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Quality assessment of different commercial and local milk available in the local markets of selected area of Bangladesh

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ABSTRACT

Objective: This study aimed to assess the organoleptic, physico-chemical, and microbial quality as well as the presence of any adulterants in different commercial and local milk samples.

Materials and Methods: Three brands of ultra-high temperature (UHT) milk, three brands of pasteurized milk, and three raw milk samples were procured and analyzed for different quality tests. Consumer preference about the milk samples were studied by evaluating the organoleptic properties by a testing panel of 15 panelists. Physico-chemical, adulteration, and microbial analysis of the milk samples were performed by following different standard methods.

Results: Most of the organoleptic properties were varied significantly at $p \leq 0.05$ for UHT and pasteurized milk samples, while raw milk samples were equally acceptable to the panelists in most cases. From physico-chemical analysis, it was found that raw milk contained the highest amount of moisture (90.68%), whereas UHT had the lowest (87.60%), and other components were ranged as 0.68%–0.78% ash, 3.20%–3.58% protein, 3.15%–3.56% fat, 4.35%–4.62% lactose, 0.14%–0.22% acidity, 6.17%–8.95% solid not fat, 9.32%–12.40% total solid, and 1.026%–1.034% specific gravity. All adulteration tests responded negatively for raw samples, whereas commercial milk samples showed positive response only on added sugar test. Total standard plate count and coliform count tests showed that there was no microorganism in a detectable range in commercial milk samples, though raw samples had a significant amount.

Conclusion: Though there were some fluctuations in some parameters of the three milk categories, but this study concluded that the quality of UHT and pasteurized milk were excellent with respect to parameters studied.

Introduction

Milk is known as ideal food with unique quality for nourishment of human being long before recorded history. It is recognized as complete meal because of its wholesome nutrients for all mammals, including human being [1]. In native conformation, milk shows the apex food value. It meets the nutritional requirement of the body more perfectly than any other single food as it carries each of the absolutely necessary nutritional components to perform every physiological activities of the body system. According to Pehrsson [2], milk has around 87.80% water, 3.20% protein, 3.50% fat, 4.80% lactose, and 0.70% minerals and 100 gm milk supplies around 66 kcal of energy.

Former evidence suggests that the people who used to get the most energy of daily requirement from milk and milk products were more prosperous and capable of effective governance and these communities possess the benefit of having complete freedom from many nutritional diseases [3]. On the other hand, the world's poor or underdeveloped countries or regions have an inadequate opportunity in drinking milk which results a large number of nutritionally deficient inhabitants [4].

Milk is considered as a highly perishable food because of its higher moisture content and its shelf life is normally 3–5 h as well as it is a great growing medium for microorganism. Before milking, milk is considered as sterile but

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its quality starts deteriorating during handling, processing and storage [5]. In addition, microbial contamination is generally happened from different sources. Common pathogenic microbes in milk include *Salmonella* sp., *Listeria monocytogenes*, *Yersinia enterocolitica*, *Campylobacter jejuni*, *Staphylococcus aureus, Escherichia coli*, etc. and these are responsible for many of food-borne diseases [6].

Pasteurization, a preservation technique for milk, is mainly performed to destroy or inactive all the harmful or pathogenic microorganisms by using heat treatment [5]. Pasteurized milk is obtained by heating milk for a minimum time of 15 sec (at a temperature of 72°C) or 30 min (at a temperature of 63°C). Ultra-high temperature (UHT) is a process of heating milk at a temperature of 135°C–150°C for a fraction of a second holding time to prolong the shelf life of milk [5]. On the other hand, pasteurization of milk can destroy most of the bacteria but few heat resistant enzymes may remain alive and can result in vital deformity of milk throughout the time of storage [7].

Food adulteration is a common phenomenon practiced in food processing and marketing sector all over the world. Adulteration of milk has recently become a major issue to be concerned [8]. According to Moore et al. [9], milk powder is ranked second among the available food items in the risk of adulteration, whereas olive oil ranks first. Azad and Ahmed [10] reported that milk processing sectors and suppliers add different adulterants and preservative for increasing the shelf life to get rid from the problem of quick deterioration of milk due to its high perishability.

