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Original Article

Biochemical composition of sheep milk of different breeds during the summer lactation period

Composição bioquímica do leite de ovelhas de diferentes raças durante o período de lactação no verão

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Abstract

The article presents the results of the study of biochemical composition of sheep milk in the summer lactation period for 4 sheep breeds. According to research results, 18 amino acids were found in sheep milk. During the summer lactation period, the amount of polyunsaturated fatty acids, both the Ordabasy breed and the South Kazakh merino exhibit higher levels (ranging from 6349 to 6989) compared to the Kazakh fine-fleeced and meat Merino breeds (ranging from 5835 to 5500). When analyzing sheep milk, a tendency towards a higher content of vitamin A (59.91 µg/100 g) and B6 (73.0 µg/100 g) was noted. The highest calcium content was found in the milk of the Kazakh fine-fleeced sheep, while the lowest was observed in the South Kazakh merino breed. Better milk productivity, along with increased fat and protein content, has been noted in sheep of the Ordabasy and South Kazakh merino breeds.

Keywords: sheep milk, amino acid composition, vitamins, minerals.

Resumo

Este artigo apresenta os resultados do estudo da composição bioquímica do leite de 4 raças ovinas durante o período de lactação no verão. De acordo com os resultados da presente pesquisa, 18 aminoácidos foram encontrados no leite de ovelha aqui analisado. Durante o período de lactação no verão, a quantidade de ácidos graxos poliinsaturados, tanto a raça Ordabasy quanto o Merino do Sul do Cazaquistão exibem níveis mais elevados (variando de 6,349 a 6,989) em comparação com as raças Merino de carne e lã fina do Cazaquistão (variando de 5,835 a 5,500) . Ao analisar o leite de ovelha, notou-se uma tendência à apresentação de um maior teor de vitamina A (59,91 µg/100 g) e B6 (73,0 µg/100 g). O maior teor de cálcio foi encontrado no leite das ovelhas de lã fina do Cazaquistão, enquanto o menor foi observado na raça Merino do Sul do Cazaquistão. A melhor produtividade de leite, juntamente com maior teor de gordura e proteína foram observadas em ovelhas das raças Ordabasy e Merino do Sul do Cazaquistão.

Palavras-chave: leite de ovelha, composição de aminoácidos, vitaminas, minerais.

1. Introduction

Sheep milk is one of the functionally active dairy products and is also considered as a nutritious source of energy. The beneficial role of sheep milk is due to its content of fatty acids, immunoglobulins, non-immune proteins, vitamins and minerals. In the human intestine, milk proteins are transformed into an excellent source of bioactive peptides with antioxidant, antimi-crobial, antihypertensive, immunomodulatory and antithrombotic roles. It is also used in anti-aging formulations and cosmetic soaps to treat psoriasis and eczema of the skin, such as chronic diseases. The unique physicochemical and biochemical properties of sheep milk also include prebiotics and probiotics, which make it an ideal functional food for promoting human health and reducing the risk of diseases.

Sheep milk is of interest as a source of fatty acids ω-3 and ω-6 in milk fat, as well as less common fatty acids - isomers of linoleic acid. Lipids in sheep milk are represented by smaller fat globules, which contributes to better digestibility by the human body (Ospanov et al., 2018; Muldasheva et al., 2019), thereby enhancing the functionality of their processed products.

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The concentration of milk fat and protein, as well as the somatic cells' count (SCC) deeply affect the milk processing and coagulation properties, which significantly affects the yield and quality of dairy products (Nudda et al., 2019).

Macrominerals Ca, P, Na and Mg are present in sheep milk at a much higher level compared to cow and goat milk. In particular, sheep milk contains about 36% more calcium than cow milk, and 31% more than goat milk. However, the mineral content in sheep milk varies significantly depending on factors such as breed, geographical location, diet, lactation stage, parity and farming methods. Sheep milk is usually processed into cheese and yoghurt and can be frozen or dried into powder for storage. Thus, sheep milk is a dense food source with a high mineral content, which attracts increasing interest and leads to the expansion of the dairy industry of this type. There are significant opportunities for a comprehensive study of the beneficial effects of minerals contained in sheep milk on human health and well-being (Chia et al., 2017).

Sheep milk is a source of fats and fat-soluble compounds, milk fat is a good dietary source of vitamin A, vitamin E and beta-carotene. Alpha-tocopherol is the main form of vitamin E in milk and has a higher biological activity than other tocopherols. Tocopherols are important for human nutrition and health and play an important role in maintaining the oxidative stability of milk and dairy products. Most vitamins affect the activity of various enzymes or are their active centers (Moatsou and Sakkas, 2019; Martini et al., 2021).

