Chemical and Microbiological Quality Assessment of Raw and Processed Liquid Market Milks of Bangladesh

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Abstract: Twelve different liquid market milks of Bangladesh were examined to evaluate their chemical and sanitary quality. Six of these were open raw milk bought from local daily markets and the other six were processed packet milk (both pasteurized and UHT (Ultra High Temperature)-processed) available in shops. The twelve samples were examined for the determination of percentage of water, total soluble solids, fat, solids non-fat, lactose, protein and ash, measurement of titratable acidity, detection of adulterants, enumeration of total bacterial count, staphylococcal count, coliform count, fecal coliform count, Salmonella and Shigella count, *Aeromonas hydrophila* count and psychrophilic count. Results revealed that most of the raw and pasteurized milks were substandard in both chemical and sanitary quality whereas the quality of UHT-treated milks was excellent. All the pasteurized and raw milks were found to be contaminated having bacterial load exceeding the acceptable limit. Pathogenic bacterial genera (Aeromonas, Salmonella and Staphylococcus) were identified in some of these samples. But none of the UHT-processed milk contained any bacteria. Water had been added in six samples whereas, sucrose was found in five of the six temperature-processed samples.

Key words: Liquid market milk, quality evaluation, chemical composition, acidity, adulteration, bacterial distribution

INTRODUCTION

Milk is considered as the nature's single most complete food (O'Mahony, 1988) and is definitely one of the most valuable and regularly consumed foods. But at the same time, it is highly vulnerable to bacterial contamination and hence is easily perishable (Kim *et al.*, 1983; OECD, 2005). Moreover, in Bangladesh milk adulteration is pretty common. Quality evaluation of milk is thus vital. Consumers certainly want clean, wholesome and nutritious food produced and processed in a sound and sanitary manner and is free from pathogens. For fulfilling consumer's demand, production of quality milk is essential. Quality milk means the, milk which has normal chemical composition is completely free from harmful bacteria and harmful toxic substances, free from sediment and extraneous substances has lower degree of titratable acidity of good flavor, adequate in keeping quality and low in bacterial counts. In Bangladesh, milk is produced mostly in non-organized way and usually it is supplied to the consumers from the urban and rural areas by milkmen. Although, there are little milk pockets specially milk vita and some established dairy farms where surplus milk is readily available, this perishable product has never received particular attention in hygienic distribution to the consumers (Khan *et al.*, 2008). But milk is an excellent growth medium for bacteria and can easily be contaminated from many different sources including the udder and body of cows, dust from the air, litter, floor, flies, insects and rodents, water supply, hands and clothes of the milker, utensils, bottles, atmosphere, etc. (Ensminger *et al.*, 1994; Heinemann, 1919; Cousin, 1982). Thus, milk and the dairy products prepared from milk can be important sources of food borne pathogens (Oliver *et al.*, 2005). Moreover, adulteration of milk with water which is very common in Bangladesh, not only causes dilution of milk reducing the milk solids but it also involves, the risk of introducing germs into the milk further decreasing its quality. So, it is naturally of the greatest importance that such a valuable and at the same time an easily-damaged food as milk should be delivered to the consumer in a pure, hygienic and unadulterated form. Not only because the abstraction of cream and the adulteration with water diminish the food value of the milk

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Table 1: Chemical and sanitary requirements of BSTI (2002) for pasteurized milk

Characteristics	Requirement
Fat, percent by mass (min.)	3.5
Solids Non-fat (SNF), percent by mass (min.)	8.0
Lactose, percent by mass (min.)	4.4
Protein, percent by mass (min.)	3.3
Ash, percent by mass (min.)	0.7
Titratable acidity (as lactic acid per 100 mL of milk) (max.)	0.15
Total count (mL^{-1} max.)	20, 000 cfu
Total coliform count (mL^{-1})	<10

but because there is great danger in the latter case of the germs of infectious and contagious diseases being introduced into the milk and so disseminated (Ghose and Maharajan, 2002; Barthel, 1910). The Bangladesh Standards and Testing Institution (BSTI, 2002) obliges various chemical and sanitary requirements for the pasteurized milk as shown in Table 1. However, no standard is known to be established for the raw and UHT-treated milk.