Adulterants added in milk are mainly inferior or cheaper materials which do not affect appearance largely. Raw milk is generally adulterated by using potable water or whey (watery part of milk remaining after making of cheese) which is known as economic adulteration and is commonly practiced by the supplier mainly to increase the quantity [11], while the other adulterants include skim milk powder, salt, detergents, cane sugar, urea, formalin, coloring agents, starch, and acids [12,13]. These adulterants adversely affect consumers' vital organs, such as kidney, liver, brain, bone marrow, respiratory tract, and causes cancer. Beside those, adulteration of milk also involves to alter the quality and standard of the processed products from milk [14]. Thus to get rid from these problems, continuous monitoring the quality and adulteration of milk are so important. There are several modern and newer techniques used to identify the presence of the adulterants in milk [11], in which the usual checking parameters of knowing the milk's quality and adulterations include the measure of amount of fat, protein, solid not fat (SNF), microbial count etc. [10].

There are several branded commercial milk available in the market of Bangladesh, namely, Aarong dairy, Programme for Rural Advancement Nationally (PRAN) farm fresh, Milk vita, etc. Beside those, raw local milk also is found. Quality milk is always getting preference to the consumers. To fulfill the consumers' demand, serving of good quality milk is very important. Several articles [8,15–19] are available on quality assessment of milk found at several regions of Bangladesh, but more investigations seem to be required for getting updated knowledge about the quality of milk. Based on these above conditions, this research was carried out to assess the physico-chemical, organoleptic, and microbial quality of the milk and to determine the presence of any added adulterants to the commercial and raw milk found in the markets around Bangladesh Agricultural University (BAU), Mymensingh.

Materials and Methods

Sample collection

To perform this study, UHT, pasteurized and raw local milk were chosen and collected from local market of Mymensingh region. Three UHT milk packets of three different commercial brands were purchased and named based on brand name as A_1 (procured from K.R. Market, BAU), A_2 (procured from Sheshmore, BAU), and A_3 (procured from Ganginapar market, Mymensingh). Similarly, three commercial branded pasteurized milk packets were purchased and named as B_1 (procured from K. R. Market, BAU), B_2 (procured from Sheshmore, BAU), and B_3 (procured from K. R. Market, BAU). On the other hand, raw milk was collected from three different farmers of Sheshmore, BAU and named as C_1, C_2, and C_3. After bringing to the laboratory, the milk containing packs were thoroughly oscillated to mix the inner content properly and opened by using a sterile scissor [18]. After that microbial analysis was performed immediately and subsequently other analyses were also conducted.

Organoleptic analysis

Different organoleptic parameters like color/appearance, flavor, body/texture, taste, and overall acceptability of the milk samples were evaluated by a testing group consisting of 15 semi-trained panelist [20]. Hedonic rating scale (9-point) was used for statistical analysis [21,22]. An evaluation sheet for organoleptic properties is given at Appendix section (Appendix-I).

Physico-chemical analysis

Moisture, ash, fat, protein, acidity, total solid (TS), SNF, lactose, and specific gravity were analyzed to compare the values among different milk samples. Quantity of moisture, protein, ash, and acidity were determined as per the methods of AOAC [23]. Amount of fat presence was calculated on accordance to the Gerber method as per described by AOAC [23]. TS was simply calculated by subtracting the

moisture content from 100. SNF and lactose content were calculated by subtraction as SNF = TS – fat (%) and lactose = SNF – (protein + ash)%.

Lactometer was used to measure the specific gravity of the milk samples. For that, the samples' temperature was adjusted to near about 60°F. The milk was mixed thoroughly by avoiding incorporation of air. Enough milk was placed in a cylinder so that the lactometer was placed in the center of the cylinder and reading was recorded within 30 sec after mixing. Again, the temperature of milk was taken. The lactometer scale was at the top of the milk meniscus. If the milk temperature was not exactly 60°F, the lactometer reading was corrected by adding 0.1 degree for each of Fahrenheit temperature above 60°F of by subtracting 0.1° for each degree Fahrenheit temperature below 60°F. Specific gravity of milk sample was calculated as formula mentioned by Awal et al. [15].

