



Bacteriological Quality Assessment of Milk in College of Veterinary Medicine (Cvm) Dairy Farm and Kalamino Dairy Farm in Mekelle, Tigray, Ethiopia



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Abstract

Milk is an important source of nutrients to human and animals, but due to its high-water activity and nutritional value, it serves as an excellent medium for growth of many kinds of microorganisms under suitable conditions. The present cross-sectional study was conducted to assess hygienic practices, determination of bacterial quality of milk and isolation and identification of bacterial pathogens in milk at each critical control point throughout the value chain in MU-CVM and Kalamino dairy farms in Mekelle from August to November 2017. A total of 40 respondents were interviewed and subsequently, 84 milk samples were collected for laboratory analysis including bacterial load assessment and isolation and identification of bacteria. Total bacterial plate counts from milk were conducted. Isolation and identification of the bacteria in the milk was also conducted following standard methods. Results showed that, attendants of study dairy farms, managing their cattle in moderate hygienic environments and practicing intensive farming system.

The mean total bacterial plate counts of raw milk samples analyzed were 2.15x10⁸ cfu/ml (udder), 3.4x10⁸ cfu/ml (storage area in the farm) and 5.96x10⁸cfu/ml (distribution center milk container). The increment of both counts at each critical control points was observed statistically significant (P=0.000). However, there was no significant variation between the two farms (P= 0.074) in the mean total bacterial count. About 26.7%, 50% and 62.5% from teat, storage area in the farm and distribution center milk containers, respectively at MU-CVM and 40.9% from the teat, 62.5% from milk storage area and 75% from distribution center milk containers, respectively at Kalamino dairy farm were graded of poor quality. In the course of this study, the frequent bacterial pathogens isolated from raw milk samples taken from different critical points include: *E. coli*, *S. aureus* and *Streptococcus spp.* From the result there were hygienic practices in the study farms, but the quality of milk used for human consumption area was found inferior quality according the standard level. Thus, it is important practice proper and restricts hygienic practices, proper transportation and storage and reducing the milk storage time, raising the awareness of dairy workers to enhance the quality of milk used for human consumption.

Keywords: Bacterial load; Bacterial isolation; Critical control point; Dairy farms; Milk

Abbreviations: TDA: Tigray Development Association; TMTc: Too Many To Count; TFTc: Too Few To Count; NSS: Normal Saline Solution; TBPC: Total Bacterial Plate Counts

Introduction

Cow milk has long been considered a highly nutritious and valuable human food and it is consumed by millions daily in a variety of different products [1]. Raw milk of good hygienic quality meets the nutritional needs of body better than any single food as it contains essential food constituents such as fat, proteins, carbohydrates, minerals and vitamins [2]. As a result of the presence of these nutritional components, milk is an excellent culture medium for many microorganisms, especially bacterial pathogens [3]. Milk is often prone to early contamination and spoilage if not handled properly [4].

Microorganisms present in milk can be classified into two main groups: pathogenic and spoilage organisms, although some may play a dual role for example *Bacillus cereus*. Pathogenic

organisms are those capable of inducing food poisoning, thus posing a threat to public health [5]. These pathogenic microbial contaminants in milk have been a major factor for public health concern since the early days of dairy industry [6]. There is a constant challenge to those involved in milk production to prevent or minimize the entry and subsequent growth of microorganisms in milk [7]. These is mainly due to the importance of producing milk of good hygienic quality, which is necessary to milk product of superior quality and prolonged shelf-life thereby to provide a safe and wholesome food for the consumers [7]. Bacterial contamination can generally occur from three main sources; within the udder, outside the udder and from the surface of equipment used for milk handling and storage [8].

Once milk is secreted out of the udder of the cow, the retention of milk requires cleanliness, sanitation and cooling [9]. Fresh milk drawn from a healthy cow normally contains a low microbial load of less than 103cfu/ml [9]. However, the bacterial load may increase up to 100-fold or more if stored for sometimes at ambient (30 to 35°C) temperature [10]. Milk produced under hygienic conditions from healthy animals should not contain more than 1×10^5 cfu/ml.

Ethiopia possesses the largest livestock population in Africa. Estimates for farmer holding in rural areas indicate that the country has about 53.99 million heads of cattle, 24.6 million goats, 25.5 million sheep and 0.92 million camels [11]. In Ethiopia dairy production depends mainly on indigenous livestock genetic resources; more specifically on cattle, goats, camels and sheep. Cattle has the largest contribution (81.2%) of the total national annual milk output, followed by goats (7.9%), camels (6.3%) and sheep (4.6%).