So far, no study had been reported on the quality evaluation of liquid market milks of Bangladesh. The objectives of this study were to determine; the bacterial load, food value and degree of cleanliness surrounding the production and handling of the milk as well as to find out the differences among the raw, pasteurized and UHT-processed milks in terms of chemical composition and bacterial distribution.

This study reveals the sanitary standard and the food value of the liquid market milks of Bangladesh. Particularly, it indicates how safe these milks are for consume and lets the people know what kind of milk they consume therefore, increasing their concern in buying these milks as well as making the government realize the importance of frequent inspection of the market milks to check whether, these milks meet the minimum legal standards. These are the 1st data about the chemical composition, adulteration and bacterial load of the liquid market milks of Bangladesh.

MATERIALS AND METHODS

Collection of samples: In Bangladesh, milk is generally sold in two ways. In most cases, the farmers bring milk in open pots and sell it directly in the market without any processing and packaging. In other cases, milk companies collect milk from the farmers or dairy farms, process it via pasteurization or UHT treatment and package the processed milk which is then sold in shops under specific brand name.

In this study, raw milks were purchased from a local daily market while brand milks were bought from different shops. A total of twelve samples were examined. Six (designated as R-1 to R-6) were raw milk bought from different vendors. Of the remaining six, three (P-7 to P-9)

were pasteurized milks each from different brand and the other three (U-10 to U-12) were UHT-processed also from different brands. All the samples were aseptically collected and immediately transported to the laboratory for examination.

Chemical analysis: Percentage of water was determined by subtracting the value of Total Soluble Solids (TSS) from 100. TSS was determined by using refractometer (Portable refractometer, model: FG 103, Brix 0-32%). Milk fat was measured by Rose-Gottlieb's method (Barthel, 1910). Amount of Solids Non-fat (SNF) was determined by subtracting the amount of fat from TSS. Lactose was determined by volumetric method (Heinemann, 1919). About 20 mL of milk was diluted with water to a volume of 400 mL and 8-16 drops of a 10% solution of acetic acid added. The precipitate was filtered off and washed with cold water. The filtrate was boiled in a flask and the albumin precipitated. This was filtered off also and the precipitate was washed with cold water. The filtrates and wash water were mixed and measured accurately. A portion of the filtrate was placed in a burette and this was run into a boiling mixture of 20 mL Fehling's solution and 80 mL water. After the copper had been completely precipitated, the number of mL used was read. About 20 mL Fehling's solution corresponds to 0.135 g milk-sugar. Protein was measured by Kjeldahl method (Crampton and Harris, 1969). Ash content was determined by the method described by Joslyn (1970). Acidity was measured by titration with 0.1 normal sodium hydroxide solution and using 1% alcohol solution of phenolphthalein as indicator (Lampert, 1947). Presence of the adulterants was tested by specific qualitative tests.

Neutralizers: About 20 mL of milk is taken in a silica crucible and then the water is evaporated and the contents are burnt in a muffle furnace. The ash is dispersed in 10 mL distilled water and it is titrated against decinormal (N/10) hydrochloric acid using phenolphthalein as an indicator. If the titre value exceeds 1.2 mL then it is construed that the milk is adulterated with neutralizers.

Added water: Water content of milk is usually 87.25% (Eckles *et al.*, 1951) and it ranges from 84.0-89.0% (Lampert, 1947). In this study water content of >90% in a sample has been regarded as adulteration with water.

Formalin: About 10 mL of milk is taken in test tube and 5 mL of conc. sulphuric acid is added on the sides of the test tube without shaking. If a violet or blue ring appears at the intersection of the two layers then it shows the presence of formalin.

Sucrose: About 10 mL of milk is taken in a test tube and 5 mL of hydrochloric acid is added along with 0.1 g of resorcinol. Then the test tube is shaken well and is placed in a boiling water bath for 5 min. Appearance of red colour indicates the presence of added sugar in milk.

Starch: About 3 mL milk is taken in a test tube and boiled thoroughly. Then milk is cooled to room temperature and added with 2-3 drops of 1% iodine solution. Change of colour to blue indicates that the milk is adulterated with starch.

