Korean Dairy Technol. 5(1) : 1～7, 1987

Chemical and Biochemical Properties of Mongolian Milk and Milk Products

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1. Introduction

In our Second Mongolian Research Project from the end of July through August 1976, much efforts have been made to obtain further information about the manufacture and chemical or biochemical properties of Mongolian traditional milk products. It was the most typical summer season during our research trip. Many kinds of Mongolian traditional milk products are produced abundantly in this season. As described our preliminary report in 1977, this tradition is the fruits of the creativity and sagacity by northern nomadic tribes. The feature is the perfect utilization of milk from all kinds of livestock for making effectively into a variety of preservative form of milk products. This fact is one of the most interesting thing in the world history of milk-using culture.

The object of this research is to survey and investigate on the manufacturing and chemical or biochemical properties of Mongolian traditional milk products. In this research trip several samples of Mongolian milk and milk products were able to collect and bring into Japan after permission of Mongolian Ministry of Agriculture. Chemical and biochemical analyses of the samples were performed in detail and much useful informations were obtained from the results. The data are summarized in this report.

The author would like to express in advance his heartful thanks to Dr. Ajush, Dr. Nyamaa and other officials of Mongolian Ministry of Agriculture for their warm cooperations and kind generosities.

2. Materials and Methods for Analyzing Milk and Milk Products

All samples of milk and milk products used in this study were collected during staying in Mongolia in 1975 and 1976. Mixed milk samples were collected from a herd of Mongolian cows, mares, ewes, goats and camels, which were keeping near Ulan Bator or around Bulgan Agricultural Research Center and Kharakhorin National Farm. A part of the milk samples collected was brought into Japan and analyzed especially for general composition (moisture or total solids, fat protein, lactose and ash) of milk, and for fatty acid composition of milk fat.

Samples of Mongolian traditional milk products were also collected during staying in Mongolia, and analyzed for general composition, fatty acid composition of milk fat and nitrogenous composition of milk protein in comparison with Japanese milk products of western type.

The method for analyzing general composition of milk and milk products was per-

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formed according to standard analytical method.

Fatty acid composition of milk fat from Mongolian milk and milk products was determined by gas-liquid chromatography using Diasolid S - diethyleneglycol succinate column. For this analysis milk fat samples were previously purified by centrifugal separation and dehydration for milk and butter-like products, or by extraction with chloroform - methanol and dehydration for cheese-like products. The purified milk fat samples were methyl-esterified directly by refluxion of 0.025 N KOH - methanol solution.

Total and water-soluble nitrogen of cheese-like milk products was determined by ordinary Kehldahl method for analysis of cheese. The ratio of water-soluble nitrogen to total nitrogen was expressed as index number of cheese ripening.

3. Analytical Results on the Properties of Mongolian Milk and Milk Products

(1) General Composition of Milk from Mongolian Livestock

Analytical values for general composition of mixed milk from a herd of Mongolian cows, mares, ewes, goats or camels are given in Table 1. Mongolian cow's milk contained higher percentages of total solids, fat, protein, lactose and ash than Japanese Holstein cow's milk. In the latter case the average percentages of milk constituents are 11.88 in total solids, 3.52 in fat, 2.98 in protein, 4.46 in lactose and 0.71 in ash.

Table 1 General composition of milk from Mongolian livestock

Animal	Moisture (%)	Total solids (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)
Cow	87.36	12.64	3.85	3.27	4.59	0.80
Mare	89.54	10.46	2.30	1.45	6.24	0.38
Ewe	82.12	17.88	6.67	5.75	4.60	0.82
Goat	86.90	13.10	4.11	3.54	4.58	0.84
Camel	85.80	14.20	5.80	3.67	4.01	0.69

Mongolian mare's milk was characterized by considerably high content of lactose in contrast to quite a low content of fat, protein and ash. The lactose content amounted to as much as 6.24 per cent, which was the highest value of five kinds of Mongolian milk samples used. Such mare's milk is comparatively similar in general composition to human milk.