In the contemporary landscape, ensuring the profitability of sheep breeding within the Republic of Kazakhstan hinges on the establishment of highly productive herds endowed with a substantial genetic potential, thus enabling its effective implementation within specific natural and climatic zones (Kulzhanova et al., 2024).

Milkiness of ewes depends on many factors: breed, feeding, co-maintenance, number of lambs, live weight of crop.

The milk productivity of sheep also depends on the constitution of the animals. Moreover, ewes that have been pregnant with twins or more generally exhibit higher milk production compared to those pregnant with singletons. Ewes that lambed two lambs and nursed them showed higher milk productivity than those raising one lamb out of two born. A correlation was observed between ewes' milkiness, the number of suckling lambs, and the frequency of suckling. For instance, ewes with four teats available for suckling are characterized by increased prolificacy and milkiness.

In the present study we considered four sheep breeds, which are widely used in Kazakhstan: Ordabasy, Kazakh fine-fleeced, meat merino, South-Kazakh merino.

The goal is to assess the potential of sheep milk as a raw material for cheese and healthy food products, leveraging its unique biochemical composition, high protein and fat content, and valuable microelements and vitamins. Analyzing the technological and biochemical composition of sheep milk allows for the evaluation of its suitability for various types of cheese and other products. By examining the levels of protein, fat, carbohydrates, vitamins, minerals, and other biologically active substances, we can determine its nutritional value and its applicability in specialized dietary and functional products. Understanding the composition of sheep milk aids in identifying its potential for producing a range of healthy food products and optimizing technological processes in cheese and dairy production.

Ordabasy breed of sheep was created by scientists of "South-West Research Institute of Animal Husbandry and Plant Industry" LLP in the period 1992-2012 by complex reproductive crossing of sheep ewes of local Kazakh fat-tailed rough-haired breed with rams of Yedilbay and Hissar breeds. It was tested in 2013. From the first days of breeding and pedigree work in the base farms a strict selection on live weight, constitution, exterior and wool of sheep of the Kazakh fat-tailed rough-haired breed was carried out.

The Kazakh fine-fleeced sheep breed was approved as a new independent breed on September 28, 1945. The work on this breed was started by V.A. Balmont in 1931 in the areas of south-eastern Kazakhstan and included a mixture of Kazakh fat-tailed sheep with fine-fleeced precocity sheep. Animals of this breed were characterized by strong growth, strong physique and good adaptation to year-round grazing on pastures.

As a result of many years of breeding and pedigree work in the Research Institute of Sheep Breeding named after K.U. Medeubekov in 2011, the first export-oriented meat fine-fleece breed in domestic sheep breeding - meat merino, successfully combining high meat productivity and merino wool, corresponding to world analogues as Prekos, Zwartbles, Sarajin, Jaydara , was created.

South-Kazakh merino is the first in Kazakhstan breed of sheep of wool-meat direction of productivity, approved in 1966. Creation of this breed solved the problem of more rational use of southern regions of Kazakhstan for merino sheep breeding. Improvement of the breed at the initial stage was carried out at purebred breeding, and since 1971 - by introductory crossing of South-Kazakh breeding ewes with rams of Australian merino breed.

One of the most important elements in feeding sheep in spring is to transfer animals from hay and mixed fodder to green fodder. Young spring grasses are rich in protein and vitamins and are very well digested, but a sudden transition can provoke diarrhea. Therefore, at the beginning of the spring period, sheep should be fed some hay. Spring ration: the main type of fodder - green grasses; some hay; 500 to 100 grams of concentrated fodder; mineral and rock salt (in the form of licks).

In summer, if there are enough high-mountain pastures (Zailiyskiy Alatau 1500-2000 m above sea level) sheep are fully provided with green fodder.

Milk productivity of the above mentioned breeds of sheep, imported from different ecological zones, in the conditions of the foothill zone of the south-eastern region of Kazakhstan has not been studied yet.

2. Materials and Methods

Experimental studies to determine the physicochemical composition and technological properties of sheep's milk were carried out in accordance with the standards. Sampling was carried out from 60 to 140 days of lactation.

2.1. Animals and samplings

The composition and properties of sheep milk primarily depend on a number of physiological factors - breed, variability between individual animals, stage of lactation, seasonal fluctuations, method of growing and feeding of animals, age, various diseases, etc.

In the Innovation farm "Qazyna" of Zhetysu region the economic experience was conducted on four groups of lactating sheep. The first group of lactating sheep included Ordabasy sheep, the second group - Kazakh fine-fleeced, the third group - meat merino, the fourth group - South Kazakh merino.

For experiments, milk was sampled from 10 sheep of each breed from June to August 2022. The sheep selected for the study were all 4 years old and were kept under the same conditions of housing and feeding. Milk sampling was carried out in the morning milking.