While the industry is growing at a rapid rate, no milk quality standards currently exist, therefore, it is important to establish milk quality standards that focus on food safety measures in order to improve public health. This is one reason why milk testing and quality control include hygiene as well as microbial qualities in addition to testing for fat content and heat stability [12]. Prior to the discovery and widespread adoption of pasteurization for instance, raw milk and its products were responsible for serious bacterial infections such as diphtheria, scarlet fever and tuberculosis [13]. Consumers all over the world are increasingly concerned about the safety of their food in general and milk and milk products. Therefore, quality should not be ignored at all stages of the dairy value chain.

There is limited data on hygienic practices throughout the dairy production system in Ethiopia and standard milking procedures do not exist. A recent study in Ethiopia showed many farmers do not properly clean teats prior to milking. The study also showed a trend of farmers either not using a towel at all for disinfection or using a collective towel for two or more cows [14]. This practice can clearly lead to the spread of contagious pathogens. Raw milk is an important vehicle for the transmission of milk-borne pathogens to humans, as can be easily contaminated during milking and handling [15]. Poor or improper handling of milk can exert both a public health and economic constraints thus requiring hygienic vigilance throughout the milk value chain [16].

In some parts of the world including developing countries like Ethiopia, milk is still a significant source of these infections and other FBDs [17]. Consumption of raw milk and its derivatives is common in Ethiopia [18], which is not safe from consumer health point of view as it may lead to the transmission of various diseases. Raw or processed milk is a well know food medium that supports the growth of several microbes with resultant spoilage of the product or infections (intoxications) in consumers [19].

Even though milk represents an important place in the nutrition of consumers as well as nutrition and income of producers, there is limited work so far undertaken regarding assessment of bacteriological quality of raw cow milk in northern Ethiopia in general and dairy farms in the Mekelle particular. Determining the current status of bacteriological quality of milk at MU-CVM dairy farm and Kalamino dairy farm would create awareness on the bacterial safety in the milk and support for strengthening the hygienic standards practiced at different levels of the production chain. Thus, the present study is designed with the following objectives

- a. To evaluate the hygienic practices and sanitary standards at MU-CVM and Kalamino dairy farms.
- b. To determine the bacteriological quality of milk at the study dairy farms.
- c. To isolate major bacterial species from milk samples having high bacterial load.

Materials and Methods

Study Area

MU-CVM and Kalamino dairy farms are in southern part of Mekelle city Tigray region, 13032'N and 39033'E, and the city is 2200m above sea level. The climate is semi-arid with an average annual rain fall of 600mm/Hg and the temperature ranges between 12 to 27.1 °C.

Both farms are intensive dairy cows, MU-CVM dairy farm is owned by the College of Veterinary Medicine of Mekelle University and Kalamino dairy farm is owned by Tigray Development Association (TDA). MU-CVM farm was established in August 2009 with 11 cows of HF cross breed, in 2012 it was modernized. During this study period 110 cattle were in the farm of which 84 were exotic breeds and 2 cross-breeds, and 30 of them were lactating cows. Kalamino dairy farm was established in 1997(GC). On its establishment the farm has begun the project by 61 cross breed cows of HF and currently the farm has 87 HF cows, with 22 lactating cows.

Study Design

A cross-sectional study was conducted from August to November 2017, to assess the general sanitary conditions of milking areas in dairy farms and examine bacteriological quality of milk. The study involved MU-CVM and Kalamino dairy farms and study unit was lactating cows in these farms where questionnaires were administered, and raw cow milk was collected for bacteriological analysis.

Sample Size and Sampling Techniques

First, a pilot survey was made in order to gather information on lactating cows of study dairy farms, fifty-two lactating cows were identified in the study farms (30 in MU-CVM and 22 in Kalamino dairy farms). In the farms there was a different critical control points throughout the value chain, such as milk collecting

areas during milking. Both farms have milk distribution centers. The milk samples were collected from udder of all lactating cows, milk containers in the collection area and utensils of distribution center of farms. Thus, a total 84 samples (52 milk direct from teats in all lactating cow were taken, 16 (8 in each farm) from milk containers in collecting area immediately after milking and 16 (8 in each farm) from distribution sites immediately before distribution of milk samples were collected by random selection using sterile bottles. At all levels of sampling, the sampling bottles were capped, labeled with a permanent marker and transported to MU-CVM microbiology laboratory in an ice box, and stored at 4 °C. Culturing was conducted within 24 hours after sampling [20].

