

Preservative Properties and Processing Methods of Milk

Hideko ARIGA

Obihiro University of Agriculture and Veterinary Medicine

Milk is a very important source of nutrition for humans and many other animals for growth and the maintenance of health. Although there are various kinds of milk including that taken from cows, goats, sheep, horses, camels and buffalos, cow milk is consumed most commonly in Japan on a daily basis. This paper will deal with cow milk.

1. Properties of Cow's Milk as a Food

The cow's milk currently produced in Japan contains 3.1% protein, 3.8% fat and 4.5% lactose. It contains 12.4% solids, of which 8.6% is non-fat solids. The protein contained in cow's milk is rich in casein, which comprises 80% of the protein present. Other components of its protein are β -lactoglobulin, α -lactalbumin, serum albumin and immunoglobulin. The amino acid composition of cow's milk has 100% nutritive value compared with the FAO/WHO (1973) and FAO/WHO/UNU (1985) amino acid pattern.

The fat in cow's milk has a higher percentage of medium and short chain fatty acid than other foods. Medium and short chain fatty acid is easily digested and is absorbed directly into the liver through the intestinal tract and portal veins. Thus, it is used by the human body effectively since it tends not to be stored in the body as subcutaneous fat and is not generally converted into chylomicron in the blood. In addition, it is important as a source of fat-soluble vitamins, particularly retinol and tocopherol.

The lactose contained in cow's milk facilitates the absorption of calcium. People of some races sometimes experience a drastic decline in the secretion of lactase, which hydrolyses lactose, after the weaning period, resulting in an inability to digest the lactose contained in cow's milk. This condition is called lactose intolerance. It has been reported that 70% of the world's population suffers from lactose intolerance. It's incidence is higher among non-European people than European people. People who suffer from lactose intolerance cannot digest lactose into monosaccharides. Therefore, the lactose in milk is not absorbed through the small intestine and passing into the large intestine generates excessive gas which induces intestinal ailments or causes diarrhea. People affected by these symptoms consciously avoid taking cow's milk. For people of color, mainly from Asia and Africa, lactose intolerance is a serious problem. These people need to consume milk containing a low percentage of lactose. They should be given cow's milk which has its lactose partially decomposed or fermented milk instead of the ordinary milk. Of the minerals contained in cow's milk, calcium is important because of its high content and percentage of utilization. The average intake of calcium by people in Japan is not sufficient, a circumstance which may lead to osteoporosis. With the increase in the number of elderly people, it has become a great problem. Milk plays an important role in increasing the daily intake of calcium.

Among the vitamins which are necessary to maintain health, people tend to fail to take a sufficient amount of retinol and riboflavin. Milk can make a significant contribution to increasing the intake of these vitamins.

2. Milk in Japan; its Uses and Preservation Methods

Milk is processed by heating or other methods. Most processing methods aim at improving the shelf life of milk. Generally speaking, milk for drinking is treated as a fresh food by processors and consumers. Drinking milk is rarely processed so that it may be preserved for a long time. Other processed milk products, however, are produced for long-term storage.

1) Use of drinking milk

People in Japan have less milk and milk products than people in Europe and America. International consumption statistics from the IDF bulletin from 1988 show that people in Japan take only 150g of milk per person per day, which ranks Japan 27th out of 29 countries. It was in 1945 when people started to drink milk. The National Survey of Nutrition by the Ministry of Health and Welfare in Japan reports that the average daily intake of milk in Japan was only 1g in 1947. Most of the 47g of animal food was taken from fish. The intake of milk increased to 7g in 1950, 13g in 1955, and 22g in 1958 when people gradually started to consume more processed milk products. After that, the intake of milk steadily rose showing an increase from 30g to 70g in the 1960's and reaching nearly 100g in the 1970's. In 1974, milk replaced fish as the major source of animal food. Of the 340g average intake of animal food currently observed, 120g are taken from milk, which reflects the highest proportion of any food group. As a special characteristic of the manner in which milk is utilized in Japan, the percentage of milk used for drinking is higher than that in Europe and America. In England, drinking milk accounted for 40% of all the uses of milk, which is the highest ratio among all the countries in Europe and America in 1986. In Japan, however, 64% of all the milk produced in 1988 was used as drinking milk. In 1989, 62.5%, which is 4,956,800 tons (total production, 8,135,000 tons), was used as drinking milk (Table 1).