2.2. Gas chromatographic analysis of fatty acid methyl esters

Determination of the fatty acid composition of the fat phase was carried out by gas chromatography. For centrifugation, milk was poured into two centrifuge tubes (50 cm each) and centrifuged at 10000 rpm for (15±1) min. Then the upper fat fraction was removed and poured into a glass with a capacity of 250 cm^3, 150 cm^3 of hexane was added to it for homogenization in a homogenizer for 3-5 minutes at a speed of rotation of knives from 2000 to 5000 rpm. Next, a hexane layer with fat dissolved in it was separated, which was transferred to a round-bottomed flask with a capacity of 250 cm^3. The flask was connected to a rotary evaporator, where the solvent was completely distilled at a temperature of (70±2)°C. The resulting fat fraction was used to prepare methyl esters of fatty acids (Correddu et al., 2019; Govari et al., 2020).

2.3. Amino acid analysis

To prepare the samples, acid hydrolysis in a solution of 6.8 hydrochloric acid was used, with the addition of norleucine as an internal standard. Hydrolysis was performed in fluoroplastic cups with a screw cap (CEM, USA), in a thermostat at 110°C for 24 hours. To determine cysteine and methionine, the samples were oxidized with a 50% solution of formic acid in hydrogen peroxide with the addition of phenol. At the end of hydrolysis, the tubes were cooled, 160 µl of hydrolyzate was taken, and dried at 100°C. The dry residue was dissolved in a buffer solution for dilution of samples and centrifuged at 13000 rpm; the supernatant was filtered through a filter (with a fluoroplastic membrane) with a pore diameter of 0.45 µm (Agilent, USA) and used for further analysis.

The analysis was performed on the Shimadzu LC-20 Prominence high-performance liquid chromatography (HPLC) system (Japan), with a reaction module for post-column derivatization with ninhydrin ARM-1000 (SevkoandRussia), equipped with an absorption detector (λabs=440nm, 570 nm) and a column with an ion exchange resin 4,6x150 m.

To calculate the amino acid score, the amino acid scale of the Joint FAO/WHO Expert Committee on Food Additives (JECFA) was used, according to which it is assumed that 1 g of the "ideal" protein contains (in mg): isoleucine - 40, leucine - 70, lysine - 55, sulfur-containing compounds (phenylalanine + tyrosine) - 60, tr––yptophan - 10, valine - 50. Amino acid score values of more than 100% indicate the full provision of this amino acid for a person's daily requirement, and values less than 100% indicate insufficient provision of a person's daily requirement. Such amino acids are referred to as limiting.

2.4. Vitamins analysis

To evaluate fat-soluble vitamins, the samples were heated (30°C), homogenized and subjected to alkaline hydrolysis. Briefly, 1.5 ml of 0.3 M ascorbic acid and 0.1 ml of d-tocopherol as an internal standard were added to 2 ml of sample. The mixture was shaken and methanol KOH (40%) was added and then the mixture was shaken again for 30 seconds. The mixture was heated to 70°C and shaken (200 rpm) 40 min. The samples were cooled for 3 min and extracted using n-hexane: dichloromethane (5:1) / isopropanol (4/1) four times. The organic phases were combined, washed with chilled water to remove KOH, evaporated under nitrogen stream reconstituted in 1 ml acetonitrile/methanol (85/15) and filtered using a 22 µm syringe filter.

The UPLC was run on the Waters Acquity system (Waters, France) equipped with a photodiode array detector, scanning between 275 and 465 nm, as well as a fluorometric detector. Acquity UPLC HSS T3 column, 1.8 mm (Waters, France) was used. The applied flow rate was 0.4 ml/min, the analysis was performed at 35°C (Chauveau-Duriot et al., 2010). Two separate isocratic chromatographic methods were used. The mobile phase for retinol is acetonitrile: methanol (85:15) / isopropanol: water (50:50) 80/20, with λ_{exc} = 325 nm and λ_{em} = 475 nm for fluorometric detection. The mobile phase for the various tocopherols analyzed was acetonitrile: methanol (85:5) / isopropanol 90/10, with λ_{exc} = 295 nm and λ_{em} = 390 nm for fluorometric detection.

Peak identification was performed using pure standards and quantification was performed using calibration curves. The pureness of the standards used was controlled by UV - visible spectra using the described method, the efficiency of hydrolysis was >97% and, based on stoichiometric calculations, the extraction of added analytes was 71% and 81% for retinol and various forms of tocopherol (Revilla et al., 2017).

2.5. Ash determination for the determination of amino acid content

Crucibles are prepared, products are charred, ashing is started without an accelerator. Ashing is carried out until the contents of the crucible turn into a loose gray mass, after which the crucibles are removed from the muffle furnace on a porcelain or metal stand and allowed to cool. Then, 2 drops of chemically pure nitric acid with a density of 1.2 g/cm^3 are added to the crucible using a pipette or a glass rod and placed on the open door of the muffle furnace to evaporate nitric acid. Evaporate nitric acid carefully, avoiding boiling, in order to avoid its splashing and loss of the ashed product. After evaporation of the acid, the crucibles are punctured in the depth of a muffle furnace heated to a temperature of 600–900°C for 20–30 min. Then the crucibles are cooled in a desiccator, weighed and the mass fraction of ash is calculated.