Questionnaire and Observational Survey

Structured questionnaire (Annex1) was used to collect information from workers of study dairy farms, such as animal health workers, individuals involved in milking as well as handlers of the milk. Twenty respondents in each farm were interviewed with pre-coded response choices (closed-ended questions). The questionnaires were designed to get information on possible risk factors for bacterial contaminations in milk. Risk factors considered in the current study were sanitary conditions of the barn/milking environment, hygiene of milking cows' udder and milk handlers, hygiene of milking equipment with special emphasis to hygiene of milking procedures and milk handling practices, milk containers used for milking, storage and transportation. The questionnaire was administered through face to face interview. While administering questionnaires, direct observation on general cleanliness and hygienic conditions and practices about milk were also done and noted.

Bacterial Load Assessment and Isolation

Total Bacterial Count

The total bacterial count was made by adding 1ml of sample into sterile test tube having 9ml normal saline solution (NSS). After thoroughly mixing, the sample was serially diluted up to 1:10-6 and 1:10-7 then duplicate samples (1ml) were pour plated using 15-20 ml standard plate count agar solution and mixed thoroughly. The plated sample could solidify and then incubated at 37 °C for 48 hours. Finally, counts were made using

a colony counter after incubation of the cultures at 37 °C for 48 hours. All colonies including those of pin point size were counted on selected plates using colony counter. Results from plates, which contained 30 to 300 colonies per plate were recorded. Plates with more than 300 colonies could not be counted and were designating as TMTC (too many to count) while plates with fewer than 30 colonies were designate as TFTC (too few to count). The plate counts were expressed as colony forming unit of the suspension (CFU/ml) [21] and the average for each sample were recorded as CFU/ml. Samples were graded as very good if the total bacterial count did not exceed 2x10⁵ CFU/ml, good if it was between 2x10⁵ and 1x10⁶ CFU/ml and fair if the count was between 1x10⁶ and 5x10⁶ CFU/ml. Samples having bacterial count above 5x10⁶ CFU/ml were graded as poor quality [22].

Bacterial Isolation

Milk samples that were graded as poor quality were considered for bacterial isolation and identification. Isolation and identification of bacterial species was carried out based on conventional culture technique and biochemical assays. After thorough mixing of each milk samples, a loop full of the milk sample was streaked on the blood agar base enriched with 7% sheep blood agar and MacConkey agar. Both agar plates were incubated at 37 °C and examined for bacterial growth after 48 hours and then bacterial colonies were identified. Pure culture colonies were selected and sub-cultured on nutrient agar (Oxoid UK) and incubated aerobically at 37 °C for 24 - 48 hours for biochemical testing. The identification of the bacterial species was performed using biochemical tests and culturing on selective media. All media were prepared according to the manufacturer's specification [23].

Data Analysis

The data was entered excel spread sheet and analyzed using SPSS version 16.0 a statistical software. Percentages were also used to express the proportion of bacterial isolation and milk quality grade based on Indian standards. The differences in bacterial load between the samples from dairy farm, milk distribution center, hands of milkers and surface milk containers were compared.

Results

Questionnaire and Observational Survey Result

Table 1: Hygienic activities related to milk in the selected farms.

Hygienic practices in the farms	MU-CVM dairy farm No= 20	Kalamino dairy farm No= 20
Water source for cleaning		
Pipe	100%	100%
Unprotected springs	0%	0%
Cleaning frequency in barn and cow		
Daily	15%	85%
Two times a day	80%	10%
Ones two days	5%	5%
Hands wash frequency in milking time		

Before starting of milking only	20%	60%
Before and after of every cow	80%	35%
Not wash	0%	0%
Wash udder and teats before milking		
Yes	90%	75%
No	10%	25%
Dry udder materials		
Collective towel	15%	15%
Individual towel	80%	75%
Hands	5%	5%
Utensils cleaning		
Water with detergent	50%	20%
Hot water	0%	10%
Normal water	50%	70%

The floor of both farms was constructed with concrete materials (cement) where it facilitates easy cleaning. About 80% of the respondents at MU-CVM farm indicated they clean the barn two times daily, while in Kalamino farm 85% reported that they clean one's day. Both farms use tap water for cleaning the farm (Table 1). In both farms milking is done manually twice a day. The study farms use aluminum container (buckets) during

milking while MU-CVM and Kalamino farms use 75% and 95% metal pots, respectively for storage and transportation. Most of the respondents practiced washing of their milk utensils daily; while MU-CVM However, the cleaning is moderate in both but not efficient and utensils are not well dried. It was observed that milkers dip their fingers in the milking vessel to moisten teats of the cows with the intention of facilitating milking (Table 2).

