ORIGINAL ARTICLE

Determination of essential nutrients in raw milk

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Abstract

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Milk production in Thailand has gradually increased since 1961. Occasional oversupply of raw milk has become one of dairy farmers' major problems. Increasing the consumption of milk by making use of its separated nutrients may offer a solution. This study was to assess the composition of raw milk produced in Thailand, which included fat, protein, lactose, solid-not-fat (SNF) and total solid (TS). A large dairy cooperatives in Saraburi Province was selected for the study. About 9% of its total members, constituting 108 farms, were randomly chosen. They consisted of small size (less than 20 cows/farm), medium size (21-100 cows/farm) and large size (>100 cows/farm). The majority was medium-size. Raw milk from each farm was sampled at the delivery site of the cooperatives in the morning. Milk data of the 108 farms were compiled at 3 different periods between February and July 2003. The raw milk was analyzed by the Fourier Transform Infrared Analysis (FTIR) using MilkoScan FT6000. The results showed the average fat content of 3.50±0.47%, protein of 3.13±0.16%, lactose of 4.59±0.12%, SNF of 8.42±0.20%, and TS of 11.92±0.54%. The samples were superior in all of the nutrients as compared to the standard levels set by the Department of Livestock Development, except for TS. This indicates the possibility of a local production of milk nutrients such as lactose and protein as ingredients for the pharmaceutical and health food industries.

Key words : raw milk, fat, protein, lactose, dairy farm

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Milk is an essential food for human. The majority of milk consumed throughout the world is bovine milk. It is often described as a complete food because it contains all essential nutrients e.g. protein, carbohydrate in the form of lactose, fat, vitamins and minerals (Komorowski and Early, 1992). Milk fat is excreted in the form of small droplets, which, in cow's milk, range from 1 to 12 μm in diameter with the mean of about 3 μm. Triacylglycerols are the predominant lipids in bovine milk, accounting for 97-98% of total lipid. The remaining lipids are diacylglycerols, monoacylglycerols, phospholipids, free fatty acids, and cholesterol and its esters (Muir, 1992). The proteins in milk fall into two distinct types, caseins (82.2%) and whey proteins (17.8%) that can be isolated by using various separation technologies (Huffman and Harper, 1999). Milk protein has a very high nutritional value, due not only to its high essential amino acid content, but also to its high digestibility. As a carbohydrate source in milk, lactose is by weight the most abundant of the milk solids. Its concentration is related to the milk yield and may range from 4.2 to 5.0%. Lactose is a disaccharide comprised of α-D-glucose linked to β-D-galactose. The sugar in raw milk may exist in two different crystalline forms, α and β, which differ in their properties. Lactose is a useful source of dietary energy and is thought by some workers to promote the absorption of calcium from the diet (Muir, 1992). Both types of lactose are widely used in the manufacture of pharmaceuticals. In the production of capsules or tablets it may be employed as a diluent, bulking agent, filler, or excipient, and in powders as a bulking agent. Characteristics such as particle size make different grades of lactose suitable for different applications (Martindale, 1996).

Milk consumption has been actively promoted in Thailand and dairy farming continuously supported by the government since 1961 (Reawdaecha and Ingkaninun, 1999). With the gradual increase in the number of dairy farms, oversupply of raw milk in certain periods of the year has become one of the major problems (Committee on Agriculture and Co-operatives, 2003). Promotion of additional milk consumption e.g. by making use of separated nutrients from raw milk may offer a solution. Ingredients separated from milk can add nutrition to the most promising new food products (Huffman and Harper, 1999). However, to be able to add value to these products quality of milk needs to be ensured. Standardization of nutritional properties of raw milk is an essential component in the quality control of dairy industry to ensure the quality of milk ingredients. The objective of this study was to assess the quality of raw milk from the local dairy industry by analyzing its nutrient composition including fat, protein, lactose, solid-not-fat (SNF), and total solid (TS).

