Hindawi
Journal of Food Quality
Volume 2019, Article ID 6972427, 10 pages
https://doi.org/10.1155/2019/6972427

Research Article

Quality Assessment of Selected Dairy Products in Sri Lankan Market

Prameesha Perera,[1] **Helani Munasinghe**,[1] **and R. A. U. J. Marapana**[2]

[1]*Department of Botany, University of Sri Jayewardenepura, Nugegoda 10250, Sri Lanka*
[2]*Department of Food Science and Technology, University of Sri Jayewardenepura, Nugegoda 10250, Sri Lanka*

Correspondence should be addressed to Helani Munasinghe; helani@sci.sjp.ac.lk

Received 26 August 2018; Revised 1 December 2018; Accepted 19 December 2018; Published 23 January 2019

Academic Editor: Ángel A. Carbonell-Barrachina

The purpose of the study was to determine the quality of selected Sri Lankan-marketed dairy products. Four brands of full cream milk powder (FCMP) (imported A and B; local C and D) and three brands of pasteurized milk (PM) attributed to the alphabetical identifies E, F, and G were tested, with raw cow's milk (CM) as control. Fat, protein, ash, carbohydrate, moisture, and water percentage, total solids (TS), titratable acidity (TA), pH, specific gravity (SG), arsenic content, and total coliform count (TCC) were assessed. The average fat and ash content per serving of milk (SOM) of FCMP was significantly lower than the PM and CM. Highest ($p > 0.05$) protein content (7.58 g ± 1.05) was recorded for CM. Carbohydrate and pH were not significantly different in three types of milk products. FCMP had a significantly lower ($p < 0.05$) TA of, 0.18 ± 0.02 than the PM, 0.20 ± 0.02. Specific gravity in Brands D (1.033 ± 0.00) and E (1.033 ± 0.00) was significantly higher ($p > 0.05$) compared to the CM (1.030 ± 0.00). All the abovementioned parameters between imported and locally produced FCMP brands were not significantly different from each other. In imported FCMP, mean moisture % was significantly higher ($p > 0.05$) than local brands; however, in each FCMP, brand mean moisture % was statistically non-significant. Total solids in PM was significantly lower ($p < 0.05$) than the CM. Every tested sample was free of arsenic. However, all PM brands and B of FCMP were contaminated with coliform. Total coliform count in B and E agreed with the Sri Lankan standard level. Nutritional value in SOM of PM and FCMP was less than CM, while the lowest value was recorded in FCMP. It can be concluded that all brands of powdered milk possess the recommend suggested standards in terms of both physicochemical and microbiological qualities. Though the physicochemical characteristics in PM brands agree with the standard levels, microbial hygiene is poor where coliform contamination was very high in Brand E.

1. Introduction

Cow's milk is considered as a highly nutritious and valuable human food. A variety of different milk products are consumed by millions of people, daily [1, 2]. Sri Lankans consume a variety of dairy products, especially both fresh milk and powder milk. Statistics have shown that consumption of dairy products has increased significantly during the past few decades.

Consumption of raw milk is popular due to the trend of "consuming natural or organic." High nutritional composition, neutral pH, and high water activity in raw milk facilitates a good growth medium for different microorganisms. Therefore, heat treatments are widely used in order to ensure microbial safety and increased shelf life of milk products [3].

Pasteurization and sterilization are commonly used heat treatments in Sri Lanka that ensure a prolonged shelf life of milk. High temperature, short times, and "low temperature," and short time pasteurization methods are practiced commonly. However, combination of different temperatures and holding times remain crucial in various processing plants in Sri Lanka especially in small-scale processing [4].

Dairy powders are frequently used due to their ease in transportation, handling, processing, and product formulations. Milk powders have several physical and functional properties, such as powder structure, particle size distribution, powder density, bulk density, particle density, interstitial air, flowability, rehydration (wettability, sinkability, dispersibility, and solubility), heat stability, emulsifying properties, and

water activity [5]. Generally, a powder particle consists of a continuous mass of amorphous lactose embedded fat globules, casein micelles, serum proteins, and air vacuoles. The particle size of milk powder determines its appearance, its reconstitution property, and its flow characteristic. The particle size influences original milk characteristics, processing conditions, and the type of equipment used in the drying process. Spray-dried powder particles are spherical in shape with diameters ranging from 10 to 250 μm [5].

The physicochemical characteristics of milk powder depend on original raw milk composition. Such characteristics may be influenced by the deficiencies in the nutrition of dairy cows [6]. Moreover, standardization, properties of concentrate before spraying (composition/physicochemical characteristics, viscosity, and thermosensibility), drying parameters (type of tower spray dryer, nozzles/wheels, pressure, and agglomeration), and thermodynamic conditions of the air (temperature, relative humidity, and velocity) determine the characteristics of powdered milk [5].

Arsenic compounds have adverse effects on the health of living beings. Arsenic contamination in groundwater and foods has been reported from many countries [7]. If such contamination continues, it may cause acute or chronic intoxication among children and adolescents [8]. During the past few decades, controversial opinions on arsenic contamination in foods have been imparted in Sri Lanka. In such a climate, conducive to contamination, detection of arsenic contamination in milk is of strong and timely importance.

Poor milk hygiene has implications on the structure of milk, its processing value, shelf life, and edible food loss [9]. Microbial contamination in raw cow and sheep milk can be a source for food-borne diseases [10–13]. Microbiological examination of milk is essential to find the degree of contamination and enumeration of indicator organisms. The microbial content of milk is a major feature in determining its quality [14, 15]. The coliform bacteria are able to grow well in a variety of substrates and to utilize a number of carbohydrates and other organic compounds as food for energy and a number of fairly simple nitrogenous compounds as a source of protein. The coliform group bacteria are defined as indicators (fecal coliform) of the suitability of milk for drinking [16].

Due to the significance of milk in the human diet, it is crucial to increase milk production and to improve its quality [1, 2]. Physicochemical and microbiological studies are an important tool to monitor the quality of food products [17].

The present study investigates some physicochemical parameters, microbial hygiene, and arsenic contamination of commercially available pasteurized milk (PM) and full cream milk powder (FCMP) available in Sri Lankan market.

2. Materials and Methodology

2.1. Collection of Samples. To perform the experiment, four commercial FCMP brands (imported A and B; local C and D) and three PM brands (local E, F, and G) were chosen. For physicochemical parameters examination, a total of 12 packets of powdered milk, 9 packets of PM containing 3 from each brand, three raw cow's milk samples (control), and five samples from each brand (powder milk $n = 20$, PM $n = 15$) for enumeration of total coliform were purchased from retail shops at Colombo and Gampaha districts. All the samples were tight and free from any damage or leakage during collection. Pasteurized milk and cow's milk samples were put in an icebox to restrict microbial multiplication and transported to the testing site immediately.

2.2. Sample Preparation. For the physicochemical examination, according to the instructions provided by the manufacturer, 25 g of FCMP was dissolved in 200 ml of distilled water (to prepare the SOM) at the room temperature. All the liquid milk samples were homogenized before analysis. For microbiological examination, accurately weighed 0.5 g of FCMP was dissolved in 50 ml of sterile distilled water (autoclaved at 121°C and 15 lb/in^2 for 20 minutes) aseptically.

