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Characterization of Mongolian Goat Milk

C Narangerel[1*], M Narangerel[2], TS Batsukh[3], B Munkhjargal[4], A Bat-Erdene[2] and TS Dorjsuren[1]

[1]*Institute of Technology, Ulaanbaatar, Mongolia*

[2]*School of Animal Science & Biotechnology, Mongolian University of Live Sciences, Mongolia*

[3]*School of Industrial Technology, Mongolian University of Science and Technology, Mongolia*

[4]*National Dairy Development Board of Mongolia, Mongolia*

[*]**Corresponding author:** Narangerel Choijilsuren, Institute of Technology, Ulaanbaatar, Mongolia, E-mail: nayag2000@yahoo.com

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Abstract

Specific compositions of the protein amino acids components, carbohydrates, fat, minerals, enzymes and immune substances of Mongolian pasture goats are showing that it is certainly a good quality product for food, child nutrition, treatment and spa food. It is also related to the Mongolian traditions of replacing breast-milk with goat's milk and use it for a variety of health treatments. It has been proven that biotransformation of cheese, which has a part of propionic acid bacteria (*P. shermanii*), contains large quantities of volatile acids, soluble proteins, flavor forming compounds and plays a great role in producing the specific taste and quality of the product. Research findings revealed that goat's milk functional properties depended on the hair color of the goats, because fat acids in the milk were different in samples from goats with different hair color. The milk sampled from white haired goats was found to have a higher amount of unsaturated fatty acids than that found in the milk from black haired goats.

Since Mongolia has a rich source of non-cow's milk, especially the rich source of goat milk, it is really important to build advanced technology, modern research methods and inventing new special milk composition, as well as, producing brand products, processing new technology, increasing the income of the herders and finding a new process for exporting the product.

Keywords: Goat milk; Coat color; Soft cheese; Fatty acids

Introduction

Mongolian goat population was 2.5 million in 1926. Since 2000, the number has been steadily increased to 13.3 million in 2006 and 23.6 million in 2015. Hence, 86.5% of livestock in Mongolia was small ruminants and goats occupied 42% and 10 million female goats [1].

Goat farming is one of the vital parts of the national economy in many countries in the world. Nowadays, goat milk is one of major sources of foodstuff for millions of people in the developing countries in Asia and Africa. 60% of the world goat population is in Asia, 34% in Africa, 4% in America, 2% in Europe and 2% in ocean countries. China has taken the first place in the world, India is the second, and entrain Pakistan, Nigeria, Sudan, Bangladesh and Mongolia is the tenth of most goats populous countries. Goat milk production mainly produced from the developing countries is accounted 2.4% of total milk production in the world [2]. It shows importance of the goat farming for food supplies in the countries. Contrary, goat milk is widely utilized for unique and precious dairy products and/or used as treating and nursing and also beauty purposes in the developed countries. Consumption of goat milk is divided into three types: general household consumption, unique interest and treating and nursing purposes. But goat milk was traditionally used for all types of the consumption in Mongolia.

Milk from Mongolian goat breeds in grazing all-round the year and still processed by traditional technology in household condition is not significantly important in food supply. Therefore it is needed to develop the traditional goat milk processing technologies and introduce new and up to date technologies [3]. For this purpose, the research was carried out related to developing technology for goat dairy products, which promotes human health.

Materials and Methods

Samples were prepared from milk of grazing goats, mares, female yaks and khainag in Mongolia. Composition and physic-chemical parameters of the milk were determined by common scientific methods of systemic attitude, analysis and theoretical-experimental approach. Physicochemical analysis of the milk of different species was performed under the same methodology used to characterize: lipids, Gerber's butyrometer, method (MNS 0399:1983); protein, Kjeldahl's method multiplying the nitrogen percentage by 6.38, method (MNS 2150:1983); ash, through muffle incineration at 550°C using method (MNS 2151:75); acidity, titration expressed as lactic acid, method (MNS 0400:1983). Copper (Cu), Zinc (Zn), Sodium (Na), Potassium (K), Calcium (Ca) and magnesium (Mg) in milk were determined by atomic absorbance spectrophotometer, fatty acids by gas chromatograph (GC-HPLC4890), amino acids by ion exchange chromatography (ARACUS, Germany).

Microbiological analysis of the soft cheeses was counted the colonies of *P. shermanii* obtained by the test tube method (cultural conditions; 30°C, 48-72 h, medium GMK-1).