Ewe's milk was remarkably rich in total solids, fat and protein, each of which exhibited the highest percentages in five kinds of milk samples. Camel's milk was also quite rich in total solids and fat, especially in the latter.

Goat's milk was not so rich in each of milk constituents when compared with milks of ewe and camel. However, the milks of cow and goat did not appear to be greatly different so far as the major milk constituents are concerned.

From a number of references on the analyses of various mammalian milks, it has been well-known that the composition of milk varies among species and races of mammals with the course of lactation and to some extent with the composition of the rations (JENNESS and SLOAN, 1970). This fact seems to be equally true of the present data on milk samples from five kinds of Mongolian livestock.

(2) Chemical Composition of Mongolian Traditional Cheese-like Products

Five samples (No. 1 - 5) of Mongolian traditional cheese-like products were collected and analyzed for chemical composition. Two different samples (No.6 and 7) of Japanese commercial cheese in western type were also analyzed in comparison with the Mongolian cheese-like products.

Table 2 Chemical composition of Mongolian cheese-like products

Sample No.	Acidity (%)	Moisture (%)	Fat (%)	Protein (%)	Ash (%)
No. 1	0.81	13.75	34.58	27.99	1.57
No. 2	2.46	14.18	13.82	42.85	3.95
No. 3	0.94	13.52	12.62	44.25	6.05
No. 4	0.90	16.94	54.94	13.50	1.66
No. 5	0.80	10.03	19.15	43.73	4.94
cf. No. 6*1	0.78	38.16	29.07	24.98	4.55
No. 7*2	0.75	54.80	33.11	8.94	1.05

*1 Commercial Gouda cheese available in Japan
*2 Commercial cream cheese available in Japan

The results are indicated in Table 2. The minimum to maximum contents of major milk constituents are 10.03 - 16.94 per cent in moisture, 12.62 - 54.94 per cent in fat, 13.50 - 44.25 per cent in protein and 1.57 - 6.05 per cent in ash. Of these cheese-like samples, sample No.4 was characterized by especially high content of fat. The samples No.1 and No.4 contained a comparatively low protein and ash, while the sample No.3 was quite rich in ash but low in fat. Distinctly high value of acidity was observed in the sample No.2. In general, Mongolian cheese-like products contained extremely less moisture and in most cases more protein than Japanese commercial cheese in western type.

Mongolian traditional cheese-like products differ considerably in their technique for preparation and manufacture from typical western cheese. The principle of the technique for making Mongolian cheese-like products is concentration and coagulation by heat with or without acidification by natural or lactic acid fermentation. Therefore heat or acid curdling in such Mongolian products is a completely different chemical action from rennet coagulation in most of western cheese.

About forty years ago SAITO and KOJIMA (1937) have surveyed and analyzed for Inner Mongolian milk products. According to their analytical results, "urum" which is a cream-like or cream cheese-like products made by heat concentration of whole milk, con-

tained 3.4 - 31.5 per cent moisture, 42.7 - 78.2 per cent fat, 3.4 - 22.4 per cent protein and 0.9 - 2.9 per cent ash. On the other hand "horoat" and related products, which are typical acid coagulated hard cheese in Mongolia, contained 7.6 - 25.1 per cent moisture, 9.3 - 25.4 per cent fat, 41.8 - 61.6 per cent protein and 1.9 - 3.2 per cent ash. Recently NYAMAA (1967 and 1970) reported on the chemical composition of Mongolian traditional milk products including urum and horoat, chemical properties of which were mostly similar to the analytical results by SAITO and KOJIMA (1937).

In consideration of our results described here when compared with those in above references, the sample No.4 will belong to the category of urum, and the other samples (No.1 - 3 and No.5) will correspond to horoat and related products.

(3) Fatty Acid Composition of Milk Fat from Mongolian Milk and Milk Products

1) Fatty acid composition of milk fat from Mongolian cow and horse

It has been known that there are distinct differences in short or long chain fatty acids composed of milk fat among various mammalian milk. In this experiment the milk fat samples from Mongolian cow and horse as well as a butter fat sample from Mongolian butter of western type were prepared to analyze for fatty acid composition by gas-liquid chromatography. The experimental results are as shown in Table 3.