Adulteration analysis

To check the presence of any adulteration, several tests were performed. The tests were mainly involved titration of sample with different reagents. Added sugar and starch existence were determined on according to the method as mentioned by Sharma et al. [24], whereas the procedures given by Singh et al. [25] were followed for finding the presence of hydrogen peroxide, soap, formalin, detergent, and urea. Salt and skim milk powder test were conducted on according to Awan et al. [26]. In addition, clot on boiling (COB) test and alcohol test were conducted according to Tessema and Tibbo [27].

Microbiological analysis

Microbiological tests like standard plate count (SPC) and total coliform count (TCC) were performed to know the microbial status of the milk samples. SPC (cfu/ml) was conducted by following the method recommended by American Public Health Association (APHA) [28] and TCC (cfu/ml) of the samples was done according to the procedure of Standard Methods for the Examination of Dairy Products as given by APHA [28].

Statistical analysis

The organoleptic data of 9-point hedonic rating scale provided by the panelists were evaluated statistically using Analysis of Variance and Least Significant Difference (LSD) procedures of the Statistical Analysis System at $p \leq 0.05$ [29,30].

Result and Discussion

Organoleptic evaluation

The evaluated scores for organoleptic properties of the UHT, pasteurized and raw milk samples are shown in Table 1. The analysis was performed to compare the acceptability of the three milk categories to the consumer. From the Table 1, it is seen that there was a significant difference of score values for color, flavor, and texture of UHT and pasteurized milk samples. But all the samples were not differed significantly from each other. In the most of the cases, one sample was differed significantly from others and rest two was equally acceptable. On the other hand, the raw milk samples were equally acceptable in case of color and flavor while significant difference was found for texture value. Taste is an important organoleptic parameter and evaluation on it showed that UHT, pasteurized and raw milk samples were got same acceptance to the panelists. The overall acceptability values revealed that A_2 sample was the mostly acceptable among three UHT milk samples as well as in case of pasteurized milk while the raw collected milk samples were equally

Table 1. Organoleptic properties of the milk samples[*].

Sample	Color		Flavor		Texture		Taste		Overall acceptability	
	Score	LSD	Score	LSD	Score	LSD	Score	LSD	Score	LSD
A_1	7.6[a] ± 0.51		7.3[a] ± 1.05		6.2[b] ± 1.03		7.4[a] ± 0.69		6.5[b] ± 1.17	
A_2	7.0[b] ± 1.05	0.531	6.4[b] ± 0.94	0.904	7.2[a] ± 1.03	0.820	6.9[a] ± 0.73	0.721	7.5[a] ± 1.08	0.673
A_3	6.6[b] ± 0.69		6.3[b] ± 1.05		6.3[b] ± 0.69		7.3[a] ± 0.94		6.4[b] ± 0.82	
B_1	7.5[a] ± 0.84		6.1[b] ± 0.99		6.3[b] ± 0.94		6.5[a] ± 0.84		6.6[b] ± 0.69	
B_2	6.7[b] ± 0.94	0.437	7.2[a] ± 1.03	0.833	7.2[a] ± 0.78	0.701	5.9[a] ± 0.87	0.633	7.4[a] ± 0.84	0.736
B3	7.2[a] ± 0.63		6.3[b] ± 0.82		5.9[b] ± 0.87		6.2[a] ± 0.78		6.4[b] ± 0.96	
C_1	7.0[a] ± 1.05		5.6[a] ± 0.84		5.7[b] ± 0.82		6.0[a] ± 0.81		7.3[a] ± 0.7	
C_2	7.3[a] ± 0.94	1.144	5.8[a] ± 0.78	0.804	6.1[b] ± 0.99	0.893	6.3[a] ± 0.94	0.834	6.4[a] ± 1.07	0.916
C_3	6.5[a] ± 1.17		5.4[a] ± 0.69		7.1[a] ± 0.87		6.2[a] ± 1.03		6.3[a] ± 0.94	

