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Physico-Chemical Characteristics of Mongolian Goat, Sheep and Cow Milk

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Abstract

For purposes of substantiation of organizing measures on industrial processing of goat's and sheep's milk in Mongolia and the production of dairy products we have conducted the studied physico-chemical characteristics of the Mongolian goat's and sheep's milks especially to recognize amino acids, minerals and vitamins in the milk and compare with the Mongolian cow's milk. And also was studied fractional structure of goat's milk whey proteins.

Keywords: Milk, chemical composition, amino acid, vitamin, mineral, whey proteins

Introduction

In Mongolia unlike the other countries of the world dairy products from five types of domestic animals (cow, mare, goat, sheep, camel) traditionally are prepared by distinctive methods from other countries are used.

However basically the products from cow's milk are popular in the industry but products from other kinds of animals are mostly processed in small volume by individual farmers by traditional methods.

The Mongolian national dairy products are known under various names in abroad, such as "Airag", "Khoormog" and "Tarag". "Airag" is a mare's milk product. "Khoormog" is a fermented drink from camel's milk. "Tarag" is a fermented milk, which is prepared by cow's, goat's and sheep's milk.

Information on composition and physico-chemical characteristics of goat and sheep milk are essential for successful development of dairy industry as well as for the marketing. There are distinct differences in physico-chemical characteristics between goat, sheep and cow milks.

The composition of cow milk in the market is expected to have minimal changes throughout the year, because the milk bulk tanks from the cow herds would vary little by seasons to year-round breeding. On the other hand, this is quitedifferent from sheep and goat milk, which is predominantly produced by seasonal breeding of ewes and does (Haenlein and Wendorff, 2006).

Therefore, changes in goat and sheep milk compositions occur by seasons, because towards the end of the lactation, the fat, protein, total solids and mineral contents increase, while the lactose content decreases (Brozos *et al*., 1998; Haenlein, 2001; 2004).

Goat milk differs from cow or human milk with the reason of having better digestibility, alkalinity, buffering capacity, and certain therapeutic values in medicine and human nutrition (Haenlein and Caccese, 1984; Park and Chukwu, 1989; Park, 1994). Sheep milk has higher specific gravity, viscosity, refractive index, titrable acidity, and lower freezing point than average cow milk (Haenlein and Wendorff, 2006). Lipids in sheep and goat milk have higher physical characteristics than in cow milk, but there are variations between different reports (Anifantakis, 1986; Park, 2006a).

Lactose content of goat milk is about 0.2－0.5% less than that of cow milk (Posati and Orr, 1976; Haenlein and Caccese, 1984; Chandan *et al*., 1992). Lactose in sheep milk as in other ruminants is lower at the beginning of lactation in colostrum and towards the end of lactation, contrary to the behavior of fat and protein contents in milk (Pulina and

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Bencini, 2004; Haenlein and Wendorff, 2006). Lactose in sheep milk as in other ruminants is lower at the beginning of lactationin colostrum and towards the end contrary to the behavior of fat and protein contents in milk (Pulina and Bencini, 2004; Haenlein and Wendorff, 2006).

Milk of most wild or less domesticated mammalsusually has more fat and lower contents of lactose when compares to goat milk (Park, 2006b). Cow milk contains minor levels of monosaccharides and oligosaccharides (Chandan *et al*., 1992). Carbohydrates other than lactose found in sheep and goat milk are oligosaccharides, glycopeptides, glycoprotein's, and nucleotide sugars in small amounts (Larson and Smith, 1974). Milk oligosaccharides have considerable antigenic properties and are valuable in growth promotion of the intestinal flora of the newborn.

The aim of our work is to organize measures on industrial processing for goat and sheep milk in Mongolia and use them in new dairy products. With this purpose we have studied physico-chemical characteristics of the Mongolian goat's and sheep's milks especially to recognize amino acids, minerals and vitamins in the milk and compare with the Mongolian cow's milk. And also was studied fractional structure of goat's milk whey proteins.

Materials and Method

Samples of goat and sheep as well as cow milk were collected in private households and herdsmen family of the central territory of Mongolia in July.