Table 2: Milking and milk management practices in the CVM and Kalamino dairy farms.

Milking and milk management	MU-CVM dairy farm N= 20	Kalamino dairy farm (No= 20)
Milking method		
Hands	100%	100%
Machine	0%	0%
Both	0%	0%
Milking frequency		
One's a day	0%	0%
Two times a day	100%	100%
Three times a day	0%	0%
Utensils for milking and transport		
Aluminum	75%	95%
Plastic	25%	5%
Milk storage		
Refrigerator	30%	30%
At room temperature	0%	20%
Distribute after milking	70%	50%
Mean of transportation		
Private car	60%	85%
Donkey	40%	0%
Horse cart	0%	15%

In the present study, majority of the respondents across the 2 farms wash their hands before milking, while around 80% of the millers at MU-CVM wash their hands before and after every cow milking, the rate of hand cleaning at Kalamino farm was 60%. About 90% and 75% of the respondents at MU-CVM and Kalamino farms respectively indicated washing udder before

milking. Generally, it was observed that the person involved in milking was not clean; also, the hygiene milking environments was moderate, although Kalamino farm was low hygiene than the MU-CVM farm and the utensils for milking and transportation were looked well in both, but there were the possibilities indicated for microbial contaminations of milk.

In both farms most of the milk was transported to their own milk distribution centers where their customers collect the milk. The milk distribution center of MU-CVM dairy farm is within the campus, but distribution centers of Kalamino dairy farm is in the down town of Mekelle city, therefore after milking takes time to reach the milk distribution center and there is opportunity increase of microbial contamination of milk.

Bacterial Load and Quality of Milk Samples

Total bacterial load: The mean for total bacterial plate counts (TBPC) of raw milk samples at three critical points

Table 3: Summary of bacterial counts presented as CFU/ml from milk samples.

Farms	Sample type	No of sample	Mean	Minimum count	Maximum count	p-value
MU-CVM	Teat	30	1.56x10 ⁸	1x10 ⁷	3.6x10 ⁸	<0.001
	SA	8	2.49x10 ⁸	9x10 ⁷	6.2x10 ⁸	
	DC	8	5x10 ⁸	2.9x10 ⁸	7.9x10 ⁸	
	Total	46	2.98x10 ⁸	1x10 ⁷	7.9x10 ⁸	
Kalamino	Udder	22	2.7x10 ⁸	4x10 ⁷	7.6x10 ⁸	<0.004
	Teat	8	4.06x10 ⁸	2.6x10 ⁸	5.6x10 ⁸	
	DC	8	6.9x10 ⁸	4.2x10 ⁸	1.08x10 ⁹	
	Total	38	4.4x10 ⁸	4x10 ⁸	1.08x10 ⁹	
MU-CVM		46	2.9 x10 ⁸	1x10 ⁷	7.9 x10 ⁸	<0.074
Kalamino		38	4.3 x10 ⁸	4x10 ⁷	1.08 x10 ⁹	
Total		84	3.7 x10 ⁸	1x10 ⁷	1.08 x10 ⁹	
CCPS	Teat	52	2.15x10 ⁸	1x10 ⁷	7.6x10 ⁸	<0.000
	SA	16	3.4x10 ⁸	9x10 ⁷	6.2x10 ⁸	
	DC	16	5.96x10 ⁸	2.9x10 ⁸	1.08x10 ⁹	
	Total	84	3.74x10 ⁸	1x10 ⁷	1.08x10 ⁹	

SA = Storage area in farm; DC = Distribution center in a farm; critical control points of sampling.

Likewise, TBPC increased by 2.56 x10⁸ CFU/ ml from milking bucket in storage area at the farm level to distribution center milk container. The increase from point of production to distribution center milk containers was 3.81x10⁸ CFU/ ml. There was a difference in mean of total bacterial count between the farms where 2.98x10⁸ and 4.4x10⁸ CFU/ml for milk samples collected from MU-CVM and Kalamino dairy farms, respectively. However, the difference was not statistically significant (p= 0.074), while analysis of variance indicated that there were statistically significant differences in total bacterial count (p< 0.001) between the critical points.