Materials and Methods

This study was a preliminary study of a project on the strategies to increase value to the local milk products (Chulalongkorn University, 2002). This research used a cross sectional design to explore and examine the quantities of milk nutrients, including fat, protein, lactose, solid-not-fat (SNF) and total solid (TS). The dairy farms and their raw milk were sampled, followed by the nutrient analysis as detailed below.

1. Dairy farm selection criteria

1. The dairy farms must be located largely in the same area and send their raw milk to the same delivery site.

2. The cows must be Holstein Friesian Crossbred and were usually milked twice daily in the morning and in the afternoon.

2. Dairy farms and milk samples

One hundred and eight dairy farms were randomly selected from one of the largest dairy cooperatives in Muaklek District, Saraburi Province, the central region of Thailand. Saraburi was one of the four provinces with the largest dairy farming in Thailand (Information and Statistics Group, 2003). The selected farms made up about 9% of the total members of the cooperatives. The dairy farms were categorized by the number of cows/farm into small size (<20 cows), medium size

(21 to 100 cows), and large size (>100 cows) (Yooyuenyong *et al.*, 2003). The majority of the farms in this study was medium size. The average age of the cows was about 79 mo. Raw milk samples were taken at the delivery site of the co-operatives from only the morning collection. All samples were kept in an ice-cooled box and sent to Department of Livestock Development. Milk data of 108 farms were collected at 2 or 3 different times in February, June and July of the year 2003 which were the periods during the late winter and rainy seasons (temperature ranging from 20.6ºC to 34.2ºC) (Meteorological Development Bureau, 2003).

3. Milk composition analysis

Fresh milk samples were analyzed for crude protein, fat, lactose, solid-not-fat (SNF) and total solid (TS) by the Fourier Transform Infrared (FTIR) analysis using the MilkoScan FT 6000 (Foss Electric, Hillerd, Denmark) at National Institute of Animal Health (NIAH), Department of Livestock Development. Milk samples for FTIR analysis were kept at 2-5ºC for less than 48 h. The milk samples of 8.5 mL (5.0-12.0 mL in range) were heated in a water bath at 40-42ºC and were then tested by the MilkoScan for 30 to 45 s.

Statistical Analysis

The data were presented as mean ± S.D. The concentrations of milk components were compared with the standard values using one-sample t test. When differences between two means were compared, paired t-test was used. Milk composition was compared across the farm size by one-way analysis of variance (one-way ANOVA), followed by Tukey multiple-comparison analysis. Differences of the means were considered to be significant when $p<0.05$.

Results

The results of the milk analysis were statistically compared with the standard contents suggested by Department of Livestock Development (Yooyuenyong *et al.*, 2003) (Figure 1). The analyses showed the average fat content of 3.50±0.47%, protein of 3.13±0.16%, lactose of 4.59±0.12%, solid-not-fat (SNF) of 8.42±0.20% and total solid (TS) of 11.92±0.54%.

The analysis using one sample t-test revealed significant differences between nutrients of the samples and the standards for fat, protein, lactose and solid-not-fat, but not for total solid, which was found to be lower than the suggested standard, as shown in Table 1. When the milk nutrients from different farm sizes were compared by one-way ANOVA, it was also found that there was no significant difference of the amounts of nutrients among the large-, medium- and small-sized farms (Table 2).

The seasonal changes were hypothesized to have an influence on the nutritional composition. The concentration of each nutrient was then

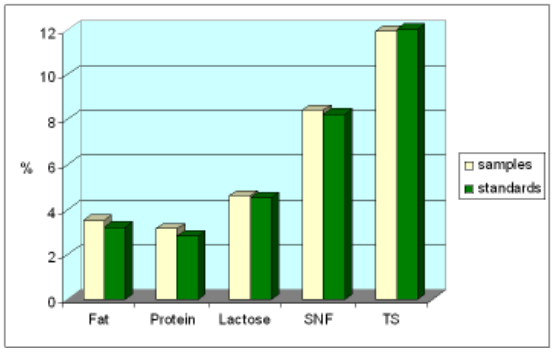

Figure 1. Comparison of nutrient contents with the standard contents suggested by Department of Livestock Development (Yooyuenyong *et al.*, 2003)

Table 1. Comparison between nutrient contents of samples and standards using one sample t-test.