Glucose: About 3 mL of milk is taken in a test tube and 3 mL Barford's reagent is added and mixed thoroughly. Then it is kept in a boiling water bath for 3 min and then cooled for 2 min by immersing in tap water without disturbance. Then 1 mL of phosphomolybdic acid is added and shaken. If blue colour is visible then glucose is present in the milk sample.

Salt: About 5 mL of silver nitrate (0.8%) is taken in a test tube and added with 2-3 drops of 1% potassium dichromate and 1 mL of milk and thoroughly mixed. If the contents of the test tube turn yellow in colour then milk contains salt in it. If it is chocolate coloured then the milk is free from salt.

Bacteriological analysis: Standard Plate Count (SPC) method recommended for dairy products (Eaton *et al.*, 1960) was followed for quantitative analysis of bacteria. For obtaining single colony isolate, the method described by Sharp and Lyles (1969) was followed.

Morphologically, dissimilar well-spaced colonies were picked up with the help of a sterile loop from the plates which had from 30-300 colonies. Each colony was streaked on to freshly prepared plates of the same media and incubated at 37°C for ≥24 h.

After incubation, typical pure colonies were taken as isolates. The selected isolates were then purified through repeated streak plating. When plating produced only one type of colony in a particular plate, it was considered to be pure.

The purified isolates were then transferred to nutrient agar slant in one drum screw capped culture vial and preserved as stock culture. Identification was done up to genus by following the Bergey's manual of determinative bacteriology (Buchanan and Gibbons, 1974). For identification, different morphological characteristics including shape, size, form, texture, opacity, edge, elevation of the isolated colonies were studied carefully and after gram staining, microscopic examination was carried out. The biochemical tests performed were Catalase test, Oxidase test, Methyl-red test (MR test), Voges-proskauer test (VP test), production of hydrogen sulphide (KIA test), hydrolysis of starch and fermentation tests.

RESULTS AND DISCUSSION

Chemical composition: The percentage of water, Total Soluble Solids (TSS), fat, Solids Non-fat (SNF), lactose, protein and ash has been showed in Table 2. From the Table 2, it follows that five (R-2 to R-6) of the six raw milks contained >90% water which is above the usual range 84.0-89.0% (Eckles *et al.*, 1951) suggesting that water had been added to these samples. Among the heat-treated milk, only P-7 contained high percentage of water (90.83%). Addition of water dilutes milk reducing its TSS content. Reduced TSS was observed in five raw (R-2 to R-6) and one pasteurized (P-7) milk; none of these samples had TSS over 9.5% though milk TSS usually ranges from 10.5-14.5% (O'Mahony, 1988). The UHT-milks were comparatively rich in TSS content each having at least 11.0% TSS (Table 2). Commercially, the fat of milk is

Table 2: Chemical composition of the samples

Samples	Percentage of constituents						
	Water	TSS	Fat	SNF	Lactose	Protein	Ash
R-1	89.00	11.00	3.75	7.25	4.83	3.57	0.80
R-2	91.00	9.00	3.15	5.85	4.30	3.16	0.70
R-3	91.00	9.00	3.18	5.82	4.14	3.07	0.74
R-4	90.50	9.50	3.41	6.09	4.21	3.20	0.72
R-5	90.73	9.27	3.30	5.97	4.53	3.26	0.74
R-6	90.77	9.23	3.12	6.11	4.10	3.30	0.69
BSTI std. for pasteurized milk			3.50	8.00	4.40	3.30	0.70
P-7	90.83	9.17	3.34	5.83	4.65	3.35	0.64
P-8	89.00	11.00	3.40	7.60	4.82	3.49	0.67
P-9	89.17	10.83	3.72	7.11	4.78	3.51	0.71
U-10	88.00	12.00	3.62	8.38	4.97	3.68	0.75
U-11	88.00	12.00	3.44	8.56	4.80	3.52	0.75
U-12	89.00	11.00	3.09	7.91	4.88	3.43	0.69

R = Raw milk; P = Pasteurized milk; U = UHT-treated milk; BSTI = Bangladesh Standards and Testing Institution; TSS = Total Soluble Solids; SNF = Solids Non-fat

without question the most valuable constituent of milk. Milk having a fair amount of fat is more valuable as a food than milk which is poor in fat. The Food and Drug Administration (FDA) requires not <3.25% milk fat for fluid whole milk. The US Public Health Service (USPHS) milk ordinance and code also recommended a minimum of 3.25% butterfat in farm milk (Graf, 1976). However in this study, three of the raw milks (R-2, R -3 and R-6) contained <3.25% fat.