Table 1 Production of raw milk and volume processed for each use

	Production of raw milk (thousand tons)	Milk for drinking (thousand tons)	Milk for dairy products (thousand tons)	Percentage of drinking milk (%)
1981	6,611.5	4,139.6	2,293.9	65.3
82	6,848.0	4,247.0	2,462.6	64.0
83	7,085.7	4,271.1	2,705.1	61.8
84	7,200.4	4,328.3	2,764.1	61.6
85	7,435.9	4,307.0	3,015.0	59.5
86	7,360.9	4,342.2	2,836.2	61.5
87	7,427.4	4,598.1	2,655.7	64.2
88	7,717.6	4,821.5	2,776.3	64.0
89	8,135.0	4,956.8	3,053.6	62.5

As this shows, although the amount of milk intake is not as much as in other countries, the ratio of domestically produced milk used for drinking is higher in Japan than in any other country. This forms a remarkable contrast with the uses of milk in countries in Europe and America, and it may be considered to be a characteristic feature of dairy production and consumption in Japan.

2) Processing for the production of drinking milk

Based on the ordinance regarding milk and milk products issued by the Ministry of Health and Welfare, drinking milk in Japan is classified into milk, special high quality milk, partially skimmed milk and liquid milk containing recombined milk. Except for some kinds of special high quality milk, the shelf life of milk is improved by pasteurization or sterilization. Heating is the only method used for drinking milk. Nothing should be added to drinking milk.

The method of heat treatment of milk most commonly used now in Japan is the Ultra High Temperature Method (UHT). By this method, milk is sterilized through a process of heat exchange using metal plates. The method is theoretically 99.99999% to 100% effective in killing the microorganisms contained in milk. Milk subjected to UHT is called sterilized milk. About 95% of all the drinking milk distributed in Japan is processed by this method. Since UHT milk retains its quality for about a week in refrigerators, it is the most commonly sold milk at retail stores.

Recently, groups of milk consumers have urged some companies in the dairy business to process milk by the High Temperature Short Time Method, that is, sterilization at 72°C for 15 seconds or at 85°C for 15 seconds. Milk processed this way has been gaining popularity among consumers. The High Temperature Short Time Method was introduced to Japan in 1952. Five years later, the Ultra High Temperature Method became the industry standard for milk sterilization because of its higher effectiveness. HTST, however, has less influence on the flavor of milk, preserves its fresh flavor and causes less degeneration of the components of milk. That is the reason why consumers tend to prefer HTST milk. Production of HTST milk hit its lowest level in 1980, and started to increase after that. However, it still accounts for only 3.5% of the total liquid milk production.

The demand for milk processed through the Low Temperature Long Time Method, which is the basic method of pasteurization, has also been increasing because the milk is less influenced by heating. This method, however, leads to a higher survival rate for bacteria, particularly heat-resistant bacteria which results in the shelf-life of the milk being shorter than HTST milk. Therefore, only raw milk of high quality in terms of its microorganism content should be chosen for the LTLT Method. Although only 1.4% of the liquid milk produced is currently heat treated by the LTLT Method, the amount of milk heat treated this way has increased by 280% during the past four years. It is expected that the LTLT Method, together with the HTST Method, will be applied more in the future.

Special high quality milk is milk which has not been heat treated or which has been pasteurized by the LTLT Method. It was in 1989 when 23kl of non-heat treated special high quality milk was brought to market. Special high quality milk pasteurized by the LTLT Method had already been on the market before that. Currently, 300 kl of LTLT special milk is produced, which is only 0.4% of the total LTLT milk production (Table 2). As described above, in response to consumer demand the temperature used for sterilizing milk has been gradually lowered. Yet, the quality of raw milk in terms of its bacterium content has been rapidly improving. Presently, the majority of the raw milk produced is of high quality, which makes pasteurization at lower temperatures possible. However, the quality of raw milk in terms of its bacterium content is not 100% ensured so that the distribution of HTST or LTLT milk involves a higher risk of bacterium contamination, a condition for which consumers, used to the way they treat UHT milk, may be unprepared.