[*]Samples having the same superscript indicate there is no significant difference at 5% level of significance. A_1, A_2 and A_3 = UHT samples; B_1, B_2 and B_3 = pasteurized samples; C_1, C_2 and C_3 = raw milk samples.

acceptable to the panelists. Arafat et al. [16] found that the organoleptic properties of three commercial milk brands, such as PRAN, Aarong, and Farm fresh as 37.67, 41.67, and 43.67 for flavor; 24.00, 26.00, and 28.00 for consistency (texture), 16.00, 18.00, and 18.67 for color, respectively. They also noticed that the quality of the samples were equally acceptable based on sensory parameters. However in this study, the samples were differed significantly in case of few sensory parameters. This difference might be happened due to acceptance criteria of panelists.

Physico-chemical properties

The raw and processed milk samples were evaluated for their physico-chemical properties, such as moisture, ash, protein, fat, lactose, acidity, SNF, TS, and specific gravity. The average data of the analyses are shown in Table 2.

The percentage of moisture content obtained from different milk samples are shown in Table 2. Three raw samples (C_1–C_3) contained more than 89.5% water. All the heat-treated milk contained water lower than the raw samples. UHT milk samples contained water in the range of 87.60%–87.86% where pasteurized milk had 88.07%–88.28% water. The obtained results for moisture values were in similar with the result 88%–91% of Hossain et al. [19]. Mixing of water with the native milk may cause in increasing the moisture content of the raw milk samples, whereas the industrial processed milks are usually standardized and the values in this case were in satisfactory level. The amount of ash in the raw milk samples were in the range of 0.72%–0.78% which was in conformity as found by Hossain et al. [19] as 0.70%–0.80%. But, the determined ash values of this study in case of raw milk were reasonably higher than the ash values mentioned by Elmagli and Zubeir [31] as ranged as 0.33%–0.69%. On the other hand, the pasteurized milk samples had the ash content of 0.70% –0.74%, which satisfied

the standard (≥0.70%) provided by Bangladesh Standards and Testing Institution (BSTI) [32] for pasteurized milk. The UHT milk samples had ash content in the range of 0.68%–0.75% which were within the limit of the ash content ranged for UHT treated milk found by Siddique et al. [33] as 0.65%–0.86%. However, among all the milk samples UHT milk sample (A_3) contained the lowest amount of ash content.

The raw milk samples had the protein content in the range of 3.20%–3.30% as shown in Table 2. Hossain et al. [19] reported 3.07%–3.57% protein for Bangladeshi cows' milk which was in conformity with this study. All the three pasteurized milk samples contained a minimum of 3.32% protein. BSTI [32] fixed up standard protein content of minimum 3.30% in pasteurized milk. Thus, the results obtained for pasteurized milk samples were met up the standard protein content as per as BSTI [32]. The UHT milk samples can be attributed as good quality in terms of protein content as all of the samples had above 3.40% protein content where sample A_2 contained the highest 3.58% of protein content. Hossain et al. [19] found almost similar result in case of protein content and mentioned that the UHT milk samples contained 3.43%–3.68% protein.

Milk fat is granted as the most desirable and important nutrient available in milk. The Food and Drug Administration (FDA) recommended not less than 3.25% milk fat for raw whole milk. From this study, 3.35%, 3.27%, and 3.15% fat was found in raw milk samples C_1, C_2, and C_3, respectively, in where C_3 didn't fulfill the FDA standard. On the other hand, any pasteurized milk should have at least 3.40% fat based on the standard provided by BSTI [32] which was not fulfilled by the samples in some extent. Similar observation was depicted by Hossain et al. [19]. Low fat content in raw milk or due to withdrawal of fat from the raw milk during processing without following the standards provided by BSTI and FDA may cause in lowering the fat content of the pasteurized milk [34].

Table 2. Physico-chemical properties of milk samples.