The other three (R-1, R -4 and R-5) however, satisfied the criterion each having at least 3.3% fat. The BSTI (2002) requirement for fat content of pasteurized milk is a minimum of 3.5% which is fulfilled by only one (P-9) of the three pasteurized milks. The other two (P-7 and P-8) had fat contents of 3.34 and 3.4%, respectively. The fat content of U-12, one of the UHT-processed milks was even less (3.09%). Data have been showed in Table 2. FDA standard for SNF content of whole milk is a minimum of 8.25% (Graf, 1976). None of the raw milks maintained this standard. Five of these even contained SNF of <6.5% indicating that these might have been adulterated with addition of water.

The pasteurized milks also failed to maintain the minimum SNF requirement set by BSTI (2002) which is 8.0%. Two (P-8 and P-9) of these had SNF values of >7% whereas, SNF of the other (P-7) was exceptionally low, 5.83%. In case of the UHT processed milk, two (U-11 and U-12) had SNF contents of >8.0% whereas SNF of the other (U-10) was near to 8.0% (Table 2). The percentage of lactose of most of the raw milks was around 4.25% similar to that found by Lingathurai *et al.* (2009). The lactose content of milk though can range from 3.6-5.5% (O'Mahony, 1988). The specifications for pasteurized milk, established by BSTI (2002) require at least 4.4% lactose in milk. All the three pasteurized milks fulfilled the requirement. The lactose content of the UHT-milks was even higher, around 4.9%, the highest being 4.97% obtained in U-10 (Table 2). The protein content of the raw milks varied from 3.07-3.57%. Lingathurai *et al.* (2009) found slightly higher (3.77%) protein content. The three pasteurized milks were of fair quality regarding standard protein content specified by BSTI (2002) to be not below 3.3%. All the pasteurized milks satisfied this requirement each having a protein content of no <3.35%. The UHT-milks were also of good quality regarding protein content each having at least 3.4% of protein (Table 2).

It was interesting to find that the raw milks though inferior in the fat, sugar and protein contents in most cases had minerals greater than the pasteurized milks. The ash content of the raw milks varied from 0.69-0.8% which falls within the usual range of 0.6-0.9% (O'Mahony, 1988).

Table 3: Titratable acidity of the samples

Samples	Titratable acidity (lactic acid (%))	BSTI std. for pasteurized milk	Max. 0.150
R-1	0.216	P-7	0.144
R-2	0.180	P-8	0.162
R-3	0.200	P-9	0.162
R-4	0.171	U-10	0.189
R-5	0.135	U-11	0.144
R-6	0.162	U-12	0.175

But it is higher than that (0.33-0.69%) found by Elmagli and El-Zubeir (2006). Ash content of the pasteurized milks ranged from 0.64-0.71% whereas BSTI (2002) demands at least 0.7% of ash for the pasteurized milk. On the other hand, two of the UHT-milks (U-11 and U-12) were quite rich in the mineral content each containing 0.75% of ash (Table 2).

Acidity: The titratable acidity of the samples has been showed in Table 3. Titratable acidity is a measure of freshness and bacterial activity in milk. Popescu and Angel (2009) reported that high quality milk has to have <0.14% acidity. The acidity of the raw milk samples varied largely from one sample to another. The highest value was 0.216 % (R-1) indicating high bacterial activity and the lowest was 0.135% (R-5) indicating it is relatively better quality regarding freshness. The acidity of the pasteurized milks ranged from 0.144-0.162% where BSTI (2002) allows a max. acidity of 0.15% for the pasteurized milks. Elmagli and El-Zubeir (2006) got a greater range of acidity (0.14-0.86%) in pasteurized milks. No bacteria were found in the UHT-milks U-10 and U-12 but both these showed high degree of titratable acidity (0.189 and 0.175%, respectively) suggesting that the high acidity might have developed prior to the heat treatment.