Table 2 Transitions in the volume of heat processed milk

	Non-heated	62-65°C	75~	Sterilized instantaneously	Total
	kg	kg	kg	kg	kg
1980	-	7,233	116,515	3,805,064	3,928,802
83		11,118	284,584	4,165,408	4,461,108
84		15,013	152,452	4,150,591	4,318,056
85		21,790	136,750	4,119,477	4,278,017
86		28,319	132,701	4,009,956	4,260,976
87		42,724	151,479	4,288,387	4,482,590
88		64,953	160,546	4,349,963	4,574,474

	Non-heated	62-65°C	75~	Sterilized instantaneously	Total
	%	%	%	%	%
1980	0.0	0.2	3.0	96.8	100.0
83	0.0	0.2	6.4	93.4	100.0
84	0.0	0.3	3.5	96.1	100.0
85	0.0	0.5	3.2	96.3	100.0
86	0.0	0.7	3.1	96.2	100.0
87	0.0	0.9	3.4	95.7	100.0
88	0.0	1.4	3.5	95.1	100.0

On the other hand, LL milk, which is sterilized by the UHT Method and aseptic filling, was put on the market in 1979. At the beginning, only about 24,000 kl of LL milk was distributed. The distributed volume of LL milk, however, increased by more than 500% to 120,660 kl in 1988. Still, LL milk accounts for only 2.6% of the drinking milk produced. In 1986, some plants manufacturing milk products to be stored at normal temperatures received permission for operation. By June, 1986, 20 plants had obtained permission. After that, six more plants were given permission. By January, 1989, 26 plants owned by 15 different manufacturers were producing LL milk products to be stored at normal temperatures.

Table 3 Production of milk for each use (thousand kl)

	For drinking milk	Liquid milk	Liquid milk containing recombined milk	Milk beverages	Fermented milk	Lactic acid bacteria beverages
1982	4,242.5	3,526.0	716.5	592.2	164.4	138.1
83	4,279.7	3,584.8	694.9	637.1	174.3	139.1
84	4,327.3	3,662.7	664.5	707.2	173.2	165.2
85	4,269.0	3,650.8	618.3	721.0	191.1	172.5
86	4,280.6	3,702.2	578.5	712.1	212.2	175.4
87	4,507.2	3,922.3	584.9	740.7	233.0	171.0
88	4,704.8	4,085.5	619.3	750.1	270.1	205.1
89	4,857.8	4,211.9	645.9	747.4	295.8	232.6

3. Fermented Milk: Its Uses and Preservative Properties

The recent trend in the uses of milk in Japan is the continuing steady consumption of drinking milk and the increase in the consumption of health-oriented drinking milk such as fermented milk and lactic acid beverages (Table 3). Fermented milk is suitable for the many people who suffer from lactose intolerance in Japan. The fresh sour taste and pleasing consistency of fermented milk products are also appreciated. In addition, people in Japan still lack enough calcium intake. Since Japanese are a people of longevity, there has been growing awareness of the importance of calcium intake. Osteoporosis affects mainly elderly people making it difficult for them to walk or move freely, which tends to result in their being bed-ridden. As was mentioned previously, daily milk intake was only 1g in 1945, and increased more than a hundred times in the 45 years after that. However, elderly people who were already adults 45 years ago rarely had opportunities to drink milk in those days. Moreover, many had insufficient secretion of lactase. Therefore, the percentage of elderly people who can make sufficient use of milk is low. For these people, fermented milk, which needs less lactose than ordinary milk to be digested, because of its lower content of lactose is good news. It has been reported that the lactose in fermented milk is about 40% less than that in ordinary milk as a result of lactose consumption by lactic acid bacteria in the fermentation process. In addition, it has been suggested that the lactase secreted by the living lactic acid bacteria contained in fermented milk helps to digest lactose in the human body. Fermented milk makes it easy for people to take protein and calcium as well as lactose. Also, the formation of lactic acid causes the pH to decline, which increases the product's resistance to spoilage. In other words, fermented milk has superior preservative properties. Stored in a refrigerator, it keeps for at least two weeks. Frozen yogurt can be stored in freezers for about a year without any deterioration of its quality. It retains an excellent flavor.