2.3. Physicochemical Properties of Milk and Arsenic Level. In this study, physicochemical analyses have been done such as percentages (%) of fat content, protein content, total solid (TS), ash, moisture, pH, titratable acidity (TA) as lactic acid percentage, and specific gravity (SG). All the experiments were done as methods described by AOAC, 1980 [18]. The analysis of fat and protein contents was determined by Rose Gottlieb and Kjeldahl methods, respectively. Another vital chemical property, pH, was measured by using the pH meter (Hanna, HI 98140). Levels of arsenic contamination was detected by atomic absorption spectrometer (iCE 3000 AA 05121002 v1.30).

2.4. Total Coliform Count

2.4.1. Presumptive and Confirm Tests. Total coliform count was determined by the most probable number, three tube method, using MacConkey broth. Presumptive test was performed according to the method described by Pepper and Gerba [19]. Presumptive positive tubes were inoculated on Eosin Methylene Blue agar (EMBA) and incubated at 35°C for 24 h.

2.4.2. Complete Test. Typical colonies on the EMBA plates were subcultured into lactose broth fermentation tubes and nutrient agar. They were incubated at 35°C for 24°h [20]. Gram staining was performed to confirm whether the colonies are Gram negative or positive.

2.5. Data Management and Statistical Analysis. Data were presented as the mean ± standard deviation (SD). The significant differences between means of collected samples were compared to the Sri Lankan Standard (SLS) using one-sample t-test. Physicochemical properties comparison as brand-wise and in between three types of milks were done orderly from one-way ANOVA and two sample t-test in Minitab 16 software package (Minitab, Inc). All the statistical analyses were designed at $p < 0.05$.

3. Results and Discussion

3.1. Physicochemical Properties of Milk. The study was performed with the intention of comparing the physicochemical parameters of commercially available FCMP and PM, with raw CM. FCMP and PM are compared with CM in this study. Therefore, CM is used as a positive control to evaluate how much physicochemical parameters deviate or agree with CM. Secondly, it is to estimate the kinds of milk as well as the milk brands, that are most suitable for consumption according to diverse user requirements.

3.2. Fat. As illustrated in Figure 1(a), the average value of fat in SOM acquired from D was significantly lower ($p < 0.05$) than the other three FCMP brands. Fat in SOM between Brand A and all three brands of PM and raw CM was not significantly different from each other. However, overall mean in levels of fat in FCMP was significantly lower ($p < 0.05$) than the raw cow's milk. A significant difference was not obtained for fat (g) in SOM of imported (6.54 ± 0.50) and locally produced (6.25 ± 0.50) milk collected from local markets (Table 1). According to the CODEX STAN 207-1999 and Sri Lankan standards (SLS 731:2008), average fat content of dried whole milk can be 26% as minimum (Table 2) [21, 22]. Brand A, B, and C are within this range, and Brand D is lower than the minimum level, i.e, 26% (Table 2). The standard in USA for fat in powder milk is 26.5% [23], only A and C are above or comparable with this value. Sudanese standard specification for fat in powdered milk is <28% and for Argentina is <40% [24]. From $27 \pm 0.03\%$ to $28.03 \pm 0.12\%$, range in content of fat was obtained by El Khier et al. [24] from powdered milk packed in Sudan. The average fat content of milk found in the current study was below the values reported by El Khier et al. [24] but agree with these standards.

According to Sri Lankan standards, minimum average fat content of raw CM and pasteurized homogenized milk is 3.5% by mass (Table 2) [25]. Similarly, the European Union quality standard for percentage of fat in unprocessed whole milk is 3.5% [26]. All the liquid milk samples (CM, E, F, and G) tested during this study coincide with both the Sri Lankan and the European Union standards. The Food and Drug Administration (FDA) standard of fat for fluid whole milk is 3.25% milk. Correspondingly, U.S. Public Health Service (USPHS) Milk Ordinance and Code requires a minimum of 3.25% butter fat in farm milk [27]. The percentage of fat found from CM in Sri Lanka satisfies the conditions set by FDA and USPHS. However, fat content reported from the current study falls below the criteria of Bangladesh Standard of Dairy product (4%) [28]. Raw cow's milk contains 3.4 ± 0.26 [29], 4.56 ± 0.4 [30], and 4–4.6 [31] fat percentage by mass. The values obtained for CM during the current study is comparable with the findings of Kader et al. [29] and lower than the findings of Kanwal et al. [30] and Hossain et al. [31]. The average fat content obtained from Sri Lanka-marketed PM brands is comparable with the findings of Awan et al. (3–3.2%) [32] and Rawan (3.4–6.2%) [33]. There are several reasons for obtaining different values for percentages of fat from different countries around the world. Fat content in milk depends on breed (i.e., fat in milk of common European breeds, Holstein/Friesians has lowest while Jersey cows contains the highest), features of an individual animal, health and age, season (highest in winter and lowest in summer), stage of lactation (fat percentage goes down during the first 4–6 weeks after parturition and then directly goes up during the rest of lactation, mainly toward the end), nutritional status, feed, gap between milking, and the point during milking, when the sample is taken [34].

3.3. Protein. There were no significant differences in protein content in SOM of four different milk powder brands collected from the local market (Figure 1(b)). Both local and foreign milk brands provide the same amount of proteins (Table 1). Protein in milk powder obtained from Kwality, Nido, Diploma, Anchor, Farmland, and Starship were 25.22 ± 0.65, 26.04 ± 0.96, 25.65 ± 0.99, 25.87 ± 1.45, 26.55 ± 1.46, and 27.02 ± 1.56 g/100 g, respectively [35]. However, Sri Lankan-marketed FCMP brands (A, B, and D) contain comparatively less protein percentages than the above foreign brands, while local brand C and Kwality have similar protein percentage values. Sudanese and USA standards for protein in powder milk are <27% [24] and <28% [23], respectively. From $27.00 \pm 00.8\%$ to 27.07 ± 0.14 %, range of protein was obtained by El Khier et al. from powdered milk packed in Sudan [27].

The average protein contents of milk found in the current study were below the values reported in literature and agree with Sudanese and USA standards. The average value of protein (g) in SOM of cow's milk was significantly higher ($p > 0.05$) than FCMP and PM. Raw milk collected from Bangladesh farms contained 3.47 ± 0.11 [29] protein percentage by mass, whereas in Ethiopia, 3.43 ± 0.00 [26]. The present study suggested that the protein percentage in Sri Lankan-marketed CM was comparatively higher than the finding of Kader et al. [29] and Gemechu et al. [26].

As given in Table 2, protein in each brand of PM and CM reported from the current study was below the criteria of the Bangladesh Standard of Dairy product (4.10%) [28]; however, comparable with the FDA, specification for percentage protein in whole milk (2.73%) [36], food and Agricultural Organization's (FAO) criteria for protein is 3.5% [37]. Only CM agrees with FAO, and all PM brands were below the level.