Adulteration: Results for the presence of adulterants are shown in Table 4. No neutralizer, preservative, added sugar, glucose, starch or salt was found in raw milks. Five (R-2 to R-6) of the raw milks however had been adulterated by the addition of water which is very common in Bangladesh, particularly in case of raw milk. Addition of water reduces the amount of total solids in milk and it also involves the danger of introducing germs into milk including the pathogenic ones. Water had also been added in one (P-7) of the pasteurized milks. The other adulterant detected was added sugar (sucrose) which was found in five (P-7, P-8, U-10 to U-12) of the six processed milks (Table 4).

Bacterial distribution: The results of bacterial distribution in the samples are showed in Table 5. All the raw milks had high bacterial load which ranged from 1.75×10^6 - 1.22×10^8 cfu mL^{-1}. The most frequent cause of

Table 4: Presence of adulterants

Samples	Added water	Neutralizer	Formalin	Sucrose	Starch	Glucose	Salt
R-1	-	-	-	-	-	-	-
R-2	+	-	-	-	-	-	-
R-3	+	-	-	-	-	-	-
R-4	+	-	-	-	-	-	-
R-5	+	-	-	-	-	-	-
R-6	+	-	-	-	-	-	-
P-7	+	-	-	+	-	-	-
P-8	-	-	-	+	-	-	-
P-9	-	-	-	-	-	-	-
U-10	-	-	-	+	-	-	-
U-11	-	-	-	+	-	-	-
U-12	-	-	-	+	-	-	-

+ = Present, - = Absent

Table 5: Distribution of bacteria

Samples	TVBC	TCC	TFCC	TSC	TSSC	TAHC	TPBC
				(cfu mL^{-1})			
R-1	1.22×10^8	1.36×10^6	3.3×10^5	2.84×10^5	1.4×10^5	1.63×10^7	2×10^5
R-2	3.3×10^7	5×10^5	9.5×10^4	1.45×10^5	2.9×10^5	6×10^4	9.2×10^4
R-3	1.75×10^6	4.5×10^3	3.8×10^3	1.2×10^5	Nil	Nil	1.6×10^4
R-4	2.9×10^7	5.4×10^5	1×10^5	1.48×10^6	Nil	Nil	1.98×10^4
R-5	6.1×10^7	3.6×10^5	Nil	1.54×10^5	Nil	Nil	1.02×10^5
R-6	2.4×10^7	2.03×10^6	4.8×10^5	5.7×10^4	5.9×10^5	4.4×10^5	2.08×10^4
BSTI std. for pasteurized milk	Maximum 2×10^4	<10	-	-	-	-	-
P-7	7.5×10^7	3.7×10^4	5.5×10^3	1.4×10^3	6.1×10^4	Nil	4.9×10^3
P-8	8.3×10^7	Nil	Nil	1.6×10^3	Nil	Nil	4×10^2
P-9	1.24×10^8	1.2×10^6	1×10^4	8.1×10^4	1.2×10^6	Nil	1.87×10^4
U-10	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U-11	Nil	Nil	Nil	Nil	Nil	Nil	Nil
U-12	Nil	Nil	Nil	Nil	Nil	Nil	Nil

TVBC = Total Viable Bacterial Count, TCC = Total Coliform Count, TFCC = Total Fecal Coliform Count, TSC =Total Staphylococcal Count, TAHC = Total *Aeromonas hydrophila* Count, TSSC = Total Salmonella and Shigella Count, TPBC = Total Psychrophilic Bacterial Count

high bacterial load is poor cleaning of the milking system. Bacterial count is elevated by milking dirty udders, maintaining an unclean milking and housing environment and failing to rapidly cool milk to less than 40°F. The TVBC (Total Viable Bacterial Count) of the pasteurized milk samples ranged from 7.5×10^7 -1.24×10^8 cfu mL^{-1}, much higher than that recommended by BSTI and USPHS, i.e., not exceeding 20,000 cfu mL^{-1} (BSTI, 2002; Jay, 2003). The reason for high bacterial count in the pasteurized milks may include defective pasteurization machinery, survival of pasteurization and post-pasteurized contamination such as poor processing and handling conditions and/or poor worker hygiene. However, TVBC of each of the UHT-processed milks was nil, indicating their excellent sanitary quality (Table 5).