Yogurt distributed in Japan is for the most part manufactured using a combination of *Streptococcus salivarius* subsp. *thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium* rather than a combination of *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*, the latter being the organisms specified by FAO/WHO. This is on account of the various positive physiological effects which *Lactobacillus acidophilus* and *Bifido-bacterium* have been reported to impart. For example, bacteriocin, an antibacterial substance suppressing the growth of pathogenic bacteria which induce gastroenteric trouble, is generated in lactic acid bacteria in yogurt. Lactic acid bacteria are also effective in suppressing the growth of tumors induced by chemical substances. It has been reported that some types of *Lactobacillus acidophilus* facilitate the absorption of nitrite from the intestinal tract, thereby inhibiting the transformation of nitrite into nitrosoamine, a carcinogenic substance, and constituting a potential antitumor mechanism. The research in addition suggests that the above substances contained in yogurt also work effectively for humans. Thus, there has been much interest from consumers toward yogurt as a health-oriented food. People are using it with salads and other dishes as well as drinking it. Previously, sweetened fermented milk had been the mainstay in Japan, but plain-type yogurt has now replaced it. The viscous substance contained in yogurt is thought to contribute to the above-mentioned physiological effects as well as to improve the texture of yogurt. Sixty percent of the fermented milk in Japan is produced by manufacturers of dairy products with the rest being produced by manufacturers of non-dairy products. Recently, the production of fermented milk has been showing the largest increase among all dairy products, marking a 10-20% increase this year compared with last year.

4. Use of Milk in Ice Cream

According to the ordinance regarding milk and milk products issued by the Ministry of Health and Welfare, ice cream and similar products are classified into three groups: ice cream, for products having more than 15% milk solids and 8% milk fat; ice milk, for products having more than 10% milk solids and 3% milk fat; and Rakuto-aisu, for products having more than 3% milk solids. Sales records from 1977 indicate that sales of Rakuto-aisu, which have the lowest percentage of milk solids, were the greatest but have been declining recently. In addition, sales of ice cream, which has the highest percentage of milk components, started to increase beginning in 1980, and their rate of increase has been accelerating particularly from 1986 in conjunction with the diversification of ice cream products (Table 4, 5).

Table 4 Production of dairy products (thousand kg)

	Condensed whole milk, sweetened	Evaporated whole milk	Whole milk powder	Modified milk powder for infants	Butter	Cheese
1981	49,431.3	2,827.6	31,989.3	60,222.5	62,316.9	70,652.2
82	52,696.2	2,770.7	34,539.2	56,331.2	66,876.1	66,664.0
83	48,080.9	2,393.5	36,178.2	56,568.6	76,007.9	68,527.6
84	52,321.1	2,241.1	34,156.7	56,029.0	80,281.8	69,157.3
85	48,759.7	2,380.6	34,858.9	57,345.4	90,777.4	69,623.4
86	48,002.8	2,280.0	31,113.1	56,050.2	80,988.6	73,185.6
87	44,437.4	1,950.7	30,368.7	55,749.9	69,328.5	77,882.8
88	50,779.7	2,268.5	32,801.2	58,433.8	70,556.6	82,922.1
89	48,182.3	2,462.3	33,055.4	60,879.5	80,549.8	86,583.4
	Condensed skim milk, sweetened	Skim milk powder	Ice cream	Cream		
1981	20,220.6	126,512.2	108.5	-		
82	18,572.9	138,317.9	129.8	5,584.6		
83	18,562.9	156,384.4	132.0	22,623.8		
84	13,710.7	160,685.6	132.2	22,242.0		
85	13,921.2	186,417.9	138.2	25,976.9		
86	13,899.5	171,501.8	156.2	31,320.4		
87	14,902.3	155,197.3	159.2	34,908.0		
88	16,054.6	163,416.0	144.9	39,170.4		
89	15,209.7	184,521.0	142.7	41,822.8		