2.6. Statistical analysis

Milk composition results were analyzed by ANOVA using JMP software (JMP®, 2007, SAS, Cary, NC, USA). The model contained fixed effects of the product type. The effect of sampling time on product composition was not significant and therefore was excluded from the statistical model. Significance of differences between means was assessed by Student's t-test, taking into account the significance of $P < 0.05$ level.

3. Results

Table 1 presents the results of the analysis of the amino acid composition of the sheep milk protein of the studied breeds.

From the presented data, it can be seen that the total amount of EAA in the analyzed milk samples obtained from sheep of the Ordabasy and South Kazakh merino breeds were quite close (2487.14-2479.178), as well as the amount of NEAA (2052.44-2029.172), on which the biological usefulness of milk proteins largely depends. The share of EAA from the total amount of AA in the protein of sheep milk of the Ordabasy and meat merino breeds was 54.7% and 54.9%, respectively, in the breeds of the Kazakh fine-fleeced and South Kazakh merino were slightly higher than 55-54.9%. The index characterizing the EAA/NEAA ratio in the sheep milk protein of the South Kazakh merino breed was relatively higher than in the sheep milk protein of other breeds. In the spectrum of isolated milk protein EAA, the maximum proportion belonged to lysine, among NEAA - to glutamic acid and proline. In minimal quantities among the EAA was cysteine, NEAA - glycine.

To determine the biological value of a protein, we chose a method for calculating the amino acid score from a number of biological and chemical methods, which allows us to determine the limiting amino acid. The score was calculated by the percentage ratio of each of the EAA in sheep milk protein in relation to its content in the "ideal" protein.

Table 1. Amino acid composition of sheep milk protein of different breeds in mg/100 g.

Name of amino acids Ordabasy		Breeds		
		Kazakh fine-fleeced	**Meat merino**	**South Kazakh merino**
		Essential amino acids (EAA), mg		
Lysine	466.50±46.65	402.198±40.220	441.27±44.13	462.723±46.272
Methionine	110.02±11,00	94.386±9.439	105.26±10.53	108.590±10.859
Cysteine	49.88±4.99	42.262±4.226	45.32±4.53	48.622±4.862
Threonine	191.42±19.14	163.415±16.342	163.41±16.34	188.006±18.801
Histidine	121.15±12.12	121.152±12.115	121.15±12.12	139.384±13.918
Arginine	167.34±16.73	145.101±14.510	160.44±16.04	166.937±16.694
Valine	306.29±30.63	260.618±26.062	288.39±28.84	299.838±29.984
Leucine	425.99±42.60	364.866±36.487	405.96±40.60	419.773±41.977
Isoleucine	224.19±22.42	195.816±19.582	213.52±21.35	225.284±22.528
Phenylalanine	217.71±21.77	188.722±18.877	188.77±18.88	217.180±21.718
Tyrosine	148.61±14.86	135.240±13.524	148.61±14.9	155.592±15.559
Tryptophan	58.04±5.80	49.306±4.931	49.31±4.93	46.549±4.655
Total EAA	2487.14	2163.082	2331.41	2479.178
		Non-essential amino acids (NEAA), mg		
Aspartic acid	224.64±22.46	190.885±19.089	209.75±20.98	219.611±21.961
Glutamic acid	945.57±94.56	819.892±81.989	882.02±88.20	943.274±94.327
Serine	264.03±26.40	225.400±22.540	250.78±25.08	259.319±25.932
Glycine	49.02±4.90	42.262±4.226	45.87±4.59	48.622±4.862
Alanine	127.69±12.77	108.474±10.847	108.47±10.85	124.797±12.480
Proline	441.42±44.14	376.840±37.684	416.99±41.70	433.549±43.355
Total NEAA	2052.44	1763.753	1913.88	2029.172
Total AA (**TAA**)	4539.51	3926.865	4245.29	4508.35
T=ΣEAA/ΣNEAA	1.21	1.226	1.218	1.221
T=ΣEAA/ΣAA	0.547	0.55	0.549	0.549

Sheep milk contains almost twice as much protein as goat and cow milk. The molecular forms and amino acid sequences of these proteins have nutritional qualities, as well as positive effects on digestibility and thermostability (Claeys et al., 2014). Sheep milk has higher serine, alanine, histidine, valine and lysine content, whereas cystine and glycine content is lower. The high nutritional value of sheep milk is also related to proline content, which affects hemoglobin production (Molik et al., 2012).