3.4. Ash. Generally, ash content of milk is relatively constant at the range of 0.7-0.8%; however, concentrations of the various ions may differ [34]. Ash (g) in SOM of milk powder obtained from A, B, C, and D were 0.63 ± 0.31, 0.95 ± 0.25, 0.97 ± 0.50, and 0.76 ± 0.34, respectively (Figure 1(c)). All tested powdered milk brands contain the same amount of ash content, but the values are less than the CM. In the SOM of powder milk samples, locally produced brands (0.86 ± 0.43) and imported brands (0.80 ± 0.31) were found to contain the same amount of ash content (Table 1). Ash content in Kwality, NIDO, Diploma, Anchor, Farm land, and Starship were 5.46 ± 0.26, 5.48 ± 0.03, 5.35 ± 0.44, 5.48 ± 0.32, 5.35 ± 0.10, and 5.41 ± 0.16 g/100 g,

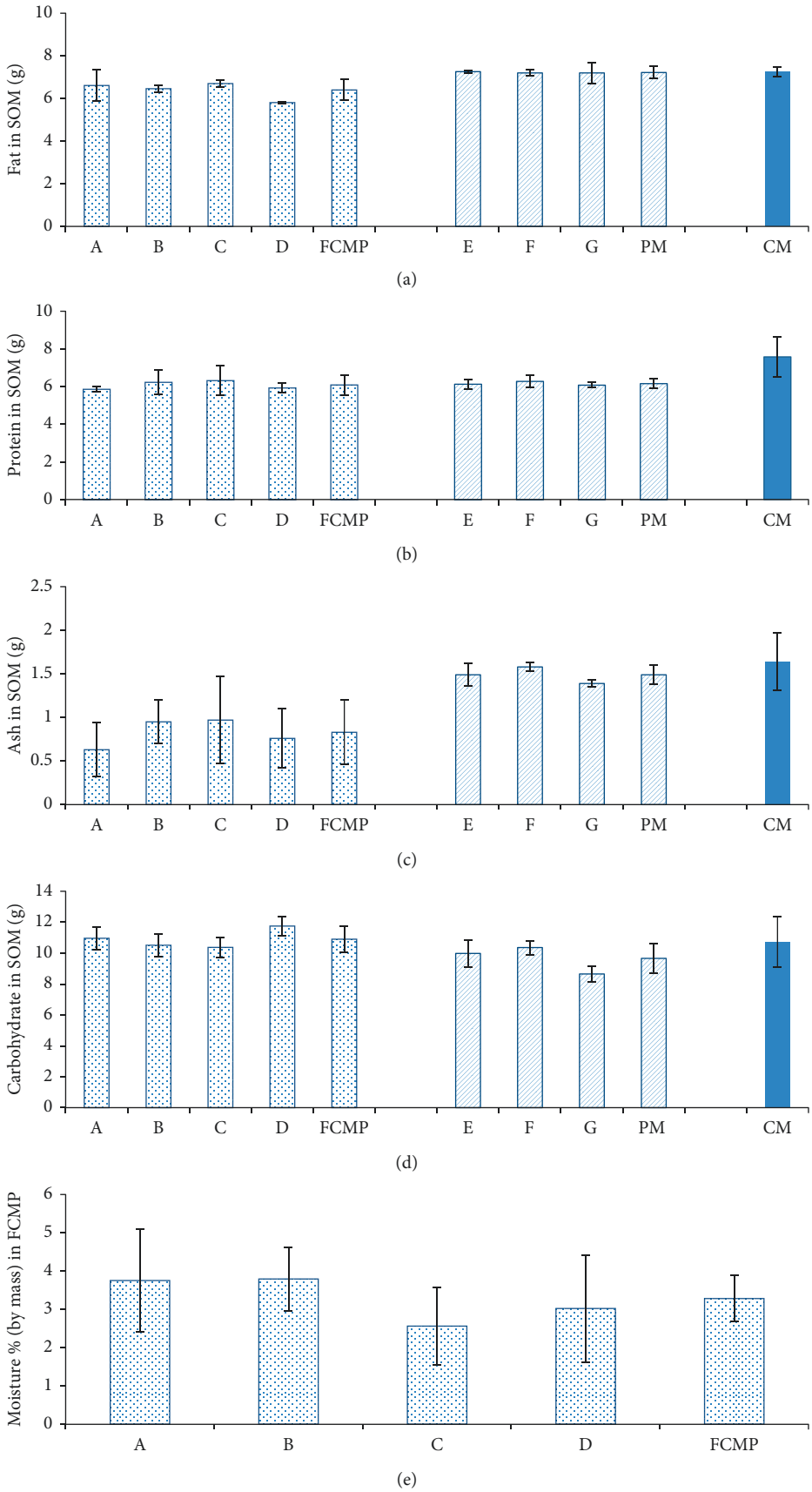

Figure 1: Continued.

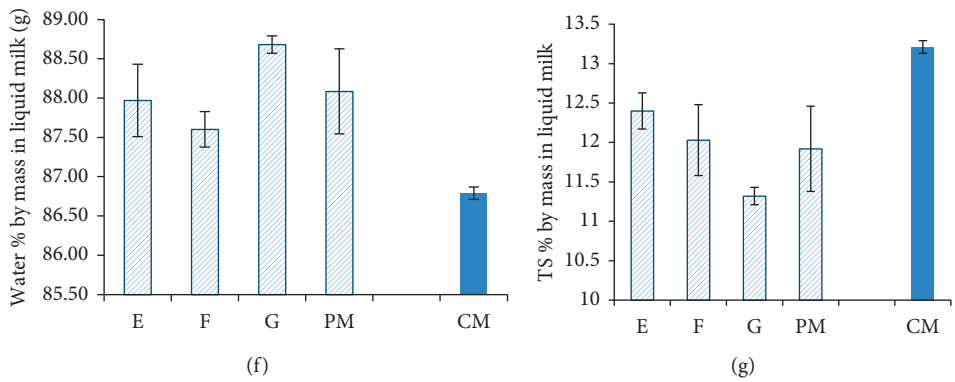

Figure 1: Proximate composition of Sri Lankan-marketed milk: (a) fat in per serving of milk; (b) protein in per serving of milk; (c) ash in per serving of milk; (d) carbohydrate in per serving of milk; (e) moisture % in FCMP; (f) water % in liquid milk; (g) TS % in liquid milk. In Figures 1(a)–1(e), A, B, C, and D are full cream milk brands, and in Figures 1(a)–1(d), 1(f), and 1(g), E, F, and G are pasteurized milk brands. FCMP, PM, and CM represent overall mean of the respective parameter in full cream powder milk, pasteurized milk, and raw cow's milk. Brandwise comparison was done in between the brands of same types of milk (i.e., between A, B, C, and D). Values of each brand with CM (i.e., protein in SOM of A with CM) and overall mean of the respective parameter in PM and FCMP with CM were compared (i.e., protein in SOM of FCMP with CM). $p < 0.05$ is considered as significant.

Table 1: Physicochemical parameters of imported and local FCMP brands.