Table 3 Fatty acid composition of milk fat from Mongolian cow and horse and from Mongolian butter of western type

Fatty acids	Cow's milk (%)	Horse milk (%)	Butter (%)
$C_{4:0}$ (butyric)	1.43	–	1.08
$C_{6:0}$ (caproic)	1.79	–	1.67
$C_{8:0}$ (caprylic)	1.34	3.80	0.95
$C_{10:0}$ (capric)	2.82	7.36	2.53
$C_{10:1}$ (caproleic)	tr.	0.84	tr.
$C_{12:0}$ (lauric)	3.23	7.91	2.68
$C_{12:1}$ (lauroleic)	tr.	–	tr.
$C_{14:0}$ (myristic)	12.0	7.42	9.03
$C_{14:1}$ (myristoleic)	2.14	0.10	1.30
$C_{15:0}$	0.38	tr.	0.20
$C_{16:0}$ (palmitic)	30.8	25.5	29.4
$C_{16:1}$ (palmitoleic)	1.10	2.18	1.09
$C_{17:0}$	0.19	0.25	0.06
$C_{18:0}$ (stearic)	15.6	0.01	14.0
$C_{18:1}$ (oleic)	29.3	15.1	33.0
$C_{18:2}$ (linoleic)	0.40	12.4	0.50
$C_{18:3}$ (linolenic)	1.18	17.1	1.80

The milk fat from Mongolian cow contained a high concentration of palmitic and oleic acids, and also contained a certain quantity of short chain fatty acids including $C_{4:0}$ (butyric) to $C_{10:0}$ (capric) acids. The results coincide essentially with those from Holstein cow's milk by our previous works (KATAOKA and NAKAE, 1971).

On the other hand Mongolian horse milk contained a high concentration of $C_{10\text{-}14}$, linoleic and linolenic acids in addition to palmitic and oleic acids. The data were consistently similar to those reported previously by GLASS *et al* (1967).

Fatty acid pattern of butter fat in this experiment was generally similar to that of milk fat from Mongolian cow. Therefore the Mongolian butter described above should be made from Mongolian cow's milk.

In most of milk fat from mammalian milk, palmitic and oleic acids are usually prominent as their constituent fatty acids. Butyric acid seems to be a hallmark of ruminant milk fat, having been found in all of the species. However horse milk fat is characterized by a high concentration of middle chain even numbered saturated acids ($C_{10\text{-}14:0}$) and also of essential fatty acids, linoleic and linolenic acids. The difference in fatty acid pattern of milk fat between cow and horse should be due to apparently different structure of stomach.

2) Fatty acid composition of milk fat from Mongolian cheese-like products

Fatty acid composition of milk fat from five samples of Mongolian cheese-like products is shown in Table 4. The fatty acid patterns were consistently similar to those from Mongolian cow's milk and butter as previously shown in Table 3.

However all samples of the cheese-like products were characterized by a high level of palmitic acid (33.8 - 38.9 per cent) and none or trace concentration of butyric, caproic, linoleic or linolenic acids. The concentration of constituent oleic acid in milk fat of the samples No.1 - 3 and No.5 was considerably lower than palmitic acid in the same milk fat. On the other hand there was scarcely difference in percentage of fatty acid composition of the sample No.4 between palmitic and oleic acids.

Fatty acid patterns in milk fat from Mongolian cheese-like products depend probably upon many factors such as kind of raw milk, method for making the cheese-like products, degree of fermentation or ripening of the products, etc. Furthermore, it should be recognized that the fatty acid patterns are closely related to organoleptic properties of the cheese-like products such as flavor and taste. The presence or absence of linoleic and linolenic acids as essential nutrients is also important thing especially in Mongolian people in connection with heart disease and arteriosclerosis.