Parameters	Milk samples								
	UHT			Pasteurized			Raw		
	A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3
Moisture (%)	87.74	87.60	87.86	88.07	88.28	88.10	90.34	89.58	90.68
Ash (%)	0.73	0.75	0.68	0.74	0.70	0.72	0.76	0.72	0.78
Protein (%)	3.40	3.58	3.53	3.44	3.32	3.35	3.30	3.20	3.28
Fat (%)	3.56	3.45	3.35	3.32	3.24	3.42	3.35	3.27	3.15
Lactose (%)	4.54	4.62	4.58	4.43	4.46	4.40	4.35	4.43	4.56
Acidity (%)	0.18	0.16	0.15	0.17	0.15	0.14	0.22	0.18	0.17
SNF (%)	8.67	8.95	8.79	8.61	8.48	8.47	6.32	7.15	6.17
TS (%)	12.26	12.40	12.14	11.93	11.72	11.90	9.66	10.42	9.32
Specific gravity	1.032	1.031	1.034	1.028	1.030	1.029	1.027	1.026	1.026

All the heat-treated samples had the lactose content in the range of 4.40%–4.46% which fulfilled the requirement of lactose content declared by BSTI [32] as 4.40%, whereas one raw sample (A_1) had lower lactose as 4.35%. Titratable acidity measures the freshness, bacterial activity, and taste of milk and acknowledged as an indicator of milk quality. In this study, the highest acidity value was found as 0.22% for raw sample C_1 and the lowest was 0.14% for pasteurized sample B_3. Popescu and Angel [35] stated that the high quality milk should have maximum acidity of 0.14%. From this study, it was found that the pasteurized milk samples had the acidity ranges from 0.14%–0.17% (Table 2). The standard of BSTI [32] permits less than 0.15% acidity in the pasteurized milk which indicates that few of the milk samples crossed the limit of acidity. Highest SNF (8.95%) was recorded for UHT sample A_2, whereas raw sample C_3 had the least SNF (6.17%) content. All the heat treated milk samples maintained the standard value of SNF as ≥8.0% provided by BSTI [32].

Dilution of milk using water can cause in lowering the TS content. In this study, the raw milk samples had the TS content in the range of 9.32%–10.42% which were lower than the TS observed by Awal at al. [15] as 10.88%–11.36% and Yoganandi et al. [36] as 13.07%. It was found that the sample A_2 gave the highest (12.40%) and the sample C_3 gave the lowest (9.32%) TS content. Each of the milk samples had slightly lower TS content than the standard of FDA [37]. According to FDA [37], milk obtained from cow should have ≥12% TS. Specific gravity of different milk samples is shown in Table 2. UHT sample A_3 scored the highest (1.034) than others UHT sample and pasteurized sample B_2 scored highest (1.030) than other pasteurized samples. Raw milk sample C_1 scored highest result (1.027) among the raw samples. Specific gravity of raw milk samples ranged from 1.026 to 1.027 which was slightly lower to Gemechu et al. [38] who found specific gravity of local milk samples ranged from 1.030 to 1.031. Specific gravity of pasteurized milk samples ranged from 1.028 to 1.030 which was within the limit of normal range of specific gravity of 1.028–1.034 [32]. After all, it can be noted that specific gravity of all the milk samples in this study fulfilled the recommended range.

Adulteration test

Various adulteration tests, such as added sugar, hydrogen peroxide, starch, soap, salt, formalin, detergent, urea, skim milk powder, alcohol, and COB in milk samples were performed and the obtained results are shown in Table 3.

These tests were qualitative which results in either present of these adulterants or not. Analyses showed that only added sugar test was positive for UHT and pasteurized milk and all other tests resulted negative response. Hossain et al. [19] also found positive response in case of

added sugar test for different pasteurized and UHT milk available in local market of Bangladesh. They also observed negative response for all others adulterants test which was in similar with this study.

Microbiological parameters

The standard plate count (SPC)

Table 4 represents the microbiological results of the milk samples. Remarkable SPC (3.0×10^5–7.7×10^5 cfu/ml) was found in the raw milk samples. Grade 'A' raw milk supplies must meet a standard not more than 1×10^6 bacteria per ml and mixed milk in the plant must not contain more than 3×10^6 bacteria per ml [39]. Poor hygienic conditions during milking are the most noticeable reason of high microbial count. In addition, contamination from dirty udder, utensils, and environment can cause in increasing of the SPC

Table 3. Different adulterant test results obtained from raw and different brands of UHT and pasteurized milk.