Table 5 Sales of ice creams (kl)

	Ice cream	Ice milk	Rakuto-aisu
1981	158,300	63,500	277,500
82	183,400	63,100	285,800
83	187,600	63,300	302,600
84	189,000	62,500	319,300
85	195,000	60,000	326,000
86	215,200	60,400	311,500
87	236,800	59,900	330,500
88	228,000	68,000	349,000

For example, available now to consumers are: high-fat ice cream, low-fat ice milk (which is called Gelato in Japan), ice cream mixed with fruit, vegetables, herbs, or materials used for cakes, ice cream emulsified using natural instead of artificial emulsifier (e.g., egg yolk), and ice cream made without stabilizers. The fresh taste of ice

cream is good for people who have little appetite such as patients with digestive organ disorders, elderly people and infants in the weaning period. The fat contained in ice cream keeps emulsification at an appropriate level. Ice cream is easily digested and absorbed. It appeals to the taste of most people. The future of ice cream is promising because many varieties have been developed to meet every consumer's wishes.

5. Use of Milk in Cheese and its Preservative Properties

The majority of cheese produced in Japan is of the European type which is manufactured through rennet coagulation. The percentage of solid weight in cheese is 4-5 times more than that of milk. Also, a special flavor is generated and shelf life is enhanced in the process of ripening cheese because enzymes coming from microorganisms or rennet digest each component beginning with the proteins. In Japan, natural cheeses are not necessarily highly preferred. But processed cheeses made from such as Gouda cheese generally suit the preferences of Japanese people and are superior in their preservative properties. Therefore, for Japanese people, who consume cheese in smaller amounts, processed cheese seems to be a suitable dairy product. Domestic production of cheese has increased by 2.4 times during the past decade. Mold ripening cheese, processed cheese, Gouda cheese, Cheddar cheese, non-ripening type cheese such as cream cheese and cottage cheese are the important ones (Table 6). Recently, a dairy product similar to non-ripening cheese like dairy food of the heat coagulation type as well as, Juku-so and So, which had been used in ancient times in Japan, have been reproduced and are attracting people's interest.

Table 6 Production of natural cheese varieties (thousand kg)

	1975	1980	1985	1986	1987	1988	1989
Gouda	9,001	9,405	12,202	15,219	15,436	13,886	16,047
Cheddar	243	636	4,208	3,863	4,259	4,157	4,296
Edam	—	—	6	11	15	13	13
Blue	—	9	16	16	19	21	31
Camembert	—	11	115	150	275	461	726
Cream	58	612	814	847	1,388	2,111	2,967
Cottage	199	759	747	796	829	617	841
Quark	—	864	1,816	1,902	2,692	3,102	2,849
Others	—	—	377	521	657	721	747

Discussion

Dr. Samarajeewa (Sri Lanka): Is there any kind of milk other than cow's milk that can be used in Japan?

Answer: Some goat milk is consumed but it is not processed or distributed by any major milk company.

Dr. Samarajeewa (Sri Lanka): In Sri Lanka it is believed that goat milk cures wheezing in children. Perhaps this is due to different protein. Do you have any comments?

Answer: There is indication that allergy is caused by the way milk is given. There are many theories but no clear findings on this at present. Research is in progress.

Mr. Miller: What is the reason for the mixture of soybean milk and cow's milk we find in stores in Japan?

Answer: Perhaps one reason is to increase the essential fatty acids through mixing.

Comment, Dr. A. A. Bakar (Malaysia): Mixing might also be a way to reduce the beany flavour in soy milk.

In Malaysia the product is commercialized under the brand name 'TWIN'. Our department has been approached by a company to conduct research on processing TWIN into products such as yoghurt, ice cream, etc.

Dr. A. A. Bakar (Malaysia): Are Japanese concerned about the high cholesterol content in milk?

Answer: There is no need to worry about cholesterol intake at the present level of consumption. Animal fat intake by Japanese is still much lower for Japanese than for Western peoples.