Coliforms are considered as indicator organisms because their presence in food indicates some form of contamination. Coliform count in the raw milks ranged from 4.5×10^3-2.03×10^6 cfu mL^{-1}. These results are higher than that obtained by Saitanu *et al.* (1996) who found TCC (Total Coliform Count) of <1000 cfu mL^{-1}. However, TCC obtained in the study of Srairi *et al.* (2006) varied from <30-2.08×10^7 cfu mL^{-1} in raw milk. Poor herd hygiene, contaminated water, unsanitary milking practices and improperly washed and maintained equipment can all lead

to elevated coliform counts in raw milk (CDFA, 2008). Pasteurized milk P-8 did not contain any coliform whereas TCC of the other two pasteurized milks were 3.7×10^4 and 1.2×10^6 cfu mL^{-1} though the standard has been set by BSTI (2002) at <10 colonies mL^{-1}. USPHS allows not over 10 colonies for grade A pasteurized milk (Jay, 2003). Coliforms do not survive pasteurization (CDFA, 2008). So, their presence in the pasteurized milks indicates recontamination after pasteurization.

The UHT-milks were completely free from any coliform (Table 5). Among the raw and pasteurized milks, two samples, R-5 and P-8 did not have any fecal coliform but others showed quite high count, higher than that found by Srairi *et al.* (2006) in the raw milk of some dairy farms in Morocco. The fecal coliforms are more closely related to fecal contamination than are the total coliforms. The organisms can originate from improperly sanitized wording surfaces in a processing plant. In these cases, their presence would reflect the quality of sanitation and not the direct pollution of the product (Banwart, 2004). The UHT-milks did not contain any fecal coliform (Table 5).

A large percentage of all cases reported as food poisoning or food infection is actually Staphylococcus poisoning and many people encounter this illness during

their lifetime. The staphylococcal food intoxication accounted for >17% of all the outbreaks and almost 34% of the cases of reported foodborne illnesses in the United States in 1981 (Frazier and Westhoff, 2005; Banwart, 2004). In this study, Staphylococcus was found in all of the raw and pasteurized milks but not found in the UHT-milk.

TSC (Total Staphylococcal Count) in the raw milks ranged from 5.7×10^4-1.48×10^6 cfu mL^{-1}. These counts are less than the findings of Ghose and Maharajan (2002) where the mean staphylococcal counts were 4.7×10^6 cfu mL^{-1} in raw milk but higher than that of Srairi *et al.* (2006) where TSC ranged from <30-10820 cfu mL^{-1}. In the pasteurized milks TSC ranged from 1.4×10^3 to 8.1×10^4 cfu mL^{-1} (Table 5). The UHT-milks, three raw milks (R-3 to R-5) and one pasteurized milk (P-8) did not show TSSC (Total Salmonella and Shigella Count). However in the remaining three raw milks, TSSC varied from 1.4×10^5 to 5.9×10^5 cfu mL^{-1}. P-7 and P-9 also showed high TSSC (Table 5).

The salmonellae are said to be ubiquitous being worldwide and found in or on soil, water, sewage, animals, humans, processing equipment, feed and various food products (Banwart, 2004). Ghose and Maharajan (2002) did not obtain any Salmonella or Shigella in raw milks in their study on microbiological quality of milk, vegetables and fruit juices. Members of Salmonella are potentially pathogenic for humans. The transmission of the disease is usually from animals to humans by ingestion of food of animal origin. Raw milk has been the vehicle for Salmonellae causing salmonellosis throughout the world whereas a widespread outbreak in 1985, affecting >16,000 people in several states, involved pasteurized milk. This incident should make us aware that pasteurization systems and proper procedures for handling pasteurized milk are needed to prevent salmonellosis and perhaps other illnesses (Banwart, 2004).