The content of dry substances, fat, protein, lactose, mineral substances and vitamins of milk were determined by commonly used standard methods. Amino acids were determined by automatic analyzator.

Fractional component of goat's milk of whey protein determined by SDS-PAAG electrophoresis method.

Results and Discussion

The increasing of population is one of the main factors that contribution need for supplying population with milk dietary products and increasing of their composition. Since 2001 along the increasing of birth rate in Mongolia, population of capital city Ulaanbaatar is growing because of mass migration rural inhabitants to the city. According to statistical data only in 2011 year the total population of Mongolia reaches 2 million 811 thousand people, and 46% of them live in Ulaanbaatar. Mongolian population of last 4 years has shown on Table 1.

Table 1. Mongolian population (2008－2011)

Years	Regions/thousand. people/				
	Western	Khangai	Central	Eastern	Ulaanbaatar
2001	422.4	558.7	446.5	202.4	812.5
2008	370.7	523.5	435.6	188.5	1,147.7
2009	365.2	523.6	442.9	187.7	1,196.8
2010	357.1	521.7	450.7	186.9	1,244.4
2011	356.2	523.7	456.2	188.4	1,287.1

Table 1 shows capital city Ulaanbaatar's population has increased much. Concurrence with this supply of milk processed products were increased. It is necessary increase dairy products by using of sheep and goats milk as resource.

According to statistical data of number of livestock animals in last 4 years are shown on Table 2.

The latest statistical calculations were shown that the total livestock animals in Mongolia have reachedat 36. 3 millions. hardly, that 30.2% more than it was in 2001.

For calculation of milk resources it need to consider not only the total amount of livestock but the amount of female animals used for breeding. It is shown on Table 3.

Table 2. Number of livestock animals

Years	Livestock animals/mill. heard/				
	Cattle	Hours	Camel	Sheep	Goat
2001	2,069.8	2,191.8	285.2	11,937.2	9,591.6
2008	2,504.4	2,186.9	266.4	18,362.3	19,969.4
2009	2,599.3	2,211.3	277.1	19,274.7	19,651.5
2010	2,176.6	1,920.3	269.6	14,480.4	13,883.2
2011	2,339.7	2,112.9	280.1	15,668.5	15,934.6

Table 3. Female livestock animals

Years	Livestock animals/mill. heard/				
	Cow	Mare	Camel	Ewe	Goat
2001	850.7	692.2	84.2	5,438.5	4,319.4
2008	971.6	631.5	85.2	8,253.5	8,589.6
2009	1,023.8	649.6	89.7	8,672.8	8,569.5
2010	901.9	593.0	90.7	7,097.5	6,850.7
2011	965.6	641.6	96.2	7,117.5	6,872.1

During the last 4 years the breeds of sheep and goats were increased. Thus, the livestock of goats and sheeps has been increased by 30.2 % compared with 2001 year. By using of growth rate date of female livestock we have calculated the total resource of milk for industrial processing for five types of livestock animals. Calculations presented in Table 4.

From the Table 4 we may see that within the period of last 4 years the resources of goat's and sheep's milk have increased correlated with the growth of their amount.

Therefore goat and sheep milk should be produced in milk factories in Ulaanbaatar the capital city of Mongolia.

First stage of this study was determined the total solids, fat, protein, lactose and ash of goat, sheep and cow's milk.

Table 4. The total resources of milk in Mongolia for producing dietary products

Year	Milk resource/min. L/				
	Cow	Mare	Camel	Sheep	Goat
2001	306.3	65.4	10.6	44.1	46.7
2008	349.8	59.7	10.7	66.9	92.8
2009	368.6	61.4	11.3	70.3	92.6
2010	324.7	56.2	11.4	57.5	74.0
2011	347.7	60.6	12.1	57.7	74.2

Table 5. Average composition of basic nutrients in Mongolian goat, sheep and cow milk

Whole milk (%)	Milk		
	Goat	Sheep	Cow
Total solids	16.76±1.10	24.19±1.51	13.15±1.20
Fat	6.04±0.20	11.79±0.60	3.88±0.50
Protein	4.95±0.15	7.19±0.40	3.87±.0.33
Lactose	4.82±0.21	4.22±0.20	4.03±0.06
Ash	0.83±0.04	1.04±0.10	0.74±0.15

Research results of the milk component those received from the Mongolian breed animals are presented in Table 5.