Results and Discussion

Composition and physic-chemical characteristics of goat milk

Traditionally, goat milk is processed with sheep milk for national dairy products based on milk composition and functional and technological properties. Composition and properties of Mongolian goat milk were determined by Tserensonom et al. [4], Indra et al. [5], Narangerel et al. [6] and Narangerel et al. [7].

Mongolian local goat milked 60-70 litres/lactation, therefore the amount of Mongolian goat milk production can't be compared to production of dairy goat breeds. Starting from the ancient times, Mongolians have been using milk from goats, sheep, cows and yaks, mares and she camels. Chemical composition of goat milk is compared with milk from the rest of the animals and human in Table 1 [5,7-11].

Composition (%)	Goat	Sheep	Cow	Mare	Camel	Yak	Human
Total solids	15.23	17.47	13.25	10.3	15.46	19	12.9
Fat	4.84	6.35	4.28	2.2	5.65	7.26	4.2
Solids, nonfat	10.39	11.12	8.97	8.1	9.81	11.74	8.7
Lactose	5.3	4.17	4.75	7.8	4.4	5.19	6.5
Protein	4.11	5.77	3.42	2.6	4.23	5.85	1.3
Casein	2.71	3.46	2.65	1.24	2.87	5.05	0.4
Albumin, globulin	1	1.61	0.57	0.94	1.35	0.6	0.3
Non-protein N	0.4	0.7	0.2	0.4	0.3	0.6	0.5
Ash	0.89	1.03	0.8	0.4	0.87	0.86	0.3
Calories[a]	83	100	73	61	88	112	71
[a]kcal/100 mL							

Table 1: Average composition of basic nutrients in goat, sheep, cow, mare, camel, yak, and human.

There are a number of unique physiological and anatomical differences between goats and cows which translate into differences in composition of goat milk and its products [12]. Chemical composition in goat milk was not so different from cow milk [5,13], but solid amount in sheep milk was 1.5 times more than it was in milk of human and other animals. Lactose in human and mare milk was 1.6 times more than in milk from other species, but mineral amount was 2.3 times less. Composition of mare milk was comparatively different from milk of other species (Table 1).

Mongolian goat's milk contains 15.17% of solids, 5.71% of fat, 3.76% of protein, 4.78% of lactose and 0.9% of minerals in an average [5,14]. Fat content of goat milk was fluctuated by lactation months due to plant development periods, climate and milk yield. In contrast, minerals in goat milk had very small changes in spite of being influenced by breeds, fodder composition, environment, minerals in soil and water, climate, seasons, lactation months, animal physiology, body condition score and etc. [15].

Minerals in goat milk in the first lactation were 0.83% in average and in the following lactations, it was 0.84%; but no significant difference was observed in geographical areas. Goat milk had contained Na in 70.5 mg/100 g, K in 115.9 mg/100 g, Ca in 76.3 mg/100 g, Mg 0.123 mg/100 g, Cu in 13.2 mcg/100 g and Zn in 313.2 mg/100 g. When compared with cow milk, the goat milk had 43.6% less Na, but 10-57% more K, Ca, Mg, Cu and Zn [16].

Differences of goat milk composition had occurred in each country and milk of Mongolian goat breed was the highest in total solids (Table 2). For example, milk of Mongolian goats contained 0.59-1.92% more fat, 0.13-1.31% more protein, 0.32-1.14% more lactose and 0.03-0.16% more minerals than those were in milk from other goat breeds. It is thought because of breed feature, environment, climate, pasture and fodder composition, and milk yield. Authors' results are very similar to results by Guo et al. [17] in China.

Density of goat milk was similar to the milk of all animals except sheep milk, but refractive index, freezing point and pH in goat milk were less than in others' milk. Specific gravity, viscosity and acidity in sheep milk were higher than in milk from others [5,7,9,10,18,19]. Viscosity in milk of Mongolian livestock was ranked as sheep>camel>goat>cow>mare.

Significance of milk fat of goats related to structure of fat globules, size and its distribution, mainly fat globules were less the 3 μm and it seems naturally homogenized. The average size of fat globules and size distribution range of particles are smaller in goat milk than in bovine milk [20].

Countries	Total solids	Fat	Protein	Lactose	Ash	Researchers
Mongolia	15.23	4.84	4.11	5.44	0.83	Narangerel et al. [7]
China	14.36	4.25	3.98	5.12	0.74	Guo et al. [17]
France Portugal Greece	11.9	3.35	3.3	4.55	0.8	Park et al., Tamime et al., Tratnik [21-23]
Oklahoma USA	10.5	2.92	2.8	4.3	0.67	Fekadu et al., Pierre [24,25]
Russia	13	4.1	3.5	4.6	0.8	Chikalev [26]

Table 2: Comparison of goat milk composition (%).