The analysis of the obtained material showed that for milk proteins of all the studied breeds, sulfur-containing methionine was the limiting factor, the content of which was 2.69-3.14% of its value on the scale of adequacy in the "ideal" protein, according to the JECFA data (Table 2). In connection with the important function of threonine in regulating metabolism, in particular, by its effect on the release of exogenous nitrogen from the human body, leading to weight loss, the FAO proposed to evaluate the balance of essential amino acids of protein also by the content of this amino acid. In the protein of milk of Ordabasy and South Kazakh merino sheep breeds, the threonine content exceeded its content in the "ideal" protein, and in the protein of milk of Ordabasy and South Kazakh merino sheep breeds, the score of this amino acid was at the level of 4.70-4.78% (relative to the "ideal" protein), which gives reason to attribute it also to the limiting amino acids in the protein of milk of this breed.

In order to determine the potential of sheep milk as a raw material for the production of dairy products with high biological value, the fatty acid composition of four sheep breeds was studied. Table 3 presents data on the content of saturated fatty acids in the milk of four breeds of sheep bred in Kazakhstan.

During the period of summer lactation, the amount of saturated fatty acids in the fat of sheep milk of the Ordabasy breed was 64.408, Kazakh fine-fleeced - 78.295, meat merino - 78.088, South Kazakh merino - 74.162. The concentration of monounsaturated fatty acids, respectively, is 24.603; 15.869; 16.462; 19.489. The amount of polyunsaturated fatty acids in the breeds of Ordabasy and South Kazakh merino is from 6.349-6.989, as well as in the breeds of the Kazakh fine-fleeced and meat merino, respectively, 5.835-5.500.

Italian scientists conducted a study on the composition of milk, coagulation properties, and individual cheese productivity in samples of 991 Sarda sheep from 47 flocks. The aim of the study was to explore the correlation between measured values and derive new synthetic indicators of milk composition and cheese properties. A multivariate factorial analysis was conducted, examining individual indicators of milk coagulation such as cheese productivity, percentage of fat, protein, and lactose, somatic cell index, percentage of casein content, NaCl composition, pH, and freezing point. Heritability estimates for the four extracted factors were found to be low to moderate.

Indian researchers have also noted the functional properties of sheep milk as a source of nutritional energy and bioactive compounds. The beneficial role of sheep milk is due to the presence of fatty acids, immunoglobulins and non-immune proteins. In the human intestine, milk proteins have been scientifically proven to be an excellent source of bioactive peptides with antioxidant, antimicrobial, hypotensive, immunomodulatory, and antithrombotic roles. Sheep milk is also used in antiaging and cosmetic soap preparations to treat chronic skin conditions such as psoriasis and eczema. The unique physicochemical and biochemical properties of sheep milk also include prebiotics and probiotics, making it an ideal functional food for promoting human health and reducing disease risk.

The levels of short and medium chain fatty acids have significant differences, butyric (C4:0) (5,063%; 4,103%; 5,127%; 3,260%), capric (C10:0) (6,769%; 8,652%; 9,036%; 8,614%), myristic (C14:0) (10,902%; 15,576%; 14,598%; 14,137%) in the milk of sheep breeds Ordabasy, Kazakh fine-fleeced, meat merino and South Kazakh merino, respectively. A significant difference in the content of butyric and capric acid (C4:0 and C10:0) in the milk of sheep of the studied breeds was found.

Table 2. Amino acid scale of the Joint FAO/WHO Expert Committee on Food Additives (JECFA)

Name of EAA	EAA content in the "ideal protein", g/100 g	In the milk of sheep breeds							
		Ordabasy		Kazakh fine-fleeced		MM		South Kazakh merino	
		EAA content, g/100 g	Score, %	EAA content, g/100 g	Score, %	EAA content, g/100 g	Score, %	EAA content, g/100 g	Score, %
Lysine	5.5	0.4665	8.48	0.402198	7.31	0.44127	8.02	0.462723	8.41
Methionine + cysteine	3.5	0.11002	3.14	0.094386	2.69	0.10526	3.007	0.10859	3.10
Threonine	4.0	0.19142	4.78	0.163415	4.08	0.16341	4.08	0.188006	4.70
Valine	5.0	0.30629	6.12	0.260618	5.21	0.28839	5.76	0.299838	5.99
Leucine	7.0	0.42599	6.08	0.364866	5.21	0.40596	5.79	0.419773	5.99
Isoleucine	4.0	0.22419	5.6	0.195816	4.89	0.21352	5.33	0.225284	5.63
Phenylalanine + tyrosine	6.0	0.36632	6.10	0.323922	5.39	0.33738	5.62	0.372772	6.21
Tryptophan	1.0	0.5804	58.04	0.4931	49.31	0.4931	49.31	0.4654	46.54

Table 3. Fatty acid composition of lipids of sheep milk of different breeds during summer lactation.