Three of the six raw milks (R-1, R-2 and R-6) contained *A. hydrophila* with the total count ranging from 6×10^4 to 1.63×10^7 cfu mL^{-1} (Table 5). These bacteria might have come from water since water is the main habitat of Aeromonas (Banwart, 2004). *Aeromonas* ssp. are often introduced from water which is thought to be the main source of contamination (Bizani and Brandelli, 2001). The isolation of Aeromonas from raw milk has been reported by Khalil (1997). Korashy (2006) also reported the presence of Aeromonas in raw and pasteurized milks. In this study, however the pasteurized and UHT-processed milks did not contain any *A. hydrophila*. Fourteen species of Aeromonas have been described, five of which including *A. hydrophila* are currently recognized as human pathogens (Janda and Abbott, 1998).

TPBC (Total Psychrophilic Bacterial Count) of raw milks varied from 1.6×10^4-2×10^5 cfu mL^{-1} and that of the pasteurized milks ranged from 4×10^2-1.87×10^4 cfu mL^{-1}. The UHT-milks did not possess any psychrophiles as usual (Table 5). Presence of psychrotrophs in the pasteurized milks indicates post-pasteurization contamination. Psychrotrophs are becoming increasingly dangerous to the dairy industry because they produce extracellular heat-resistant lipases and proteases. Milk altered by the activity of these enzymatic systems is depreciated and must be eliminated from processing. TPBC is used as a supplementary indicator of milk quality. Data on TPBC are required by some dairies because of specific technological requirements and quality-dependent payment for raw milk supplies. The current EU standards for top quality milk require that TPBC shall not exceed 5,000 cfu mL (Cempirkova, 2002).

CONCLUSION

In essence, the UHT-treated milks were of excellent quality but quality of the raw and pasteurized milks, particularly the sanitary quality was very poor. The government therefore should conduct frequent inspection of the marketed milks to check whether they meet the minimum legal standards and should monitor the overall hygienic condition surrounding the production and handling of milk. Realistic standards for the raw milks need to be devised and appropriate training should be given to the raw milk producers in hygienic handling of milk.

REFERENCES

BSTI, 2002. BDS 1702: 2002, Bangladesh standard: Specification for pasteurized milk. Bangladesh Standards and Testing Institution, Tejgaon Industrial Area, Dhaka, pp: 2-3.

Banwart, G.J., 2004. Basic Food Microbiology. 2nd Edn., CBS Publishers and Distributors, New Delhi.

Barthel, C., 1910. Methods Used in the Examination of Milk and Dairy Products. Macmillan and Co. Ltd., St. Martin's Street, London, pp: 260.

Bizani, D. and A. Brandelli, 2001. Antimicrobial susceptibility, hemolysis and hemagglutination among *Aeromonas* spp. isolated from water of a bovine abattoir. Braz. J. Microbiol., 32: 334-339.

Buchanan, R.E. and N.E. Gibbons, 1974. Bergey's Manual of Determinative Bacteriology. 8th Edn., Williams and Wilkins Co., Baltimore, MA, USA.

CDFA, 2008. New Coliform standard for milk sold raw to consumers. California Department of Food and Agriculture.

Cempirkova, R., 2002. Psychrotrophic vs. total bacterial counts in bulk milk samples. Vet. Med. Czech, 47: 227-233.

Cousin, M.A., 1982. Presence and activity of psychrotrophic microorganisms in milk and dairy products. J. Food Protein, 45: 172-207.

Crampton, E.W. and L.E. Harris, 1969. Applied Animal Nutrition. 2nd Edn., W.H. Freeman, San Francisco, pp: 753.

Eaton, A.E., L.S. Clesceri and A.E. Greenberg, 1960. Standard Methods for the Examination of Water and WasteWater. American Public Health Association, USA.

Eckles, C.H., W.B. Combss and H. Macy, 1951. Milk and Milk Products. 4th Edn., McGrow-Hill Book Co. Inc., New York, pp: 48.

Elmagli, A.A.O. and I.E.M. El-Zubeir, 2006. Study on the compositional quality of pasteurized milk in khartoum state (Sudan). Int. J. Dairy Sci., 1: 12-20.

Ensminger, M.E., A.H. Ensminger, J.E. Konlande and J.R. Robson, 1994. Foods and Nutrition Encyclopedia. Vol. 1, 2nd Edn., CRS Press, Boca Raton, Florida, pp: 2415.