From the data that presented in the Table 5, the compositions of goat, sheep, and cow milks are different. Milk of the Mongolian animals high in total solids and rich in fat and protein. Sheep milk contains higher total solids and major nutrient contents than goat and cow milk.

Lipids are the most important components of milk in terms of cost, nutrition, and physical and sensory characteristics that they impart to dairy products.

The average protein content in sheep milk (7.2%, w/w) is higher than in goat (5.0%, w/w) or cow milk (3.9%, w/w). Protein contents are vary widely within species, and are influenced by breed, stage of lactation, feeding, climate, parity, season, and udder health status.

Compared to cow milk, lactose contents in sheep milk are at about the same level, while fat and protein levels are much higher (Table 5).

Studied technological properties of goat, sheep and cow milk. The results are shown in Table 6.

Density lower of goat and sheep milk is comparable to that of cow milk. Viscosity of goat milk is slightly higher, while that of sheep milk is much higher than in cow milk.

The important factor for processing milk and dairy products is amino acid content. In order to reveal biological and nutritional value of milk it is needed to determine amino acid components.

In this connection we have determined amino acid in collected milk samples. The results are shown in Table 7.

The data presented in the Table 7 are shown, that the goat, sheep and cow milk are characterized by high contents of amino acids such as glutamin acid, asparginov acid, leitsin, lizin and prolin. The content of irreplaceable amino acids in the protein of goat, sheep and cow milk of the Mongolian

Table 6. Some physical properties of goat, sheep and cow milk

Properties	Milk		
	Goat	Sheep	Cow
Specific gravity (density)	1.030 - 1.038	1.036 - 1.039	1.027 - 1.032
Viscosity (Cp)	2.95	3.12 - 3.23	2.4
Freezing point (- ℃)	0.560 - 0.58	0.59	0.54 - 0.56
Acidity (^{0}T)	20 - 24	23 - 26	18 - 20
pH	6.50 - 6.80	6.51 - 6.85	6.65 - 6.71

Table 7. Amino acid in goat, sheep and cow's milk of Mongolian breed

No	Amino acid (%)	Milk		
		Goat	Sheep	Cow
1	Valine	6.34	6.39	5.89
2	Isoleucine	5.19	5.41	5.27
3	Leucine	9.38	9.69	9.73
4	Lysine	8.11	8.55	8.16
5	Methionine	1.73	2.38	2.08
6	Tryptophane	4.44	4.15	4.04
7	Tyrosine+Threonine	3.32	3.47	3.54
8	Phenylalanine	4.61	4.81	4.41
9	Alanine	3.93	2.77	4.82
10	Arginine	3.13	3.63	3.12
11	Aspartate	8.05	8.10	8.21
12	Hystidine	1.74	1.80	1.79
13	Glycine	2.03	2.04	2.20
14	Glutamate	22.56	21.50	22.40
15	Proline	10.00	9.85	8.82
16	Serine	4.32	4.06	4.46
17	Cystine	2.17	2.03	1.80
	Sum	101.05±0.72	100.63±0.58	100.64±0.50

*The error of measurements was ±0.05

breed is 43.64%, 45.41%, and 44.49%. According to these data as goat, sheep and cow milk have similar food value.

The latest investigations are shown that goat's milk give beneficial effect on patients, wreaked children suffering by intestinal diseases and allergy by Bulatova (2004).

Goat's milk protein rediffer from cow's milk protein by fractional composition. The main whey protein of cow's milk is β-lactoglobulin, whereas goat's milk's is α-lactalbumin. The clusters formed of stomach from goat's milk are less on size and have substantially less density than cow's milk. That lightens digestion by proteolytic enzymes. This cluster resembles cluster arising after digesting of human's milk Denisova (2004).

A study carried out by Bellioni-Businco *et al*. (1999) strongly indicated that goat's milk was not an appropriate cow's milk substitute for children with IgE medicated cow's milk allergy. Perhaps a warning on the lack of safety of goat's milk for children with cow's milk allergy should be on the label of goat's milk formulas to prevent severe allergic reactions in babies with cow's milk allergy.