Although more investigation is needed in structure of fat globule cover, but it is established two layers which had different contents [27-30]. Globule cover contains proteins, phospholipids, sphingolipids, sterols, β karyotin, vitamin A, D and E, enzymes, Fe, Cu and others which play significantly roles to unique and nutritious properties of milk fat for food.

Geographical location, climate, diet, rearing condition influence fat globule size, which can also be affected by species and breeds [20]. Fat globules in goat milk were 1.3 times smaller than in cow milk, and less cream layer created on top of goat milk. Also no homogenization is required when goat milk is used for UHT milk line, and quickly broken down by enzymes in the human digestive system and suitable in utilization as a treatment and nourishment purposes and neonate diet.

Breeds	Fat globule						Researchers
	Goat milk			Cow milk			
	Quantity (million per ml)	Size (μm)	Specific surface area (cm^2/ml)	Quantity (million per ml)	Size (μm)	Specific surface area (cm^2/ml)	
Mongolian goats and cows	10950	2.43	20.21	4437	3.24	14.6	Narangerel [7]
Goats and cows in Poland	1900	3.1	-	1500	3.6	-	Mehaia [31]
Alpine goats and Holstein cows	-	2.76	21.77	-	3.51	17.11	Richter et al. [20]

Table 3: Fat globule size and its distribution in goat and cow milk.

Fat globule size in Mongolian goat milk was 2.43 ± 0.12 μm, which is 1.3 times smaller; and quantity of fat globules per ml of goat milk was in 10950 million, which is 2.5 times more than it is in cow milk, respectively (Table 3). Thanks to fat content and quantity of fat globules, specific surface area of goat milk is larger than it is in cow milk.

Composition of amino acids in milk proteins is important in baby and nourishment diets. Therefore, compared investigation had been implemented in constitution of amino acids in milk from goats, mares, khainags and yaks. The results have revealed that 20 μL of goat milk had in 115 nmol while mare milk in 25 nmol, khainag milk 50 nmol, yak milk 127 nmol; ranked by amino acids as yak>goat>khainag>mare.

Biological unique value of milk proteins are expressed by their amino acids, especially the composition, and it consists of essential amino acids [32]. Fifteen amino acids included eight essential amino acids were determined in milk of above four species. Contents of histidine-which is believed one of most essential amino acids for babies–in milk of goats and yaks was 2-3 times more than in milk of the rest of animals. Also amount of essential amino acids: methionine, phenylalanine, threonine, and non-essential amino acids: glutamine, glycine, serine, tyrosine in goat milk was higher than other livestock.

Goat coat color and characteristics of milk

Traditional medicine in Far East has recommended using goat milk concerned its coat color as a treatment and nourishment purposes for human. That is good example that some products from livestock depended on their coat color might be unique composition. It implies livestock depended on their coat color receive different/various spectra from sun which might affect metabolic reactions in their bodies.

The evolution foundation of the natural phenomenon is in their unique different features. Traditionally, Mongolian nomads based on the livestock coat color related to differentiation phoenix of life have been consuming raw and processed milk from red cow and white mare, goat and female camel for folk's medicine until now [16]. Because of above traditional habit of using goat milk for well-being can be continued for the future, biological unique properties including its functional properties of goat milk are needed to study more widely.

Lipids are the most important components of milk in terms of cost, nutrition, and physical and sensory characteristics than they impart to dairy products. Most FA, from acetic (C2:0) to arachidic acid (C20:0), contain an even number of carbon atoms [33].

Fat in milk of different goat breeds and coat colors mainly contains 5 fatty acids (C10:0, C14:0, C16:0, C18:0 and C18:1) which occupied more than 75% (Table 4). Domination of capric (C10:0) (5.57%, 6.07%, 7.50%, 7.82%), lauric (C12:0) (3.86%, 4.23%, 5.27%, 4.38%) and myristic (C14:0) (10.24%, 9.85%, 9.54%, 10.4%) was observed, but C12:0 acid in milk of Mongolian white goats was dominator.

