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Nutritive Value of Goat and Cow Milk Sampled from the Region of East Kazakhstan

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AS, SD and ZY designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AN, GN and ST managed the analyses of the study. Authors NI, AA and EO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This paper presents the results of a nutritional profile of goat's milk sampled from the region of East Kazakhstan. The chemical composition determined showed that goat's milk contained 4.63% fat, 3.5% protein and 8.14% non-fat milk solids, while cow's milk had less fat (4.15%), protein (3.2%), but more non-fat milk solids (12.05%). The vitamin and mineral composition of goat milk consisted of vitamin B1 (0.036 mg/100 g), vitamin B2 (0.125 mg/100 g), vitamin B6 (0.057 mg/100 g), vitamin C (0.183 mg/100 g), sodium (193 mg/l), potassium (167.72 mg/l), calcium (386.43 mg/l), phosphorous (302.56 mg/l) and magnesium (42 mg/l). For cow's milk, the major mineral elements were represented by potassium (151.03 mg/l), calcium (125.73 mg/l), sodium (51.67 mg/l) and magnesium (14.54 mg/l). The majority of the essential amino acids were represented by histidine (0.278 g/100 g), leucine (0.264 g/100 g) and arginine (0.260 g/100g) in goat's milk. The overall nutritional profile of goat's milk was demonstrated to have particularly beneficial and healthful effects on the human body.

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1. INTRODUCTION

Milk processing and production of milk food is the main sector of agricultural industry of the Republic of Kazakhstan. Milk is one of the basic foodstuffs of the human diet [1]. Milk, as a food source, provides the human body with essential and complete nutrients and biological substances, ferments, vitamins and minerals [2].

Goat milk is a valuable milk product. The production of goat's milk is a dynamically growing industry as it represents an alternative to the consumption of cow's milk [3]. The biochemical composition, physical-chemical properties, and microbiology of goat milk is dependent on genetic factors and environment conditions. Goat's milk is related to functional food and well known for its health properties. It is a good source of essential fatty acids (especially, polyunsaturated fatty acids), vitamins, minerals (calcium, phosphorous, potassium, cobalt, manganese and selenium), and amino acids [4]. The fatty acid profile of goat milk is rich in ω-3 and ω-6 polyunsaturated fatty acids and conjugated linoleic acid, which is beneficial to the cardiovascular system and metabolism. Compared to cow milk, goat's milk has more mineral elements, such as calcium, phosphorous, manganese and potassium, as well as vitamin B3 and vitamin A [5].

Goat's milk is more compatible with the physiological functions of human body than cow's milk. Special attention has been given to the hypoallergic and biological properties of goat's milk [6]. Goat's milk does not cause allergic reactions and digestive disturbances due to it having a different protein composition to cow's milk protein. The protein in goat's milk contains two times less aSI-casein than cow's milk, which is a strong allergen in humans, but more p-casein (2.3 times more than in cow's milk), which is easily digestible. Protein molecules in goat's milk are smaller than cow's milk, leading to their faster and fuller protein breakdown by enzymes. High amounts of different minerals and vitamins help prevent avitaminosis and other, similar complications [7,8]. Goat's milk is used to treat diseases such as digestive disturbance, childhood epilepsy, jaundice, asthma, radiation hazard, blinding headache, liver, pancreas and cholecystis diseases [9]. In pharmacy, goat's milk is used in nutraceuticals, food supplements, and follow-on formulae for baby nutrition.

This study has been conducted to evaluate the nutritional and mineral content of goat's milk.

2. MATERIALS AND METHODS

Goat and cow milk were sampled from local farmers in East Kazakhstan. 25 samples of goat and 25 samples of cow milk were collected for analysis. The current research included 10 Saanen breed goats and 10 Kholmpgory breed cows.

2.1 Chemical Composition

Fat content was determined using the method described by Gerber [10]. 10 mL of H_2SO_4 (92% w/v), 11 mL of milk and 1 mL of isoamyl alcohol were added to a butyrometer, which was then sealed with a rubber cap and vigorously shaken until all particles had dissolved. The butyrometer was then placed in a water bath set at 60°C for 15 min and centrifuged for 5 min at 1,200 rpm. The separated milk fat was determined using a divider.

Protein content was determined using the Kjeldahl method in which the total nitrogen was obtained and multiplied by a factor of 6.38 [11]. Total solid content was determined by drying the samples at 105°C for 2 h. Lactose was quantified using the polarimetry method which was based on the specific rotation of polarized light due to the asymmetric carbon of lactose described in [12].