Parameter	Imported brands	Local brands
Fat (g) in SOM by mass	6.54 ± 0.5^a	6.25 ± 0.5^a
Protein (g) in SOM by mass	6.05 ± 0.5^a	6.13 ± 0.6^a
Carbohydrate (g) in SOM by mass	10.72 ± 0.75^a	11.06 ± 0.94^a
Ash (g) in SOM by mass	0.8 ± 0.31^a	0.86 ± 0.43^a
Moisture (%) by mass	3.77 ± 1.06^a	2.8 ± 1.18^b
pH	6.75 ± 0.01^a	6.73 ± 0.13^a
TA (% of lactic acid)	0.17 ± 0.01^a	0.18 ± 0.02^a
SG	1.032 ± 0.00^a	1.033 ± 0.00^a

TA = titratable acidity; SG = specific gravity; means followed by different superscript letters within a row are significantly different ($p < 0.05$).

respectively [35]. Values obtained from current study are lower than the findings of Kajal et al. [35]. Sudanese and USA standards for ash in powder milk are <7.3% [24] and <6% [23]. From 5.70 ± 00.1% to 5.70 ± 0.04%, range of ash was obtained by El Khier et al. from powdered milk packed in Sudan [24]. The average ash content of milk found in the current study was below the findings of El Khier et al. [24] and agree with Sudanese and USA standards. Percentage of overall mean of ash (g) in SOM increased in FCMP (0.83 ± 0.37) to PM (1.49 ± 0.11) and raw cow's milk (1.64 ± 0.33). Mean ash percentages of buffalo, cow, goat, and sheep milk in Pakistan are 0.40 ± 0.01, 0.36 ± 0.06, 0.28 ± 0.64, and 0.58 ± 0.52, respectively [30]. As given in Table 2, the percentage of ash by mass in raw cow's milk (0.80 ± 0.16), PM brands E (0.72 ± 0.06), F (0.77 ± 0.03), and G (0.67 ± 0.02) found in the present study are much higher compared to these values. Difference may be due to the influence of breed, stage of lactation, and feed of animal [26].

3.5. Carbohydrate. The main carbohydrate in milk is lactose, which is known as milk sugar [38]. There was no significant difference in carbohydrate content of SOM of milk powder brands (Figure 1(d)). In the SOM of FCMP, imported brands (10.72 ± 0.75) and locally produced brands (11.06 ± 0.94) were found to contain similar amounts of carbohydrate content (Table 1). Percentage of lactose/carbohydrate content in Kwality, NIDO, Diploma, Anchor, Farmland, and Starship were 37.41 ± 0.69, 37.31 ± 0.83, 37.22 ± 0.72, 36.64 ± 2.11, 37.62 ± 0.78, and 37.65 ± 0.78 g/100 g, respectively [35]. In the current study, percentages of carbohydrate by mass in FCMP samples were in the range of 41.48 ± 2.70 to 47.00 ± 2.38. Obtained values were comparatively higher than the finding of Kajal et al., (2012) [35]. Sudanese, American Dry Milk Institute (ADMI), and USA standards for carbohydrate in powder milk are <34% [24], 38% [39], and <35.5% [23], respectively. From 37.15 ± 0.05% to 38.98 ± 0.12%, range of carbohydrate was obtained by El Khier et al. [24] from powdered milk packed in Sudan. The average carbohydrate content of milk found in the current study was higher than these levels of Sudanese, ADMI, and USA standards. Moreover, there was no statistically significant difference ($p < 0.05$) between the overall mean of carbohydrate in SOM of FCMP (10.90 ± 0.85) and PM (9.66 ± 0.97) with that of the cow's milk (10.74 ± 1.62).

In PM, significantly lower carbohydrate (g) in SOM was reported in G (8.65 ± 0.51), followed by E (9.98 ± 0.86) and F (10.36 ± 0.45). As reported by Kanwal et al., mean lactose/carbohydrate percentage range of buffalo, cow, goat, and sheep milk was 3.28–4.8, 3.0–4.6, 4.0–5.5, and 3.0–4.2, respectively [30], and Gemechu et al. found that mean lactose percentage of milk collected from Ethiopia was 4.43 ± 0.06 [26]. According to Table 2, percentage of carbohydrate in each brand of PM (E 4.83 ± 0.42, F 5.02 ± 0.22, and G 4.02 ± 0.25) and raw cow's milk (4.69 ± 0.46) is found to be relatively higher than reported in Kanwal et al. [30] while comparable to the previous studies of Gemechu et al. [26].

Percentage of lactose in milk can vary within the range from 3.6 to 5.5% [40]. Percentage of lactose/carbohydrate

Table 2: Comparison between physicochemical parameters of samples with Sri Lankan standards.

Parameter	SLS 731 : 2008 specification	A	B	C	D
Fat (%)	26[a]	26.44 ± 2.89[a]	25.86 ± 0.62[a]	26.80 ± 0.69[a]	23.23 ± 0.18[b]
Protein (%)	—	23.44 ± 0.57	24.93 ± 2.58	25.29 ± 3.15	23.71 ± 1.10
Ash (%)	—	2.53 ± 1.25	3.81 ± 0.99	3.88 ± 2.00	3.03 ± 1.40
Carbohydrate (%)	—	43.84 ± 3.0	42.04 ± 3.0	41.48 ± 2.70	47.00 ± 2.38
Moisture (%)	4[a]	3.75 ± 1.34[a]	3.79 ± 0.8[a] 3	2.56 ± 1.00[a]	3.02 ± 1.40[a]
pH	—	6.74 ± 0.09	6.77 ± 0.11	6.62 ± 0.07	6.85 ± 0.03
TA	1.5[a]	0.17 ± 0.01[a]	0.17 ± 0.01[a]	0.20 ± 0.01[a]	0.16 ± 0.01[a]
SG	—	1.032 ± 0.00	1.031 ± 0.00	1.032 ± 0.00	1.033 ± 0.00
	SLS 181 : 1983 specification	E	F	G	CM
Fat (%)	3.5[a]	3.51 ± 0.03[a]	3.49 ± 0.07[a]	3.49 ± 0.24[a]	3.51 ± 0.10[a]
Protein (%)	—	2.97 ± 0.12	3.04 ± 0.16	2.95 ± 0.07	3.68 ± 0.52
Ash (%)	—	0.72 ± 0.06	0.77 ± 0.03	0.67 ± 0.02	0.80 ± 0.16
Carbohydrate (%)	—	4.83 ± 0.42	5.02 ± 0.22	4.20 ± 0.25	5.21 ± 0.77
Water (%)	—	87.97 ± 0.46	87.60 ± 0.23	88.68 ± 0.11	86.79 ± 0.08
TS (%)	—	12.40 ± 0.23	12.03 ± 0.45	11.32 ± 0.11	13.21 ± 0.08
pH	—	6.86 ± 0.05	6.81 ± 0.05	6.72 ± 0.02	6.76 ± 0.04
TA	1.5[a]	0.18 ± 0.01[a]	0.20 ± 0.02[a]	0.19 ± 0.01[a]	0.17 ± 0.04[a]
SG	—	1.033 ± 0.00	1.032 ± 0.00	1.031 ± 0.00	1.030 ± 0.00

SLS = Sri Lankan standards; TA = titratable acidity; SG = specific gravity; TS = total solids; means followed by different superscript letters within a row are significantly different ($p < 0.05$).

obtained in liquid milk from this study are comparable with the reported range. Lactose content may vary with the occurrence of bacteria in raw milk due to the differences in storage temperature [41].