Trivial name of fatty acid	Fatty acid index	In the milk of sheep breeds			
		Ordabasy	Kazakh fine-fleeced	Meat merino	South Kazakh merino
Saturated fatty acids					
Butyric	C4:0	5.063±0.253	4.103±0.410	5.127±0.256	3.260±0.326
Caproic	C6:0	3.016±0.151	2..878±0.288	3.475±.,174	2.588±0.259
Caprylic	C8:0	2.651±0.133	2.641±0.264	3.078±0.154	2.539±0.254
Capric	C10:0	6.769±0.338	8.652±0.865	9.036±0.452	8.614±0.861
Undecanoic	C11:0	0.066±0.003	0.103±0.010	0.098±0.005	0.084±0.008
Lauric	C12:0	4.440±0.222	5.401±0.540	5.498±0.275	5.613±0.561
Tridecanoic	C13:0	0.084±0.004	0.128±0.013	0.122±0.006	0.114±0.011
Myristic	C14:0	10.902±0.545	15.576±1.558	14.598±0.730	14.137±1.414
Pentadecanoic	C15:0	1.033±0.052	1.550±0.155	1.402±0.070	1.341±0.134
Palmitic	C16:0	20.632±1.032	26.304±2.630	24.319±1.216	24.000±2.400
Margaric	C17:0	1.151±0.058	1.294±0.129	1.183±0.059	1.232±0.123
Stearic	C18:0	11.275±0.654	8.825±0.883	8.477±0.424	9.797±0.980
Arachidic	C20:0	0.140±0.007	0.644±0.064	0.504±0.025	0.573±0.057
Behenic	C22:0	0.296±0.015	-	0.338±0.017	0.065±0.007
Lignoceric	C24:0	0.123±0.006	-	0.194±0.010	0.206±0.021
Heneicosanoic	C21:0	0.763±0.038	0.198±0.020	0.640±0.032	-
SFA		64.408±3.220	78.295±7.830	78.088±3.904	74.162±7.416
Monounsaturated fatty acids					
Myristoleic	C14:1 (cis-9)	0.312±0.016	0.259±0.026	0.250±0.013	0,273±0.027
Pentadecenic	C15:1(cis-10)	0.277±0.014	0.414±0.041	0.366±0.018	0.386±0.039
Palmitoleic	C16:1(cis-9)	0.820±0.041	0.999±0.100	0.922±0.046	1.101±0.110
Margaroleic	C17:1(cis-10)	0.441±0.022	0.460±0.046	0.425±0.021	0.499±0.050
Oleic	C18:1(trans-9)	0.179±0.009	13.394±1.339	14.127±0.706	16.976±1.698
Oleic	C18:1(cis-9)	22.446±1.122	0.272±0.027	0.238±0.012	0.119±0.012
Eicosenoic	C20:1 (cis-11)	0.128±0.006	0.071±0.007	0.085±0.004	0.101±0.010
Erucic	C22:1(cis-13)	-	0.071±0.008	-	0.035±0.004
MUFA		24.603±1,23	15.94±1.594	16.413±0.82	19.49±1.95
Polyunsaturated fatty acids					
Linoleic	C18:2 n6t	1.480±0.074	1.407±0.141	0.985±0.049	1.375±0.138
Linoleic	C18:2 n6c	2.553±0.128	1.544±0.154	2.128±0.106	1.769±0.177
ɣ-linolenic	C18:3 n6	0.201±0.010	0.174±0.017	0.154±0.008	0.161±0.006
Eicosadienoic	C20:2	0.330±0.017	-	0.368±0.018	0.083±0.008
Eicosatrienoic	C20:3n6c(cis8,11,14)	0.216±0.022	0.216±0.022	0.216±0.022	0.276±0.028
Arachidonic	C20:4 n6	0.321±0.016	0.188±0.019	0.229±0.011	0.177±0.018
Eicosapentaenoic	C20:5 n3	-	0.791±0.080	0.178±0.009	0.722±0.072
Docosadienoic	C22:2c	0.103±0.005	0.176±0.018	5.500±0.275	0.179±0.018
PUFA		6.989±0.349	5.835±0.584	5.500±0.275	6.349±0.635

The concentrations of the monounsaturated fatty acids found were below 1%, with the exception of oleic acid C18:1c9. The lowest content of the trans-isomer C18:1 trans-9 was observed in the milk of the sheep breed South Kazakh merino (0.119%) and Ordabasy (0.179%). The content of these fatty acids largely depends on the breed of sheep.