Nutrients (%)	Samples (n=108)	Standards (%)	t Value	p Value
Fat	3.50±0.47	3.20	6.637	0.000
Protein	3.13±0.16	2.80	20.641	0.000
Lactose	4.59±0.12	4.50	8.283	0.000
Solid-not-fat	8.42±0.20	8.25	9.004	0.000
Total solid	11.92±0.54	12.00	-1.574	0.118

Table 2. Comparison of nutrient contents among various farm sizes using one-way ANOVA.

Nutrient	Farm Size			F	p Value
	Small (19.7%)	Medium (77.8%)	Large (2.5%)		
Fat	3.50±0.40	3.50±0.50	3.63±0.18	0.074	0.929
Protein	3.15±0.23	3.12±0.13	3.28±0.12	1.127	0.329
Lactose	4.59±0.13	4.60±0.11	4.62±0.24	0.049	0.952
Solid-not-fat	8.44±0.25	8.42±0.18	8.60±0.36	0.883	0.417
Total solid	11.94±0.54	11.92±0.56	12.23±0.18	0.309	0.735

compared across the different time periods using paired t-test. The studied milk data included milk collected in February, June, and July of the year 2003. The results showed that fat level was not significantly affected by different time periods. However, protein contents of milk samples from 3 different months were significantly different. Lactose contents between February and June as well as June and July were significantly different but not between February and July (Table 3).

Discussion and Conclusion

The results from the nutrient analysis of raw milk samples from the cooperatives indicated that the samples had higher nutrient levels than those suggested in the standards. Samples from different farm sizes were not significantly different in nutrient levels. The results appeared to suggest that milk quality within the cooperatives was quite consistent, indicating a high standard of farming practices. These farms were members of one of the largest dairy cooperatives in the country which had enforced Good Agricultural Practice (GAP) on its members. The results of this study reinforced the value of GAP in helping to maintain high quality standard in the Thai dairy industry.

The seasonal factors, e.g. different times of year, appeared to influence the levels of protein and lactose in raw milk. This affected the general quality of raw milk and, therefore, milk products. However, the data analyzed in this study were very limited and, therefore, no definite conclusion could be drawn on these factors. It merely recognized the importance of seasonal effects on milk quality. More in-depth study on these factors is, therefore, recommended.

This study has shown that general quality of milk produced by members of a large cooperatives in central Thailand was consistently high. It revealed that fat, protein, lactose and solid-not-fat of the milk are higher than the standard values set for raw milk by the Department of Livestock Development. This increases the feasibility of

Table 3. Paired t-test of milk nutrients across different time periods

Nutrient	Month Pair	Number of Samples	Mean Difference ± SD *	Significant Level (*p* value)
Fat	February-June	81	-0.0027±0.76	0.974
	February-July	100	-0.1154±1.06	0.279
	June-July	85	-0.0945±0.88	0.326
Protein	February-June	81	-0.1011±0.20	0.000
	February-July	100	-0.1512±0.25	0.000
	June-July	85	-0.0473±0.18	0.015
Lactose	February-June	81	+0.1607±0.19	0.000
	February-July	100	+0.0153±0.17	0.369
	June-July	85	-0.1467±0.14	0.000

Note: * The positive sign (+) means the nutrient of the first month is greater than the second. The negative sign (-) means the nutrient of the first month is less than the second.

alleviating the oversupply problems by promoting a local industry in which raw milk is separated into nutrient fractions for use as ingredients in the pharmaceutical and dietary supplement industries.

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