A double bonded-unsaturated fatty acids (32.94%, 33.95%, 26.55%, 22.41%) were determined and myristoleic (C14:1) (0.23%, 0.2%, 0.75%, 0.28%), palmitoleic (C16:1) (9.21%, 7.85%, 2.5%, 1.03%) and oleic (C18:1) (23.5%, 25.9%, 23.3%, 21.1%) dominated in Mongolian goat milk. Poly-unsaturated fatty acids (9.25%, 8.24%, 5.66%, 4.01%) were determined and linoleic acid (5.9%, 4.43%, 3.26%, and 3.21%) and linolenic acids (3.35%, 3.81%, 2.4%, 0.8%) dominated in Mongolian goats. Chemical compositions of milk, such as fatty acids content were varied depending on the goat coat color.

Correlation between goat coat color and milk properties was determined by the authors using the blood test from the people who consumed white or black goat milk and had been shown results of decreased sugar, cholesterol and triglyceride concentrations. It is raised a prediction because of amount of linolenic, eicosatrienoic and linoleic acids in goat milk. But reduction of sugar, cholesterol and triglyceride concentrations in human blood vary depending on the goat coat color [16].

Investigation results of goat soft cheese

Compared to cow milk, the goat milk contains more proteins, fats and calcium, as well as plenty of essential amino acids, vitamins (including C, A, B_1 and B_2) and minerals. Goat's milk is traditionally consumed as a treatment and nourishment for anaemia, metabolic disorder and a wide variety of gastro-intestinal disorders among many Mongolians. Propionic acid bacteria-with functional properties for human health are only used for hard cheese with repeated-high temperature processed, but the authors have developed soft cheese from goat and cow milk processing technology used the culture.

Fatty acids	Goat milk[a]	Goat milk		Goat milk[d]
		Black coat color[b]	White coat color[c]	
C8 : 0	0.41	0.3	-	2.64
C10 : 0	5.57	6.07	7.5	7.82
C12 : 0	3.86	4.23	5.27	4.38
C13 : 0	0.2	0.1	0.8	0.7
C14 : 0	10.24	9.85	9.54	10.4
C15 : 0	0.78	0.46	1.6	0.47
C16 : 0	15.8	16	25.3	25.9
C17 : 0	1.48	1.03	3.2	0.63
C18 : 0	12.3	11	9.79	9.57
C21 : 0	0.32	0.38	3.4	-
C14 : 1	0.23	0.2	0.75	0.28
C15 : 1	0.1	0.12	-	-
C16 : 1	9.21	7.85	2.5	1.03
C17 : 1	0.8	1.02	-	0.2
C18 : 1	23.5	25.9	23.3	21.1
C20 : 1	0.42	0.54	-	-
C18 : 2n9c	5.9	4.43	3.26	3.21
C18: 2n9t	3.59	3.74	1.35	0.74
C18 : 3n6	2.17	2.28	1.8	-
C18 : 3n3	1.18	1.53	0.6	0.8
C20 : 3n6	0.16	0.12	0.04	-
C20 : 0	1.04	1.07	1.04	0.45

[a]Narangerel et al. [34]; [b,c]Narangerel et al. [7], Narangerel et al. [6]; [d]Goudjil et al. [21]

Table 4: Comparative fat composition of goat milk (% in fatty acids).

Enzymes from the stomach easily affect goat milk, that the coagulation time is shorter and it drains (loses whey) faster than cow milk. It has been confirmed that high temperature treatment of goat's milk prolongs the coagulation period, while the drainage of the whey is improved, and the result is a hard coagulum (completely different from cheese production using cow's milk) [35]. It has been determined that biological pre-processing in goat milk is turned up milk acidity, increased firmness and texture of the coagulum and shortened coagulation period likely cow milk.

Soft-cheeses using propionic acid bacteria contain sufficient water-soluble proteins, volatile fatty acids and other nutritious ingredients which gives unique aroma and flavour in the resulting products.

Soft cheeses produced using starter culture of propionic acid bacteria that characterized by high content of viable bacteria, propionic acid bacteria cells that gives products to probiotic properties. Soft cheese from Mongolian goat milk, which is used by propionic acid bacteria have 10^9-10^{10} CFU/g [36,37].

Conclusions

Instable milk production in Mongolia is due to nomadic and pasture based livestock system. There are many possibilities to extend the scope and frame of scientific research and innovation and cooperate with foreign and/or international organizations, specialists and scientists in the sector regarding to analyze composition of milk from Mongolian goats in year-round pasture. To develop new and integrated technology probiotic and prebiotic goat milk derived protein based products like soft cheeses enriched by propionic acid bacteria, with bifid bacteria and water soluble protein product.

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