Quality of Milk Samples: Milk samples having total bacterial counts higher than acceptable level (2x10⁶CFU/mL) according to Sherikar [22] were considered as poor quality. Out of the total milk samples collected from MU-CVM dairy farm, 26.7%, 50% and 62.5% of the samples from direct cow's teat (udder), burkes in milk storage area and milk containers in distribution center, respectively were considered as poor quality while 40.9%, 62.5% and 75% milk samples collected from Kalamino dairy farm from direct cow's teat, buckets in milk storage area and milk containers at distribution center, respectively were graded as poor quality (Figure 1).

within the two farms are shown in Table 3. The overall mean TBC was 2.15x10⁸, 3.4x10⁸ and 5.96x10⁸ CFU/ml for milk samples collected directly from the udder, milking container in temporary storage area in the farm and milk containers in distribution centers, respectively. There was an increasing trend of total bacterial count as the milk passed through udder, milking storage area and distribution centers. Accordingly, the count increased by 1.25x10⁸ CFU/ ml from point of production (milk sampled directly from the teat) to milk samples taken from milking bucket in storage area at the farm.

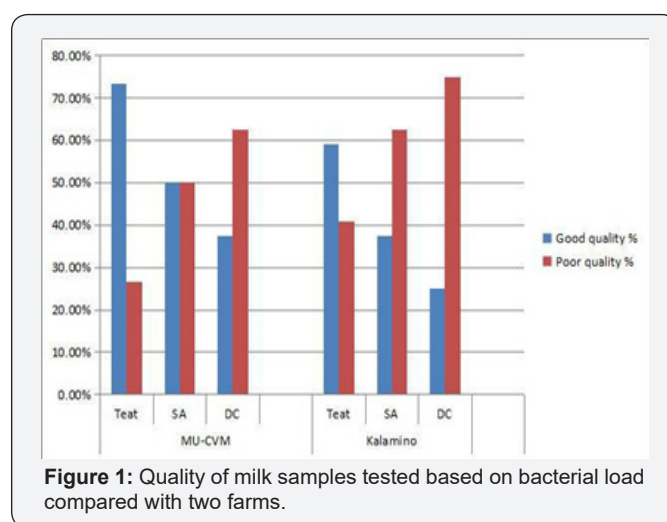


Figure 1: Quality of milk samples tested based on bacterial load compared with two farms.

Bacterial Isolation

The major bacteria isolated out of from milk samples having high bacterial load include *S. aureus*, *Staphylococcus* species other than *S. aureus* and *Streptococcus* species, *E. coli*, other coliform bacteria, *Salmonella*, *Klebsiella* and *Pseudomonas* (Table 4).

Table 4: Bacterial isolates from raw milk samples of different sources.

Bacterial species isolated	Milk source			Total Prevalence No. %
	Udder	SA	DC	
<i>S. aureus</i>	5	4	5	14 (27.45)
<i>Staphylococcus species other than S. aureus</i>	2	2	1	5 (9.8)
<i>Streptococcus species</i>	1	2	4	7 (13.7)
<i>E. coli</i>	1	4	4	9(17.6)
<i>Other coliform bacteria</i>	3	1	2	6(11.8)
<i>Salmonella</i>	-	1	2	3(5.9)
<i>Shigella</i>	1	1	-	2 (3.9)
<i>Pseudomonas</i>	1	1		2 (3.9)
Total	15	16	18	51

Discussion

The overall purpose of this study was to assess the hygienic condition and bacterial quality of raw cow milk in MU-CVM and Kalamino dairy farms in Mekelle. The result of questionnaire survey and observation in the study farms showed that milk was generally produced by dairy producers under moderate hygienic environmental condition. This study further revealed that both dairy farms managed their cattle in shaded cattle houses that are cleaned daily. Attendants try to clean environments but there are sources of milk contaminations. The present study also showed that most of the persons involved in milking activities were also not clean with their body and clothes during milking and milking utensils although better than traditional way, these possibilities predisposed milk to microbial contaminations at farm level.

It was further found that factors that were likely sources of microbial contamination in milk include hand milking in a same times dirty animal house, not washing udder and/or teats before and after milking with clean water and some milkers not drying the udder before milking. Most of the respondents (80%) clean the barn on daily basis by removing the feces except weekends. Similar finding was also reported in Sidama highlands of Southern Ethiopia [24].