2.2 Amino Acid Determination

Liquid chromatography was used to quantify the amino acids present. The instrument used was a Shimadzu LC-20 Prominence liquid chromatography system (Shimadzu, Japan) equipped with fluorometric and spectrophotometric detectors. The chromatographic column used was a SUPELCO C18, 5 µm (Sigma-Aldrich, USA) offering a surface area of 200 m^2/g. The chromatographic analysis was performed under a linear gradient with an eluent flow rate of 1.2 mL/min, and the column was heated in an oven at 400°C. Amino acids were detected using fluorometric and spectrophotometric detectors at wavelengths of 246 nm and 260 nm following acidic hydrolysis

and treatment with a phenylisothiocyanate solution in isopropyl alcohol to give phenylthiohydantoins. Identification and estimation was performed by comparison to an amino acid standard solution (AAS18 Sigma-Aldrich Denmark A/S, Brondby, Denmark) and plotting the calibration curve.

2.3 Mineral Elements Determination

The content of elements in muscle samples was determined via inductively coupled plasma–mass spectrometry (ICP-MS, Varian-820 MS, Varian Company, Australia). The method was validated using certified reference materials. Var-TS-MS, IV-ICPMS-71A (Inorganic Ventures Company, USA) calibration standards were used to calibrate the mass spectrometer. The sensitivity of the mass spectrometer was tuned using a diluted calibration solution of Var-TS-MS with concentrations of Ba, Be, Ce, Co, B, Pb, Mg, Tl, and Th of 10 µg/L. Three calibration solutions were used for the detector calibration, which were IV-ICPMS-71A of Cd, Pb, Cu, and Zn diluted to 10, 50 and 100 µg/L. Discrepancies between the certified values and concentrations quantified were below 10 %. The operating parameters of the ICP-MS were as follows: plasma flow, 17.5 L/min; auxiliary flow, 1.7 L/min; sheath gas, 0.2 L/min; nebulizer flow, 1.0 L/min; sampling depth, 6.5 mm; RF power, 1.4 kW; pump rate, 5.0 rpm; stabilization delay, 10.0s.

2.4 Vitamin Composition Determination

The amounts of vitamins were determined by the method reported by Rudenko and Kartsova [13]. Liquid chromatography was used to quantify the vitamins. The instrument used was a Shimadzu LC-20 Prominence liquid chromatography system (Shimadzu, Japan) equipped with fluorometric and spectrophotometric detectors.

2.5 Sensory Evaluation

Sensory evaluation was performed by a panel of seven (7) skilled persons. In the case of defects in flavour and aroma (inadequately pronounced flavour, weedy flavour, and slightly acid flavour), and consistency and colour, the score was reduced for each defect according to the special sensory evaluation scale.

2.6 Statistical Analysis

Statistical analysis was performed using Statistical 12.0 (STATISTICA, 2014; StatSoft Inc., Tulsa, OK, USA). The differences between samples were evaluated using the ANOVA method. The differences were considered to be statistically significant at $p \leq 0.05$.

3. RESULTS AND DISCUSSION

The chemical composition of the cow's milk samples is presented in Table 1. In terms of its composition, the fat and non-fat milk solid content in goat's milk were significantly different from that of cow's milk. Fat contents were 4.63% and 4.15% for goat's and cow's milk, respectively. Non-fat milk solids were higher in cow's milk (12.05%) than in goat's milk (8.14%). Mineral and protein content in goat's milk did not vary significantly from those of cow's milk.

The protein molecules' size in goat milk is smaller than in cow's and therefore it can be more easily and quickly broken under the influence of digestive enzymes, including protease. Lipids in goat's milk consist of a greater number of short-chain fatty acids ($C_{4/0} – C_{12.0}$) and the average size of fat droplets is 3.49 nm, but for cows is 4.55 nm [14].

Table 2 presents the organoleptic and sensory analysis of cow's and goat's milk, where these properties were confirmed to meet the requirements of National Standards (GOST 31450-2013 and GOST 32940-2014) [15,16].

Mineral elements play a significant role in human body in helping it to perform its functions properly. They promote the transfer of oxygen to the human body (iron, copper) [17]. Calcium, sodium, potassium, phosphorous and magnesium are the major mineral elements found in goat's and cow's milk. The mineral composition of goat's milk is represented by sodium (193 mg/l), potassium (167.72 mg/l), calcium (386.43 mg/l), phosphorous (302.56 mg/l) and magnesium (42 mg/l). For cow's milk, the major mineral elements are represented by potassium (151.03 mg/l), calcium (125.73 mg/l), sodium (51.67 mg/l) and magnesium (14.54 mg/l). Heavy metal content in goat's milk was as follows: arsenic – 0.06 mg/l, lead – 0.063 mg/l, cadmium – 0.04 mg/l, while in cow's milk for the content was: arsenic – 0.005 mg/l, lead – 0.078 mg/l, cadmium – 0.01 mg/l (Table 3).

Vitamin content analysis (Table 4.) showed that goat's milk can be distinguished by its larger amount of vitamin B6 (0.057 mg/100 g)

and vitamin B1 (0.036 mg/100 g), while cow's milk showed higher amounts of vitamin B2 (0.156 mg/100 g) and vitamin C (0.219 mg /100 g).