3.6. Moisture and Water Content. The amount of water in dairy products varies within the range of 2.5 to 94% (w/w). Water is the major constituent by weight of most dairy products, such as milk and cream. Moisture or water activity plays a major role in food technology, together with temperature and pH. Water content is critical in low moisture foods including dehydrated milk powders (2.5–4%). Water is most important in physical, chemical, and microbiological fluctuations seen in dairy products [34]. Percentage of moisture in FCMP obtained from A, B, C, and D were 3.75 ± 1.34, 3.79 ± 0.83, 2.56 ± 1.00, and 3.02 ± 1.40, respectively. Statistically, it was found that there were non-significant differences within the moisture percentage of different types of milk powder (Figure 1(e)). It was observed that the average percentage of moisture found from imported milk powder was significantly ($p > 0.01$) higher than that of locally produced FCMP (Table 1). According to SLS 731:2008 [22] and Argentinian standards [24], average maximum moisture percentage of FCMP is 4%, while as mentioned by the CODEX STAN 207-1999, maximum water content in cream powder, whole milk powder, partly skimmed milk powder, and skimmed milk powder is 5% [21]. The ADMI criterion for moisture of the whole milk powder ranged from 2–5% [42]. All FCMP brands agreed with the standards (Table 2). According to the current study, only Sri Lankan powder milk Brand C satisfied the Sudanese standard specification for percentage of moisture in powdered milk (<3%) [24]. From 2.06 ± 0.05% to 2.40 ± 0.03%, range of moisture was obtained by El Khier et al. [24] from powdered milk packed in Sudan. All FCMP brands of the current study were above these values.

Percentage of water obtained from E, F, and G were 87.97 ± 0.46%, 87.60 ± 0.23%, and 88.68 ± 0.11%, respectively (Figure 1(f)). Overall mean of water percentage by mass in overall mean of PM and CM is 88.09 ± 0.54% and 86.79 ± 0.08%. Percentage of water in CM is significantly lower ($p < 0.05$) than every brand of PM and overall mean of PM. As described by Fox et al., water content of pasteurized whole milk is 88% [34]. Sri Lankan-marketed PM brand is shown to be comparable with this value, whereas CM is below the reported value.

3.7. Total Solids. As shown in Figure 1(g), Brand G had lowest ($p < 0.05$) percentage of total solids (11.32 ± 0.11), followed by F (12.03 ± 0.45), while the highest was found in E (12.40 ± 0.23.). Statistically, it was found that there were significant differences ($p < 0.05$) within the TS percentage of raw cow's milk (13.21 ± 0.08) and overall mean of PM (11.92 ± 0.54) collected from the local market.

European Union recognized standards, Bangladesh, and FAO standards for minimum percentage of total solids in CM is 12.5% [26], 12.5% [28], and 13.47% [37], respectively. In respect to such standards, TS percentage obtained from CM of the present study satisfied only European Union recognized standards and Bangladesh standards, whereas E, F, and G did not satisfy all three standards. Percentages of TS in cow's milk were 12.16 ± 0.33 [29], 12.87 ± 0.11 [26], and 13.5 ± 1.22 [38]. Values reported by Imran et al. [38] are found to be similar with the current study while relatively higher with that of Kader et al. [29] and Gemechu et al. [26].

3.8. Titratable Acidity. As illustrated in Table 3, it was observed that the mean TA obtained from C (0.20 ± 0.01) was significantly higher than the other FCMP brands. Acidity of reconstituted milk powder obtained from Kwality, Nido,

Diploma, Anchor, Farmland, and Starship was 0.13 ± 0.00, 0.13 ± 0.01, 0.11 ± 0.01, 0.13 ± 0.01, 0.14 ± 0.01, and 0.16 ± 0.01 percent, respectively [35]. According to the Sri Lankan (SLS 731 : 2008), USA, and Sudanese standards, TA percentage of FCMP is maximally 1.5% [22–24]. All the tested samples agreed with the standards, while A, B, and C relatively higher than the reported values of Kajal et al. [35]. Furthermore, Starship and D were shown to be similar in percentage in lactic acid. In the FCMP, imported brands (0.17 ± 0.01) and locally produced brands (1.18 ± 0.02) were found to contain similar percentage of lactic acid (Table 2). Means of the TA in FCMP (0.18 ± 0.002) were significantly lower ($p < 0.05$) than the PM (0.20 ± 0.02). Nevertheless, TA in PM and cow's milk (0.17 ± 0.04) was not significantly different. Titratable acidity range of buffalo, cow, goat, and sheep milk are 0.11–0.18, 0.12–0.19, 0.11–0.17, and 0.16–0.19, respectively [30]. In F and G, TA is found to be higher, while raw cow's milk and E are comparable to the previous studies of Kanwal et al. [30]. According to BDA and FAO quality standards, TA in CM is not to be less than 0.15% [28] and 0.16% [29], respectively. The TA of CM and all PM brands agree with the FAO and BDA quality standards.

3.9. pH. pH values of milk powder obtained from A, B, C, and D were 6.74 ± 0.09,6.77 ± 0.11, 6.62 ± 0.07, and 6.85 ± 0.03, respectively (Table 3). It was observed that the average pH acquired from B and D was significantly different ($p < 0.05$) with C. However, the pH value in A is non-significant with that of B and C. There were no significant differences between pH values of imported (6.75 ± 0.01) and locally produced (6.73 ± 0.13) milk collected from local markets (Table 1). pH quality standards for powder milk, defined by USA [23], Sudan, and Argentina [24], range from 6.6–6.8. In respect to such starndards, only Brand D is slightly higher in pH. Furthermore, pH values of reconstituted milk powder obtained from Kwality, Nido, Diploma, Anchor, Farmland, and Starship were 6.73 ± 0.06, 6.7 ± 0.10, 6.73 ± 0.06, 6.8 ± 0.00, 6.7 ± 0.00, and 6.67 ± 0.06, respectively [35]. The results of the present study were comparable with the literature. Mean of pH in raw cow's milk, FCMP, and PM was 6.76 ± 0.04, 6.75 ± 0.14, and 6.81 ± 0.07, respectively, while these values were non-significant with each other. It is observed that the average pH obtained from G was significantly lower ($p < 0.05$) than the pH of the other two brands.