It was the reason for studying whey protein's fractional composition of goat milk. The data of study is shown in Table 8.

As shown at Table 8 goat's milk is differed from cow's on serum albumin, β-lactoglobulin, α-lactoalbumin fractions.

In addition of mineral and vitamin-composition of goat, sheep and cow's milk were determined.

In Table 9 it is presented the mineral composition of Mongolian pastorals animals.

Sheep milk has around 0.9% total minerals or ashcompared to 0.7% in cow milk.

The levels of Ca, P, Mg, Zn, and pH are higher in sheep than in cow milk, while the opposite appears to be the case for Na, and Mn (Table 8).

In general, mineral contents of sheep milk seem to vary much more than those of cow milk (Rincon *et al*., 1994) due to feeding differences and months of the year. The trace minerals in sheep milk have not been extensively studied

Table 9. Mineral composition of Mongolian pastorals animal's milk

Elements	Content of mineral substances in milk (mg% of ash)		
	Goat	Sheep	Cow
Calcium	22.88±1.50	28.56±2.27	18.83±1.46
Sodium	4.15±2.42	7.03±2.56	4.76±1.95
Potassium	16.90±0.06	13.0 ±0.41	22.4 ±0.59
Magnesium	1.53±1.17	2.16±1.60	1.64±3.46
Phosphorus	17.48±0.44	15.12±0.51	18.40±0.74
Zinc	0.05±0.86	0.08±2.20	0.04±0.41

Table 8. Fractional composition of goat's milk whey protein

Milk	Fractional content (%)			
	Serum albumin	β-Lactoglobulin	α-Lactoalbumin	Immunoglobulins
Goat	8.95±1.50	20.87±1.90	58.3 ±1.90	11.80±0.80
Cow	10.20±0.88	45.5 ±1.59	18.11±2.09	12.62±1.36

even though they may be of considerable nutritional and possibly human health interests.

In the Table 9, calcium in goat milk is more than in cow milk, but it is much lesser than in sheep milk. Calcium, sodium and magnesium contents in sheep milk are higher than in goat and cow milk. According to the results that is visibled; the sheep milk contains approximately twice more sodium, than goat and cow milk but sodium is approximately similar in contents. Calcium in cow milk is more than in goat and sheep milk by its amount.

Milk is a valuable source of vitamins and it is important to preserve vitamins during industrial processing of milk.

Goat and sheep milk have higher amounts of vitamin A than in cow milk (Table 9). Because goats convert all β-carotene into vitamin A in the milk, caprine milk is whiter than bovine milk. Goat milk supplies adequate amounts of vitamin A and niacin, and excesses of thiamin, riboflavin and pantothenate for a human infant.

If a human infant fed solely on goat milk, the infant is oversupplied with protein, Ca, P, vitamin A, thiamin, riboflavin, niacin and pantothenate in relation to the FAO-WHO requirements (Jenness, 1980). Vitamin B levels in goat and cow milk are a result of rumen synthesis, and are somewhat independent of diet (Haenlein and Caccese, 1984; Mann, 1988).

In Table 6 it's presented results of determination of vitamins in goat, sheep and cow's milk.

In Table 10 the results of determination of vitamins in goat, sheep and cow milk.

As shown at Table 10 quantitative content of vitamin B_1 and B_2 in sheep's milk are higher than the goat's and cow's milk. Content of vitamin A in cow's milk is lesser than goat's and sheep's milk. Data obtained after determination of mineral and vitamin composition of goat's and sheep's milk in comparison with cow's has givena possibility to make conclusions about their high value.

Table 10. Vitamin contents of goat, sheep and cow milk

Vitamins (mg%)	Milk		
	Goat	Sheep	Cow
Niacin B_1	38.96	74.85	30.08
Riboflavin B_2	156.12	417.66	180.37
A	381	465	146
E	1,717	1,870	1,855

Conclusion

During the last 4 years the breeds of sheep and goats were increased. Thus, the livestock of goats and sheeps has been increased by 30.2% compared with 2001 year.

Milk of the Mongolian animals high of total solids and rich of fat and protein. Sheep milk contains higher total solids and major nutrient contents than goat and cow milk.