Frazier, W.C. and D.C. Westhoff, 2005. Food Microbiology. 4th Edn., Tata McGraw-Hill Publishing Co. Ltd., New Delhi, pp: 417.

Ghose, A.K. and K.L. Maharajan, 2002. Milk Marketing Channels in Bangladesh: A case study of three villages from 3 districts. J. Int. Dev. Cooperat., 8: 87-101.

Graf, T.F., 1976. Market Implications of Changing Fat Content of Milk and Dairy Products. In: Fat Content and Composition of Animal Products, BARR, CNR, FNB, ALS and NRC (Eds.). National Academies Press, USA., pp: 189-190.

Heinemann, P.G., 1919. Milk. W.B. Saunders Co., Philadelphia, pp: 674.

Janda, J.M. and S.L. Abbott, 1998. Evolving concepts regarding the genus Aeromonas: An expanding Panorama of species, disease presentations and unanswered questions. Clin. Infect. Dis., 27: 332-344.

Jay, J.M., 2003. Modern Food Microbiology. 4th Edn., CBS Publishers and Distributors, New Delhi, pp: 447.

Joslyn, M.A., 1970. Methods in Food Analysis. 2nd Ed., Academic Press, New York, pp: 845.

Khalil, N.G., 1997. Incidence of *Aeromonas hydrophila* group in raw milk and some dairy products in Assiut City. Assiut Vet. Med. J., 37: 100-100.

Khan, M.T.G., M.A. Zinnah, M.P. Siddique, M.H.A. Rashid, M.A. Islam and K.A. Choudhury, 2008. Physical and microbial qualities of raw milk collected from Bangladesh agricultural university dairy farm and the surrounding villages. Bangl. J. Vet. Med., 6: 217-221.

Kim, H., J. Hardy, G. Novak, J.P. Ramet and F. Weber, 1983. Off-tastes in raw and reconstituted milk. FAO Animal Production and Health Paper 35, Vol. 35, Food and Agriculture Organization of the United Nations, Rome.

Korashy, N.T., 2006. A study on mesophilic *Aeromonas* in milk and some milk products in Port Said City. J. Applied Sci. Res., 2: 1037-1041.

Lampert, L.M., 1947. Milk and Dairy Products: Their Composition, Food Value, Chemistry, Bacteriology and Processing. Chemical Publishing Co., Brooklyn, New York, pp: 291.

Lingathurai, S., P. Vellathurai, S.E. Vendan and A.A.P. Anand, 2009. A comparative study on the microbiological and chemical composition of cow milk from different locations in Madurai, Tamil Nadu. Indian J. Sci. Technol., 2: 51-54.

OECD, 2005. Dairy Policy Reform and Trade Liberalization. Organisation for Economic Co-Operation and Development Publishing, Paris, France, pp: 165.

Oliver, S.P., B.M. Jayarao and R.A. Almeida, 2005. Foodborne pathogens in milk and the dairy farm environment: Food safety and public health implications. Foodborne Pathog. Dis., 2: 115-129.

O'Mahony, F., 1988. Rural Dairy Technology: Experiences in Ethiopia. ILRI (aka ILCA and ILRAD), Addis Ababa, Ethiopia, ISBN-13: 9789290530923, pp: 64.

Popescu, A. and E. Angel, 2009. Analysis of milk quality and its importance for milk processors. Lucrari Stiintifice Zootehnie Si Biotehnologii, 42: 501-503.

Saitanu, I.A., K.R. Chuanchuen, S. Nuanuarsuwan, C. Koowatananukul and V. Rugkhaw, 1996. Microbiological quality of raw cow milk. Thai J. Vet. Med., 26: 193-214.

Sharp, M.S. and S.T. Lyles, 1969. Laboratory Instructions in Biology of Microorganisms. Mosby, St. Louis, Missouri, pp: 558.

Srairi, M.T., J. Moudnib, L. Rahho and A. Hamama, 2006. How do milking conditions affect the hygienic quality of raw milk? Case study from Moroccan dairy farms. Livest. Res. Rural Dev., Vol. 18.