Table 1. Chemical composition of goat milk

Milk sample	Fat, %	Protein, %	Non-fat milk solids, %	Mineral elements, %	Density, kg/cm^3
Goat milk (n=25)	4.63	3.5	8.14	0.8	1028
Cow milk (n=25)	4.15	3.2	12.05	0.7	1027

Table 2. Organoleptic and sensory properties of cow and goat milk

Indicator	Type of milk	
	Cow	Goat
Consistency	Homogenous, without flakes and precipitate	Homogenous, without flakes and precipitate
Odour and flavour	pleasant flavour	pleasant flavour
Colour	White with yellowish shadow	White with greyish shadow

Table 3. Mineral composition of goat milk, mg/l

Mineral element		Goat milk	Cow milk
Sodium	Na	193.0	51.67
Magnesium	Mg	42.01	14.54
Aluminium	Al	1.36	0.052
Potassium	K	167.72	151.03
Calcium	Ca	386.43	125.73
Chromium	Cr	0.09	0.002
Iron	Fe	1.85	0.07
Cobalt	Co	0.07	0.01
Copper	Cu	0.63	0.012
Manganese	Mn	0.05	0.006
Arsenic	As	0.06	0.005
Rubidium	Ru	0.35	0.089
Barium	Ba	0.02	0.01
Zinc	Zn	0.85	0.4
Selenium	Se	0.012	0.002
Strontium	Sr	0.15	0.017
Lead	Pb	0.063	0.078
Cadmium	Cd	0.04	0.01
Nickel	Ni	0.028	0.012
Phosphorous	P	302.56	103.65

Table 4. Vitamin composition of milk, mg/100g

Milk type	Vitamin content, mg/100g			
	Vitamin B1 (thiamine)	Vitamin B2 (riboflavin)	Vitamin B6 (pyridoxine)	Vitamin C (ascorbic acid)
Goat milk (n=5)	0.036	0.125	0.057	0.183
Cow milk	0.024	0.156	0.039	0.219

Biological effect of vitamins:

- Vitamin B1 stabilizes the work of the heart and nervous system, and controls carbohydrate metabolism;
- Vitamin B2 helps in cell regeneration, and stimulates the nervous and immune systems;
- Vitamin B6 stimulates metabolism and improves the nervous system;
- Vitamin C strengthens blood vessels, cartilage and bone tissue, and provides anti-inflammatory action, and reduces cholesterol levels in the blood [18].

Table 5 shows the amino acid composition of goat's and cow's milk. A high concentration of glutamic was observed in goat milk (0.603 g/100 g), followed by tyrosine (0.480 g/100 g), histidine (0.278 g/100 g), leucine (0.264 g/100 g) and arginine (0.260 g/100 g). A lower content of methionine (0.05 g/100 g), tryptophan (0.05 g/100 g), glycine (0.03 g/100 g) and cystine (0.02 g/100 g) were also observed.

Table 5. Amino acid composition of goat's milk, g/100 g

Amino acid	Goat's milk	Cow's milk
Essential		
Arginine	0.260	0.117
Valine	0.152	0.196
Histidine	0.278	0.086
Isoleucine	0.163	0.198
Leucine	0.264	0.275
Lysine	0.201	0.258
Methionine	0.050	0.083
Threonine	0.129	0.146
Tryptophan	0.050	0.051
Phenylalanine	0.128	0.18
Non-essential		
Alanine	0.105	0.10
aspartic	0.208	0.227
Glycine	0.030	0.049
glutamic	0.603	0.526
Proline	0.231	0.273
Serine	0.137	0.183
Tyrosine	0.480	0.18
Cystine	0.020	0.029

In the study in [19], the chemical composition of milk from Mongolian goats was determined, from which it was reported that fat, protein and non-fat solids were 4.30, 3.93 and 13.91%, respectively. The authors in [20] determined the chemical composition of Saanen goat's milk and found 3.80% fat, 2.90% protein, 0.79% total ash. Znamirowska et al. analysed the quality of raw goat's milk for the production of yoghurt [21]. The protein, fat and dry matter content were 2.69%, 2.98% and 10.78%, respectively.

4. CONCLUSION

Goat's milk is an excellent source of protein, which is more easily digested in the human body than cow's milk. Goat's and cow's milk show differences in their vitamin and mineral compositions, where goat's milk can be distinguished by its higher amounts of vitamin B6, B1, calcium, potassium, copper, and phosphorous. In terms of amino acid composition, cow's milk has a slightly higher content of essential amino acids such as valine, isoleucine, leucine, lysine, threonine and phenylalanine. Therefore, the data from this study supports the use of goat's milk along with cow's milk in daily nutrition and in the production of milk products with a positive effect on human health and wellbeing at any age.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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