In the composition of polyunsaturated fatty acids, the maximum amount is characteristic of linoleic acid C18:2 n6c (2,553%; 1,544%; 2,128%; 1,769%) in the milk of sheep breeds Ordabasy, Kazakh fine-fleeced, meat merino and South Kazakh merino, respectively. In the fat of milk of sheep breeds meat merino and South Kazakh merino, the content of linoleic acid was less by 0.7 and 1%.

Polyunsaturated fatty acids are characterized by high biological activity - they participate in cellular metabolism and have an antisclerotic effect. In milk fat, according to the content of the most biologically important polyunsaturated fatty acids, the milk of Ordabasy sheep has an advantage - 4.68% (Nudda et al., 2019).

Balthazar et al. (2016) showed that the most abundant fatty acids in sheep milk yogurt are oleic acid (C18: 1n9), Followed by palmitic acid (C16:0) and myristic acid (C14:0) respectively (Balthazar et al., 2016; Balthazar et al., 2015).

Polyunsaturated fatty acids (PUFAs) in sheep milk fat: mainly composed of linoleic acid (cis-9, cis-12 C18:2) and **α**-linolenic acid (cis-9, cis-12, cis-15 C18:3) acids, as well as smaller amounts of their positional and geometric isomers (Recio et al., 2009). Mono- and polyunsaturated fatty acids in sheep milk may contribute to the prevention of cardiovascular disease due to atherogenicity and thrombogenic indices as described by Balthazar et al. (2016). In ruminants, sheep milk fat contains not only one of the highest levels of conjugated linoleic acid (0.65 g CLA/100 g fatty acids), but also high amounts of vaccenic acid (VA), its physiological precursor (Revilla et al., 2017).

Thus, as a result of the study of the fatty acid composition of milk fat of Ordabasy sheep of the summer lactation period, a difference was revealed between the four experimental groups in the amount of saturated fatty acids 64.408% in favor of Ordabasy sheep, monounsaturated fatty acids 24.603% in favor of Ordabasy sheep. It was revealed that the breed significantly affects the fatty acid profile of sheep milk lipids.

To assess the reliability of colorimetry as a predictor of raw milk quality and coagulation, Spanish scientists analyzed 1200 individual milk samples from four flocks of Manchega sheep in the Castilla-La Mancha region of Spain. The study aimed to investigate the relationships between milk composition, hygienic quality, and color values. The correlation structure analysis revealed direct correlations between color values, fat and protein content, and total solids content, while weak correlations were observed with lactose content and somatic cell index. These findings suggest that measuring color values can serve as a quick and effective tool to complement standard analyses in determining the clotting ability of Manchega sheep milk.

The vitamin content of sheep milk is in most cases higher than in cow and goat milk, except for carotene and folate, which are in lower concentrations, and pantothenic acid and vitamin D, whose concentrations are equal to those in cow milk (Park et al., 2007; Wijesinha-Bettoni and Burlingame, 2013). Riboflavin is abundant in sheep milk, and cow, goat and buffalo milk are adequate sources of riboflavin. A reference intake of riboflavin (0.5 mg/day) can be provided by 2 cups (300 mL) of sheep milk. Sheep milk can also be considered a source of vitamin C, containing an average of 4.6 mg/100 g (Wijesinha-Bettoni and Burlingame, 2013). Since sheep milk consumption is not widespread, it is likely that 2 cups of sheep milk yogurt or its dairy equivalent per 90 g sheep cheese meets these daily requirements (Recio et al., 2009). In addition, sheep milk fat is a good dietary source. Vitamin A and vitamin E are found in sheep milk only in the form of retinol, since dietary β-carotene is completely converted to this form (Raynal-Ljutovac et al., 2008).

The composition of sheep milk is subject to sharp fluctuations and depends on a number of factors, including the breed of animals and the composition of fodder (Chauveau-Duriot et al., 2010). During the research, the aim was set to determine the vitamin and mineral composition of sheep milk of different breeds. The milk of sheep of four breeds was studied: Ordabasy, Kazakh fine-fleeced, meat merino, South Kazakh merino. The scientific experiment was conducted during summer lactation. The data on the content of vitamins and minerals in the milk of sheep of different breeds are given in Table 4.

Table 4. Vitamin and mineral composition of sheep milk of different breeds during summer lactation (in 100 g).

