochemical parameters of milk from Saanen goats. Milk obtained during the period of feeding probiotic preparations to goats has a 20% higher mass fraction of fat and protein. The increase in quality indicators of goat milk is explained by the improvement of digestive processes in the body of animals in the experimental groups [17].

In the Urals, the company UGMK-Agro LLC is implementing a project that will allow the production of goat cheese in industrial quantities. Small farms popping up across the country, like cow farmers, can count on farm grants and regional support.

In the conditions of the Matveev farm, the technology for the production of Crotten cheese (with white mold) and Caciotta cheese from goat milk, which were developed in Italy, was tested [5555.

Scientists from Mari State University have developed and carried out industrial testing of soft cheese technology based on a mixture of cow, goat and mare's milk. New types of cheese were highly appreciated by tasters [**Ошибка! Источник ссылки не найден.**].

At the Altai Technical State University named after. I.I. Polzunov studied the main breeds of dairy goats in the Altai Territory, determined the composition and properties of milk obtained from different breeds of goats, substantiated its cheese suitability and developed the technology of soft fresh cheese based on goat milk "Altai Goat".

Samara State Technical University has developed ice cream with a high content of vitamin C based on goat milk. The use of rosehip syrup in the recipe made it possible not only to enrich it with vitamin C, but also to reduce the amount of added sugar when compared with the classic ice cream recipe. The data obtained indicate high overrun rates, which can be characterized by a high percentage of ice cream saturation with air and a high amount of milk proteins [4].

The development of functional food products based on goat milk, according to the authors [7], is also a popular area.

At the Maikop State Technological University [6], they selected probiotic cultures to develop a technological process for the production of Mozzarella cheese based on goat milk. The processes of coagulation and fermentation of goat milk under the influence of probiotic starter cultures have been studied. The study showed the possibility of using goat milk in the production of cheeses with cheddarization and thermomechanical processing. Microscopy of a probiotic starter sample revealed that probiotic cultures survive heat treatment at high temperatures.

At the Research Institute of Baby Nutrition of the Russian Academy of Agricultural Sciences, a product based on goat's milk was developed for feeding lactating women. In patent No. 2415596, the claimed product increases lactation functions and improves the general health of lactating women. The product is balanced in vitamin and mineral composition and fully satisfies the needs for complete protein and essential amino acids. [11].

At the Kuban State Agrarian University named after I.T. Trubilin developed a method for producing curd mass from goat milk. Patent No. 2769726 describes a technology for producing a functional curd product with quinoa seeds, mango and persimmon pieces. This study allows us to expand the range of products in the dairy industry from goat milk. [12].

At the Center for Food Systems. V.M. Gorbatov studied the quality indicators of ice cream produced using freeze-dried goat milk. The authors argue that dairy ice cream using goat milk can be produced at existing industry enterprises in order to expand the range of products it produces. The use of freeze-dried goat milk will make it possible to produce products at enterprises remote from farms [13].

At the Omsk State Agrarian University named after P.A. Stolypin, biotechnological parameters and component composition for the production of a curd product based on goat milk have been developed. The novelty of the technical solution for the production of a new product is reflected in patent No. 2642317 [16].

New Zealand goat's milk-based infant formulas are the most clinically studied of all goat's milk formulas in the world. The experience of using NENNY children's adaptive formulas in Russia confirmed the results of foreign studies. NENNY mixtures have undergone extensive clinical testing in leading scientific and clinical centers in Russia. The positive effect of NENNY mixtures on reducing the manifestations of functional disorders of the gastrointestinal tract in healthy children of the first year of life has been proven, which was confirmed by the relief of intestinal colic and flatulence, and the reduction or disappearance of regurgitation. While taking formulas, the observed children showed positive dynamics in the processes of digestion and absorption of nutrients in the gastrointestinal tract, which was confirmed by the disappearance of scatological syndromes [14, 15].

According to Spanish scientists, goat milk is better absorbed in the gastrointestinal tract of infants, which is due to a number of biochemical characteristics of its main nutritional components. Goat milk has high levels of some amino acids also found in human milk, including lysine and cystine, which facilitate the absorption of minerals and increase the formation of antibodies to microbes. It has been proven that the digestion and absorption of iron (30%) and calcium (up to 58%) of goat milk is better than that of cow milk (10 and 38%, respectively), but does not reach the level of absorption of iron and calcium (>50%) of human milk [15].

Conclusion. Thus, the development of products based on goat milk is a promising direction for creating functional food products, since goat milk contains more useful substances than cow milk. In addition, goat milk has unique properties, such as high nutritional value and the ability to reduce the risk of developing diseases. However, before introducing these products into mass production, more research must be conducted to ensure their safety and effectiveness. It is also necessary to take into account the individual needs and taste preferences of consumers in order to create products that are as healthy and palatable as possible. Overall, the development of goat milk products has great potential to improve human nutrition and health.

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Вклад авторов: все авторы внесли равный вклад в подготовку публикации.
Конфликт интересов: авторы заявляют об отсутствии конфликта интересов.

Contribution of the authors: the authors contributed equally to this article.
Conflict of interest: the authors declare no conflicts of interests.

Статья поступила в редакцию: 12.07.2023;
одобрена после рецензирования: 15.08.2023;
принята к публикации: 06.09.2023.

The article was submitted: 12.07.2023;
approved after reviewing: 15.08.2023;
accepted for publication: 06.09.2023.