The content of irreplaceable amino acid in the protein of goat, sheep and cow milk of the Mongolian breed is 43.64%, 45.41%, and 44.49%. As shown at goat's milk differ from cow's on serum albumin, β-lactoglobulin, α-lactoalbumin fractions (Table 8). Calcium in goat milk is more in cow milk, but it is much less than in sheep milk. Calcium, sodium and magnesium contents in sheep milk is high than in goat and cow milk (Table 9).

Vitamin contents in sheep milk are mostly higher than in cow and goat milk, except for carotene (Table 10), however, research data on vitamins in sheep milk are sparse.

Thus, investigation on chemical, amino acid, mineral and vitamin composition of milk from Mongolian pastoral animals confirm their enormous value and the need for conducting in future detailed investigations for substantiation of parameters of industrial technology for products with preventive directivity.

References

1. Anifantakis, E. M. 1986. Comparison of the physico-chemical properties of ewe's and cow's milk. In: International Dairy Federation (Ed.), Proceedings of the IDF Seminar Production and Utilization of Ewe's and Goat's Milk, Bulletin No. 202. Athens, Greece, pp. 42-53.
2. Bellioni-Businco, B., Paganelli R., Lucenti, P., Giampietro, P. G., Perborn, H. and Businco, L. 1999. Allergy of goat's milk in children with cow's milk allergy. Journal of Allergy and Clinical Immunology, 103(6):303-307.
3. Brozos, C., Saratsis, P., Boscos, C., Kyriakis, S. C. and Tsakalof, P. 1998. Effects of long-term recombinant bovine somatotropin (bST) administration on milk yield, milk composition and mammary gland health of dairy ewes. Small Rumin. Res. 29:113-120.
4. Drouet, M. 1997. Milk protein. Allergy and Immunology 15(5):129-130.
5. Chandan, R. C., Attaie, R. and Shahani, K. M. 1992. Nutritional

aspects of goat milk and its products. In: Proc. V. Intl. Conf. Goats, vol. II: part II, New Delhi, India, p. 399.
6. Larson, B. L. and Smith, V. R. (Eds.), 1974. Lactation, vol. 4. Academic Press, New York, p. 1994.
7. Mann, E. J. 1988. Ewe's and goat's milk and products. 1. Dairy Ind. Int. 53:23.
8. Haenlein, G. F. W. 2001. The nutritional value of sheep milk. Int. J. Animal Sci. 16:253-268.
9. Haenlein, G. F. W. 2004. Goat milk in human nutrition. Small Rumin. Res. 51:154-163.
10. Haenlein, G. F. W. and Caccese, R. 1984. Goat milk versus cow milk. In: Haenlein, G. F. W., Ace, D. L. (Eds.), Extension Goat Handbook. USDA Publ., Washington, DC, p. 1, E-1.
11. Haenlein, G. F. W. and Wendorff, W. L. 2006. Sheep milk-production and utilization of sheep milk. In: Park, Y. W., Haenlein, G. F. W. (Eds.), Handbook of Milk of Non-Bovine Mammals. Blackwell Publishing Professional, Oxford, UK, and Ames, Iowa, USA, pp. 137-194.
12. Jenness, R. 1980. Composition and characteristics of goat milk: Review 1968-1979. J. Dairy Sci. 63:1605-1630.
13. Park, Y. W. 2006b. Minor species milk. In: Park, Y. W., Haenlein, G. F. W. (Eds.), Handbook of Milk of Non-bovine Mammals. Blackwell Publishing Professional, Oxford, UK/Ames, Iowa, pp. 393-406.
14. Parkash, S. and Jenness, R. 1968. The composition and characteristics of goat's milk: A review. Dairy Sci. Abstr. 30:67-75.
15. Pulina, G. and Bencini, R. 2004. Dairy sheep nutrition. CABI Publ., Wallingford, UK, p. 222.
16. Rincon, F., Moreno, R., Zurera, G. and Amaro, M. 1994. Mineral composition as a characteristic for the identification of animal origin of raw milk. J. Dairy Res. 61:151-154.
17. "Statistical Information" issued by the National Statistics Office of Mongolia, UB, 2001; 2008-2011.

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