Mean pH range of buffalo, cow, goat, and sheep milk are 6.60–6.90, 6.63–6.68, 6.34–6.68, and 6.40–6.80, respectively [30]. According to the Kader et al. mean pH of milk is 6.67 ± 0.10 [29]. Furthermore, Gemechu et al. cited that the pH range of fresh cow's milk is 6.6–6.8 [26]. A pH value higher than 6.8 indicates mastitis milk, and if the pH value below 6.6 indicate the increase of acidity in milk due to bacterial growth. In raw CM and PM, pH value is found to be higher than that of Kanwal et al. [30] and Kader et al. [29] while comparable with the figures expressed by Gemechu et al.[26]. This indicates the Sri Lankan-marketed-liquid milk products are good in the quality with respect to the pH parameter.

3.10. Specific Gravity. Statistically, a significant difference was obtained for the SG of B and D collected from the local market (Table 3). SG of the Brand D is significantly higher ($p > 0.05$) than the cow's milk (1.030 ± 0.00). It was observed that difference of means of SG measured from imported (1.032 ± 0.00) and locally produced (1.033 ± 0.00) milk were statistically non-significant (Table 1).

The SG measured from Kwality, NIDO, Diploma, Anchor, Farmland, and Starship was 1.03 ± 0.00, 1.03 ± 0.00, 1.02 ± 0.00, 1.03 ± 0.00, 1.03 ± 0.00, and 1.04 ± 0.00, respectively [35]. All the Sri Lankan-marketed FCMP brands have shown approximately the same values for SG with Kwality, NIDO, Anchor, and Farmland. In PM, G had lowest SG (1.031 ± 0.00), followed by F (1.032 ± 0.00) and E (1.033 ± 0.00). The average value of SG in E was significantly higher ($p > 0.05$) than the overall mean of SG in raw cow's milk. Higher value for SG (1.035) indicates the skimming of fat, and the lower value than the normal (1.020) indicates the addition of water [26]. Adulteration of milk with water is usually performed for the purpose of increasing the quantity. Addition of water lowers milk's SG, while addition of cream, removal of fat, and reduction of temperature increase SG of milk [43]. Results obtained from the present study which are around the 1.031–1.033 range at 20°C indicate good quality of Sri Lankan-marketed milk.

3.11. Arsenic Contamination. Arsenic was not detected in any of the samples tested (Table 3). Contamination of heavy metals such as arsenic has a health risk. Rosas et al. reported that total arsenic concentrations of cow's milk ranged from 0.9 to 27.4 ng/g [44]. However, the present study had similar results for arsenic as found in the study conducted by Qin et al. [45]. This indicates that tested brands in Sri Lankan market are safe with regard to arsenic contamination.

3.12. Microbiological Quality of Milk. Microbial quality of the Sri Lankan powdered and pasteurized milk was evaluated with respect to the total coliform count. Presence of coliform in general and *E. coli* indicates fecal contamination. Also presence of nonfecal coliform indicates the risk of presence of other pathogenic bacteria. Health of the dairy herd, milking, and prestorage conditions also influence the quality of milk [46].

Minimum 5 sample units (n) should be tested to decide the coliform MPN in full cream powder milk. Minimum (m) and maximum (M) coliform MPN (per g) limit is between <0.03 and 20. Maximum allowable number of sample units yielded a value of 1 between m and M (c) [22]. As illustrated in Table 4, coliform bacteria were present in one sample of Brand B. According to 95% confidence level, coliform MPN is 1 per g of powder milk which is between m (0.3) and M (20). European Commission quality standards for Coliform in dry milk is 10 (m)–100 cfu/g (M), whereas $n = 5$, $c = 2$ [47]. Moreover, Codex Alimentarius coliform Criteria for dry milk is 10 (m)–100 cfu/g (M), where $n = 5$, $c = 1$ [48]. Sri Lankan-marketed Brand B is comparable with these standards. Meanwhile, four samples of Brand B and all the tested samples of A, C, and D are free from the

Table 3: Physicochemical properties and arsenic contamination of Sri Lankan-marketed milk.

	Brand	pH	TA (% lactic acid)	SG	Arsenic
FCMP	Brand A	$6.74 \pm 0.09^{ab,p}$	$0.17 \pm 0.01^{b,p}$	$1.032 \pm 0.00^{ab,p}$	ND
	Brand B	$6.77 \pm 0.11^{a,p}$	$0.17 \pm 0.01^{b,p}$	$1.031 \pm 0.00^{b,p}$	ND
	Brand C	$6.62 \pm 0.07^{b,q}$	$0.20 \pm 0.01^{a,p}$	$1.032 \pm 0.00^{ab,p}$	ND
	Brand D	$6.85 \pm 0.03^{a,r}$	$0.16 \pm 0.01^{b,p}$	$1.033 \pm 0.00^{a,q}$	ND
	Overall mean of FCMP	6.76 ± 0.14^{p}	0.18 ± 0.02^{r}	1.032 ± 0.00	ND
PM	Brand E	$6.86 \pm 0.05^{A,q}$	$0.18 \pm 0.01^{A,p}$	$1.033 \pm 0.00^{A,q}$	ND
	Brand F	$6.81 \pm 0.05^{A,p}$	$0.20 \pm 0.02^{A,p}$	$1.032 \pm 0.00^{AB,p}$	ND
	Brand G	$6.72 \pm 0.02^{B,p}$	$0.19 \pm 0.01^{A,p}$	$1.031 \pm 0.00^{B,p}$	ND
	Overall mean of PM	6.80 ± 0.07^{p}	0.19 ± 0.02^{p}	1.032 ± 0.00	ND
Control	Cow's milk	6.76 ± 0.04^{p}	0.17 ± 0.04^{p}	1.030 ± 0.00^{p}	ND

TA = titratable acidity; SG = specific gravity; ND = not detected; means followed by different superscript letters within a column are significantly different ($p < 0.05$).

Table 4: Total coliform count in full cream milk powder (FCMP) and pasteurized milk (PM).

Brand	Number of coliform positive samples	Coliform MPN (per g) (95% confidence limit)
Brand A	Nil	<3
Brand B	1	1
Brand C	Nil	<3
Brand D	Nil	<3
		Range of coliform in 100 ml (95% confidence limit)
Brand E	1	<3–36
Brand F	3	<3–240
Brand G	5	<3–>1100
Controls	*E. coli*	
	Bacillus sp.	
	Sterile distilled water	
	Sterilized milk	

Nil, coliform not recorded.

Table 5: Total coliform count in PM brands.

Brand	Coliform in 100 ml (95% confidence limit)	Coliform in 1 ml	SLS 181 : 1983 achievement
Brand E_1	<3		Achieved
Brand E_2	<3		Achieved
Brand E_3	<3		Achieved
Brand E_4	<3		Achieved
Brand E_5	36	<1	Achieved
Brand F_1	<3		Achieved
Brand F_2	<3		Achieved
Brand F_3	93	1	Not achieved
Brand F_4	240	2	Not achieved
Brand F_5	240	2	Not achieved
Brand G_1	>1100	>11	Not achieved
Brand G_2	>1100	>11	Not achieved
Brand G_3	>1100	>11	Not achieved
Brand G_4	>1100	>11	Not achieved
Brand G_5	>1100	>11	Not achieved

Achieved = satisfies the Sri Lankan standards 181:1989, specification for raw and processed milk; not achieved = does not satisfy the standards.

coliform bacteria or less than the detectable level. Presence of coliform in processed food is an indication of poor hygienic conditions during the manufacturing and post-manufacturing stages [35]. Current study suggests that good sanitary practices were followed during the manufacturing and packaging processes of the full cream milk powder. Kajal et al. reported that coliform was not recorded in the sample of Kwality, NIDO, Diploma, Anchor, Farmland, and Starship collected in Bangladesh market [35]. Results of the current study indicated that the microbial quality of Sri Lankan-marketed milk powder including both local and imported brands are similar with the Bangladesh-marketed powdered milk.