Name of indicators, units of measurement	In the milk of sheep breeds			
	Ordabasy	**Kazakh fine-fleeced**	**Meat merino**	**South Kazakh merino**
Vitamins				
Vitamin A, µg	59.91±5.99	43.4±4.7	51.57±6.19	47.3±4.3
Vitamin $D_{3,}$ µg	not detected	not detected	not detected	not detected
Vitamin B_1, µg	4.75±4.8	38.0±3.8	51.7±5.2	47.0±4.7
Vitamin B_2, µg	615±6.2	119.64±11.96	635±6.4	248±24.8
Vitamin B_6, µg	73.0±7.3	15.0±1.5	21.5±2.2	21.0±2.1
Vitamin B_9, µg	not detected	not detected	not detected	not detected
Vitamin C, µg	4.001±0.400	4.062±0.467	3.998±0.396	4.007±0.41
Minerals				
Calcium (Ca), mg	191.64±38.33	220.57±44.11	231.23±46.25	176.45±35.29
Magnesium (Mg), mg	126.17±25.23	57.32±11.46	116.21±23.22	26.75±5.35
Iodine (I), µg	not detected	1.3±0.6	not detected	2.6±1.2
Iron (Fe), mg	5.24±1.05	5.33±1.07	6.73±1.35	2.59±0.52
Zinc (Zn), mg	19±6	2.56±0.85	24±8	4.2±1.4
Selenium (Se), µg	not detected	not detected	0.28±0.13	not detected
Manganese (Mn), mg	0.042±0.009	0.040±0.005	0.041±0.008	0.042±0.004

4. Discussion

The composition of fats contained in sheep milk includes vital fat-soluble and water-soluble vitamins A (retinol), B_1 (thiamine), B_2 (riboflavin), B_6 (pyridoxine), B_9 (folic acid) and C (ascorbic acid).

When analyzing the above data on the vitamin composition of sheep milk of the studied breeds, there is a tendency to increase the content of vitamins A, B_1, B_2, B_6 in the milk of Ordabasy and meat merino sheep breeds. The tendency of a higher vitamin A content - 59.91 µg/100g, B6 - 73.0 µg/100g was noted when analyzing the milk of Ordabasy sheep, and the milk of Kazakh fine-fleeced sheep contained a relatively smaller amount of vitamins A - 43.4 µg/100g, B_2 - 119.64 µg/100g, B_6-15.0 µg/100g. The content of vitamin D_3 and B_9 in sheep milk was not found in all the studied breeds. The concentration of ascorbic acid in the milk of sheep in all the studied breeds is almost in the same ratio.

Sheep milk is a rich source of minerals (Table 4). The levels of calcium, phosphorus, magnesium, zinc, manganese and copper are higher in sheep milk than in cow milk (Park et al., 2007; Wijesinha-Bettoni and Burlingame, 2013). Calcium and phosphorus are more abundant in sheep milk, is a fundamental element for bone growth and maintenance and is essential for newborns (Al-Wabel, 2008). The bioavailability of these minerals makes sheep milk a valuable source of these elements. Calcium is bound to casein, both in organic and mineral forms, showing significant availability during milk digestion (Guéguen and Pointillart, 2000); hence, the bioavailability of calcium in sheep milk is closely related to high levels of casein (Gaucheron, 2005). Essential nutrients such as calcium (Ca) and selenium (Se) play crucial roles as coactivators of important enzymes and proteins essential for maintaining health (Zhao et al., 2019).

The calcium content in the milk of sheep of different breeds ranges from 176.45 to 231.23 mg. The highest calcium content was found in the milk of sheep of the Kazakh fine-fleeced breed - 231.23 mg, the lowest in the South Kazakh merino breed - 176.45 mg. The highest magnesium content was found in the milk of Ordabasy sheep breed - 126.17, less in South Kazakh merino breed - 26.75 mg. The content of selenium in the milk of sheep of the Ordabasy breed, Kazakh fine-fleeced and South Kazakh merino, as well as iodine in the Ordabasy and meat merino breeds were not found, the content of these elements in the milk of sheep of other breeds is contained in insignificant amounts. The manganese content in all samples of sheep milk of four breeds shows almost the same results from 0.41 to 0.42 mg.

5. Conclusions

Studies have consistently demonstrated that milk obtained from sheep of all breeds exhibits improved properties, increased nutritional value, and a balanced chemical composition. Specifically, better milk productivity, along with increased fat and protein content, has been noted in sheep of the Ordabasy and South Kazakh merino breeds.

When analyzing the data on the vitamin composition of sheep milk of the studied breeds, there was a tendency to increase the content of vitamins A, B_1, B_2, B_6 in the milk of sheep of the Ordabasy and meat merino breeds.

They significantly surpassed other breeds in the production of fat and protein, which indicates the perspective of this breed. Moreover, it should be noted that the protein of this milk is significantly represented by casein fractions, which should increase the efficiency of the production of protein-containing products from it (cheese, cottage cheese, and others).

When analyzing the data on the vitamin composition of sheep milk of the studied breeds, there was a tendency to increase the content of vitamins A, B1, B2, B6 in the milk of sheep of the Ordabasy and meat merino breeds.

The content of calcium in the milk of sheep of different breeds ranges from 176.45 to 231.23 mg. The highest calcium content was found in the milk of sheep of the Kazakh fine-fleeced breed - 231.23 mg, the lowest in the South Kazakh merino breed - 176.45 mg.

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