Adulterants	Milk samples								
	UHT			Pasteurized			Raw		
	A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3
Added sugar	√	√	√	√	√	√	X	X	X
Hydrogen peroxide	X	X	X	X	X	X	X	X	X
Starch	X	X	X	X	X	X	X	X	X
Soap	X	X	X	X	X	X	X	X	X
Salt	X	X	X	X	X	X	X	X	X
Formalin	X	X	X	X	X	X	X	X	X
Detergent	X	X	X	X	X	X	X	X	X
Urea	X	X	X	X	X	X	X	X	X
Skim milk powder	X	X	X	X	X	X	X	X	X
COB test	X	X	X	X	X	X	X	X	X
Alcohol test	X	X	X	X	X	X	X	X	X

√ = positive response, X = negative response.

Table 4. Microbiological results of different branded and raw milk samples.

Milk Samples		SPC (cfu/ml)	TCC (cfu/ml)
UHT	A_1	X	X
	A_2	X	X
	A_3	X	X
Pasteurized	B_1	X	X
	B_2	X	X
	B_3	X	X
Raw	C_1	7.7×10^5	6.3×10^4
	C_2	5.2×10^5	5.8×10^4
	C_3	3.0×10^5	4.4×10^4

X = Not found in detectable range.

count. However, the SPC of the thermally processed milk (pasteurized and UHT) was not found in detectable range which indicates their excellent sanitary quality. This result is agreed to Hossain et al. [19] and Arafat et al. [16] who did not find any SPC in UHT and pasteurized milk samples.

Total coliform count (TCC)

Coliform count of the three raw milk samples was varied in the range of 4.4×10^4–6.3×10^4 cfu/ml. The obtained result was in the range mentioned by Banik et al. [17] as they found 1.3×10^4–2.5×10^5 cfu/ml in raw milk. According to CDFA [40], there are several reasons which increase the TCC of milk, such as unhygienic herd, unhygienic milking system, using of contaminated water, and equipment. The TCC value of the pasteurized and UHT milk samples were not in detectable range which state their good sanitary quality which could be happened due to higher temperature treatment.

Conclusion

UHT, pasteurized and raw milk are widely available in the local market of Bangladesh. Organoleptic analysis of the milk samples revealed that consumer like the commercial processed milks than the raw local milk. Most of the raw and pasteurized milk showed appreciable amounts of lactose, protein, and ash according to BSTI standard but slightly lower amount fat was found in few samples. Among the adulteration tests, positive response was noticed in case of added sugar in UHT and pasteurized milk, though no other adulterants found in milk samples. SPC of 3.0–7.7×10^5 cfu/ml and TCC of 4.4–6.3×10^4 cfu/ml was found in raw local milk, whereas processed milk samples were free from any microbial load. So based on the parameters studied, this study concluded that all of the milk samples available in the selected areas possessed satisfactory quality. However, further study needs to be conducted on trace elements, metal, antibiotic, shelf stability, etc.

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Conflict of interests

The authors confirm no conflict of interests for this study.

Authors' contribution

AK designed and performed the work and prepared the draft manuscript. PCD helped in data analysis and preparing the draft manuscript and AI supervised the research work, helped during data analysis, and interpretation and manuscript preparation.

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Sensory evaluation form

Name of panelist…………………….….....   Date………………
Hedonic rating test of………………………. (1-9)

Please test the sample and give numerical score ranging from (1-9) in the appropriate space.

Sensory attributes	Sample identity		
	Sample-1	Sample-2	Sample-3
Color			
Flavor			
Texture			
Taste			
Overall acceptability			

Hedonic scale used		
Like extremely = 9	Neither like nor dislike = 5	
Like very much = 8	Dislike slightly = 4	Dislike extremely = 1
Like moderately = 7	Dislike moderately = 3	
Like slightly = 6	Dislike very much = 2	

…………………………………

 Signature (Panelist)