However, TCC range per 100 ml of milk obtained from PM was E (<3–36), F (<3–240), and G (<3–>1100). One sample out of five in Brand E, three samples out of five in Brand F, and all the samples in Brand G were positive for the total coliform test (Table 5). According to the SLS 181:1983, Coliform should be absent in 1 ml of pasteurized homogenized and unhomogenized milk [25]. According to the European Commission, coliform criteria for pasteurized milk is 0 (m)–5 cfu/ml (M), where $n = 5$ and $c = 1$ [47]. Brand E lies within above quality standards, while the other positive samples of PM were beneath the acceptable standards.

Deshapriya et al. reported that the total viable count in raw milk was 10^4–10^7 CFU/ml, while the count was reduced up to 10^3–10^5 CFU/ml on factory pasteurization [4]. Coliform obtained from before and after packaging of PM were 10^3–10^5 CFU/ml. Based on these results, Deshapriya et al. highlighted that the main hygienic failure in processing was in the phase of after pasteurization [4]. The results obtained by the present and past studies revealed the necessity of actions which can uplift the hygienic conditions of Sri Lankan-marketed PM.

Locally produced full cream milk powder Brand C contains high fat, protein, ash, and carbohydrate content compared to the other local and imported brands. It also has an acceptable level of coliform count. However, the pasteurized milk G, which is produced by the same local company that produces C comes under the same trade name, is highly contaminated with coliform. Therefore, it is necessary to develop the milk industry in Sri Lanka by maintaining proper hygienic conditions.

4. Conclusions

Nutritional value of SOM of 3 types of milk is highest to lowest as CM, PM, and FCMP. From the obtained results, fat content in SOM of the FCMP is lower than the CM and the PM. Protein content in SOM of CM is significantly higher than the FCMP and PM. Therefore, CM is a good protein source than PM and FCMP. Locally produced Brand C has higher protein content than the other FCMP brands including imported brands. All three types of milk provide the same amount of carbohydrate. However, the difference in ash in SOM of PM and CM milk are non-significant.

Evaluated physicochemical parameters and arsenic level of three types of milk and microbial quality of FCMP are within the acceptable level. However, microbial quality of PM is low. Therefore, there is a timely need to improve the microbial quality of the Sri Lankan-marketed PM products without decreasing its nutritional value.

Data Availability

The raw data used to support the findings of this study have been deposited in the Figshare repository (doi: https://doi.org/10.6084/m9.figshare.7011677.v1).

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

The study was made possible through the support of the Department of Botany and the Department of Food Science and Technology at University of Sri Jayewardenepura, Sri Lanka.

References

[1] G. Dănuţm, A. Coorevits, V. De Jonghe et al., "Quality control of raw cow milk from Galati county," *Journal of Agroalimentary Processes and Technologies*, vol. 17, no. 3, pp. 303–307, 2011.

[2] P. Zajác, M. Tomáška, A. M. JozefČapla, and J. Čurlej, "Quality and safety of raw cow's milk in Slovakia in 2011," *Potravinarstvo*, vol. 6, no. 2, pp. 64–73, 2012.

[3] W. L. Claeys, S. Cardoen, G. Daube et al., "Raw or heated cow milk consumption: review of risks and benefits," *Food Control*, vol. 31, no. 1, pp. 251–262, 2013.

[4] R. M. C. Deshapriya, K. F. S. T. Silva, and R. A. Wilbey, "Ivestigation of suitable pasteurization conditions for raw milk in srilanka," *Sri Lanka Veterinary Journal*, vol. 53, no. 1, pp. 1–6, 2006.

[5] A. Sharma, A. H. Jana, and R. S. Chavan, "Functionality of milk powders and milk-based powders for end use applications-a review," *Comprehensive Reviews in Food Science and Food Safety*, vol. 11, no. 5, pp. 518–528, 2012.

[6] T. Filipejová, J. kováčik, K. Kirchnerová, and V. Foltýs, "Changes in milk composition as a result of metabolic disorders of dairy cows," *Potravinarstvo*, vol. 5, no. 1, pp. 10–16, 2011.

[7] M.A. C. S. Jayasumana, P. A. Paranagama, M. D. Amarasinghe et al., "Possible link of chronic arsenic toxicity with chronic kidney disease of unknown etiology in Sri Lanka," *Journal of Natural Sciences Research*, vol. 3, no. 1, p. 64, 2013.

[8] M. Arianejad, M. Alizadeh, A. Bahrami, and S. R. Arefhoseini, "Levels of some heavy metals in raw cow's milk from selected milk production sites in Iran: is there any health concern?," *Health Promotion Perspectives*, vol. 5, no. 3, pp. 176–182, 2015.

[9] D. M. Barbano, R. R. Rasmussen, and J. M. Lynch, "Influence of milk somatic cell count and milk age on cheese yield," *Journal of Dairy Science*, vol. 74, no. 2, pp. 369–388, 1991.

[10] E. Dudriková, L. Poľaková, and J. Pukáčová, "Health and hygienic conditions of Ewe's milk processing from the aspect of food safety," *Potravinarstvo*, vol. 4, no. 3, pp. 14–18, 2010.

[11] J. Fabianová, V. Ducková, M. Čanigová, and M. Kročko, "Presence of Enterococci in cow milk and their antibiotic resistance," *Potravinarstvo*, vol. 4, no. 2, pp. 17–21, 2011.

[12] L. Poľáková, E. Dudriková, and J. Gallo, "Presence of *S. aureus* and Enterococcus spp. in goat's cheese and their antibiotics resistance," *Potravinarstvo*, vol. 5, no. 3, pp. 33–37, 2011.

[13] F. Zigo, M. Vasil', M. KadášI, J. Elečko, and Z. Farkašová, "Bacteria *Staphylococcus* spp. izolated from mastitis of sheep their enterotoxigenic properties," *Potravinarstvo*, vol. 5, no. 4, pp. 70–72, 2011.

[14] R. C. Chandan, A. Kilara, and N. P. Shan, *Dairy Processing and Quality Assurance*, Wiley-lackwell, Ames, IA, USA, 2008, ISBN: 0-8138-2756-6.

[15] A. Y. Tamime, *Milk Processing and Quality management*, John Wiley & Sons in Blackwell Publishing Ltd., Chichester, UK, 2009, ISBN: 978-1-4051-4530-5.

[16] J. G. Wells, L. D. Shipman, K. D. Greene et al., "Isolation of *Escherichia coli* serotype O157: H7 and other Shiga-like-toxin-producing *E. coli* from dairy cattle," *Journal of Clinical Microbiology*, vol. 29, no. 5, pp. 985–989, 1991.