(4) Properties of Nitrogenous Compounds of Mongolian Cheese-like Products

It is well-known that cheese or cheese-like products cause more or less biochemical and physico-chemical changes during their ripening process. Major changes by ripening are decomposition of milk protein. The protein changes during ripening are usually measured by the determination of water-soluble nitrogen in comparison with total nitrogen in cheese. The ratio of water-soluble nitrogen to total nitrogen in cheese is commonly used as index number of cheese ripening, the value of which is about twenty to forty per cent in hard cheese such as Gouda or cheddar cheese.

Table 4 Fatty acid composition of milk fat from Mongolian cheese-like products (Sample No.1 - 5)

Fatty acids	Sample number				
	No. 1 (%)	No. 2 (%)	No. 3 (%)	No. 4 (%)	No. 5 (%)
$C_{4:0}$ (butyric)	–	–	–	–	–
$C_{6:0}$ (caproic)	–	–	–	–	–
$C_{8:0}$ (caprylic)	0.05	0.56	0.40	0.61	0.64
$C_{10:0}$ (capric)	2.60	4.50	6.52	2.05	2.69
$C_{10:1}$ (caproleic)	–	–	–	tr.	tr.
$C_{12:0}$ (lauric)	3.00	3.15	3.43	2.56	2.30
$C_{12:1}$ (lauroleic)	–	0.17	0.12	–	–
$C_{14:0}$ (myristic)	10.8	10.6	9.93	11.3	10.5
$C_{14:1}$ (myristoleic)	1.09	1.08	0.90	1.10	1.08
$C_{15:0}$	0.15	tr.	–	0.27	0.17
$C_{16:0}$ (palmitic)	38.9	34.3	36.5	33.8	37.4
$C_{16:1}$ (palmitoleic)	2.15	1.15	1.09	1.36	1.20
$C_{17:0}$	0.15	0.31	0.22	0.15	0.25
$C_{18:0}$ (stearic)	14.5	17.2	19.1	12.2	18.2
$C_{18:1}$ (oleic)	25.5	27.2	23.0	33.7	25.5
$C_{18:2}$ (linoleic)	tr.	tr.	–	tr.	–
$C_{18:3}$ (linolenic)	tr.	tr.	0.50	0.40	tr.

Table 5 indicates the contents of total and water-soluble nitrogens in five samples of Mongolian cheese-like products and their index numbers of ripening in comparison with those in two samples of commercial cheese of western type.

Table 5 Total and water-soluble nitrogens in Mongolian cheese-like products and their index numbers of ripening

Sample number	Total-N (mg/g)	Water-soluble-N (mg/g)	Index number*1 of ripening
No. 1	43.87	1.27	3.0
No. 2	65.37	9.49	15.5
No. 3	69.36	4.45	6.4
No. 4	21.16	2.59	12.2
No. 5	68.54	6.37	9.3
No. 6*2	39.15	7.8	19.9
No. 7*3	14.02	1.2	8.6

*1 Index number of ripening = water-soluble-N/total-N x 100
*2 Commercial Gouda cheese available in Japan
*3 Commercial cream cheese available in Japan

Total and water-soluble nitrogen in Mongolian cheese-like products contained 21.16 - 69.36 mg/g and 1.27 - 9.49 mg/g, whereas the same values were 39.15 and 7.8 mg/g in a commercial Gouda cheese, and 14.02 and 1.2 mg/g in a commercial cream cheese. Therefore the index numbers of ripening were 3.0 - 15.5 per cent in Mongolian cheese-like products, 19.9 per cent in Gouda cheese, and 8.6 per cent in cream cheese.

NAKANISHI and TOKITA (1965) have reported that average index number of ripening in commercial Gouda cheese was 24.9. The fact shows that the index number of ripening in Mongolian cheese-like products is generally lower than that in Gouda cheese as typical western hard cheese. It means therefore that the curd proteins in Mongolian traditional cheese-like products such as horoat and the related products are not so decomposed.

For further investigation on Mongolian traditional milk products, more detailed experiment and analysis for their chemical and biochemical properties will be required in next research project.

The author expresses thanks to Mr. T. MIYAMOTO for technical assistance.

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