[17] K. A. Hettinga, H. J. F. van Valenberg, and A. C. M. van Hooijdonk, "Quality control of raw cows' milk by headspace analysis," *International Dairy Journal*, vol. 18, no. 5, pp. 506–513, 2008.

[18] AOAC (Association of Analytical Chemist), *Official Methods of Analysis of the Association of Analytical Chemist*, Association of Analytical Chemist, Washington, DC, USA, 13th edition, 1980, ISBN: 0-935584-14-5.

[19] I. L. Pepper and C. P. Gerba, *Environmental Microbiology: A Laboratory Manual*, Elsevier Academic Press, Amsterdam, Netherlands, 2nd edition, 2004, ISBN: 0-12-550656-2.

[20] C. H. Collins, P. M. Lyne, and R. L. Grange, *Microbiological Methods*, Butterworth: Heinemann Ltd., 7th edition, 1995, ISBN: 0750606533.

[21] CODEX STAN 207, *Codex Standard for Milk and Milk Products*, Food and Agriculture Organization of the United Nations & World Health Organization, Rome, Italy, 2nd edition, 1999.

[22] Sri Lankan Standards 731:2008 (Rev. 1-2009), Specification for Milk Powder.

[23] FDSPM (Fundamentals of Dairy Science Powder Milk), *USA Standards of Powder Milk*, FDSPM, New York, NY, USA, 2nd edition, 2003.

[24] M. K. S. El Khier and A. Y. Abu El Gasim, "Quality assessment of milk powders packed in Sudan," *Pakistan Journal of Nutrition*, vol. 8, no. 4, pp. 388–391, 2009.

[25] Sri Lankan Standards 181:1983(Rev. 1-1986), Specification for Raw and Processed Milk.

[26] T. Gemechu, F. Beyene, and M. Eshetu, "Physical and chemical quality of raw cow's milk produced and marketed in Shashemene Town, Southern Ethiopia," *ISABB Journal*

of Food and Agricultural Sciences, vol. 5, no. 2, pp. 7–13, 2012.

[27] T. F. Graf, "Market implications of changing fat content of milk and dairy products," in *Fat Content and Composition of Animal Products: Proceedings of a Symposium*, National Academies Press, Washington, DC, USA, 1974, https://www.ncbi.nlm.nih.gov/books/NBK216537/.

[28] BDS (Bangladesh Standard of Dairy product), *Bangladesh Standard Testing Institutions*, BDS, Bangladesh, 1985.

[29] A. Kader, M. Deb, M. A. Aziz, M. M. H. Sohag, and S. R. Rahman, "Evaluation of physico-chemical properties and microbiological quality of milk collected from different dairy farms in Sylhet, Bangladesh," *Food Science and Technology*, vol. 3, no. 3, pp. 37–41, 2015.

[30] R. Kanwal, T. Ahmed, and B. Mirza, "Comparative analysis of quality of milk collected from buffalo, cow, goat and sheep of Rawalpindi/Islamabad region in Pakistan," *Asian Journal of Plant Sciences*, vol. 3, no. 3, pp. 300–305, 2004.

[31] M. B. Hossain and S. R. Dev, "Physiochemical characteristics of various raw milk samples in a selected dairy plant of Bangladesh," *International Journal of Engineering*, vol. 1, no. 3, pp. 2305–8269, 2013.

[32] A. Awan, M. Naseer, A. Aasfa, R. Muhammad, and I. Furhan, "A study on chemical composition and detection of chemical adulteration in tetra pack milk samples commercially available in Multan," *Pakistan Journal of Pharmaceutical Sciences*, vol. 27, no. 1, pp. 183–186, 2014.

[33] A. F. Rawan, *Evaluation of Milk Composition for Fat and Bacteriological Quality of Raw Preprocessed and Pasteurized Milk in Nangarhar Province*, 2017.

[34] P. F. Fox, P. L. McSweeney, and L. Paul, *Dairy Chemistry and Biochemistry*, Blackie Academic & Professional, London, UK, 1st edition, 1998.

[35] M. F. I. Kajal, A. Wadud, M. N. Islam, and P. K. Sarma, "Evaluation of some chemical parameters of powder milk available in Mymensingh town," *Journal of the Bangladesh Agricultural University*, vol. 10, no. 1, pp. 95–100, 2012.

[36] H. Raff, "Market implications of changing fat content of milk and dairy products, fat content and composition of animal products," *J. Food Science and Technology*, vol. 5, no. 2, pp. 6–17, 2011.

[37] FAO (Food and Agriculture Organization of the United Nations), *Overview of the Turkish Dairy Sector within the Framework of Eu-Accession*, FAO, Rome, Italy, 2007.

[38] M. Imran, H. Khan, and S. S. Hassan, "Physicochemical characteristics of various milk samples available in Pakistan," *Journal of Zhejiang University Science B*, vol. 9, no. 7, pp. 546–551, 2008.

[39] ADMI (American Dry Milk Institute) Inc., *Standards for Grades for the Dry Milk Industry Including Methods of Analysis*, Bulletin 916, ADMI, Chicago, IL, USA, 1962.

[40] F. O'Mahony, *Rural Dairy Technology-Experiences in Ethiopia*, ILCA manual No. 4, Dairy Technology Unit, ILCA, Addis Abeba, Ethiopia, 1998.

[41] L. U. Ballou, M. Pasquini, and R. D. Bremrl, "Factors affecting herd milk composition and milk plasma at four levels of somatic cell counts," *Journal of Dairy Science*, vol. 78, no. 10, pp. 2186–2195, 1995.

[42] ADMI (American Dry Milk Institute) Inc., *Standards for Grade of Dry Milk Including Methods of Analysis*, Bulletin 916, ADMI, Elmhurst, IL, USA, 1971.

[43] C. B. O'Connor, *Rural Dairy Technology ILRI Training Manual No. 1*, International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia, 1994.

[44] I. Rosas, R. Belmont, A. Armienta, and A. Baez, "Arsenic concentrations in water, soil, milk and forage in Comarca Lagunera, Mexico," *Water, Air, and Soil Pollution*, vol. 112, no. 1-2, pp. 133–149, 1999.

[45] L. Qin, X. Wang, W. Li, X. Tong, and W. Tong, "The minerals and heavy metals in cow's milk form China and Japan," *Journal of Health Science*, vol. 55, no. 2, pp. 300–305, 2009.

[46] A. Aumaître, "Quality and safety of animal products," *Livestock Production Science*, vol. 59, pp. 113–124, 1999.

[47] EC (European Commission), *Overview of Microbiological Criteria for Foodstuffs in Community Legislation in Force*, 2001, http://europa.eu.int/comm/food/fs/sfp/mr/mr_crit_en.pdf.

[48] CAC (Codex Alimentarius Commission), *Recommended International Code of Hygienic Practice for Dried Milk, CAC/RPC 31*, 1983, ftp://ftp.fao.org/codex/standard/en/CXP_031e.pdf.