Milking was also performed in the same place after cleaning. Although, the high proportion of dairy cows their barn floors, clean, dry and comfortable bedding condition is important to minimize the growth of pathogenic microorganisms. Practices that expose the teat end to these organic bedding sources, wet and muddy pens increase the risk of occurrence of mastitis and milk contamination [25]. Unless properly handled, milk can be contaminated by microorganisms at any point from production to consumption. Producers should therefore make udder washing a regular practice in order to minimize contamination and produce good quality milk. Most of the respondents who practiced udder and teat drying use towel (80% in CVM 75% in Kalamino). It was reported by [26], that pre-milking udder preparation and teat sanitation play important part in the microbial load of milk, infection with mastitis, and environmental contamination of raw

milk during milking. Cleaning the udder of cows before milking is important since it could have direct contact with the ground, urine, dung and feed refusals while resting. Lack of washing udder before milking can impart possible contaminants into the milk.

Production of milk of good hygienic quality for consumers requires good hygienic practices (clean milking utensils, washing milker's hands, washing the udder and use of individual towels) during milking and handling, before delivery to consumers or processors [27]. In the study area, most of the respondents practiced washing of their milk utensils. However, some of worker of study farms not uses detergents for cleaning and utensils are not properly dried. Surfaces such as milking equipment's and hands meeting milk if not clean enough may cause milk contaminations. During the current study, aluminum containers were the major utensils for collection and storage of milk. In such a situation, microorganisms can rapidly build up in potentially nutritious milk residues of storage containers consequently contaminating the milk on subsequent uses. Contrary observations were also reported by Shija [28], who observed high microbial load in milk which was correlated with narrow necked plastic containers used in handling of milk.

The increment of bacterial load could be attributed to contamination of the milk throughout the value chain from production by different environmental factors through different exposures of contamination like pooling of milk from different animals together with unhygienic handling and leaving the milk without cooling. In the present study highest bacterial load was in distribution center and followed by bulks in storage area and least bacterial load was from milk collected directly from cow's teats (udder). This result agreed with the report by Zewdu [24] in Sidama highlands of Southern Ethiopia and Farah [29] in Somalia who also reported an increase in bacterial counts through milk value chain showing the highest count from bulk milk of cow stored for 24 hrs. without cooling. After milk passed one critical control point to another (from udder to temporary storage area) due to interactions of milk handles, transfer of milk in different containers and multiple sources the milk contamination rate will rise. This was also evidenced in the present study.

The mean total plate bacterial counts from teat milk samples was lower than mean value reported by Alehegne [30]. Similarly, the mean value of total plate bacterial counts for milk samples taken from the milking bucket in temporary storage area at farm level (3.4×10^8 CFU/ml) were lower than that of previous reports for the same sample source [31]. The probable reason for the difference could be the use of aluminum containers which are easy to clean and better hygienic standards in the farms considered in the present study.

In general, present study is lower TPBC than majority of the previews study reported in Ethiopia due to improvement of hygiene on study farm and also these farms are generally proper milk hygiene and milking activities compared with reported

dairy farming systems in Ethiopia in previous studies, although mean of TPBC observed in the current study was higher than the maximum recommended level of 2.0×10^6 CFU/ml. That mean as observed during sampling, high TPBC obtained in the current study might be related to the overall sanitary conditions followed which causes bacterial contamination in a milk.

Out of the total milk samples collected from MU-CVM dairy farm, 26.7%, 50% and 62.5% of the samples from direct cow's teat (udder), burkes in milk storage area and milk containers in distribution center, respectively were considered as poor quality while 40.9%, 62.5% and 75% milk samples collected from Kalamino dairy farm from direct cow's teat (udder), buckets in milk storage area and milk containers at distribution center, respectively were graded as poor quality, similarly by Redda [32] poor quality milk in dairy farms, cafeterias and wholesalers in Adigrat town of Tigray region.

The most predominant bacteria isolated in the present study were *Staphylococcus spp.* (37.25%), *Streptococcus spp.* (13.7%), *Escherchia coli* (17.6%), other coliform bacteria spp. (11.8%), *Salmonella spp.* (5.9%), *Shigellas pp.* (3.9%) and *Pseudomonas spp.* (3.9%). These bacterial groups are the most common contaminants of raw milk and responsible for causing mastitis in dairy farms [33-36].

Conclusion and Recommendations

Milk intended for human consumption must be free from pathogens and must, if conditions permit, contain no or few bacteria. Clean milk could only be obtained if effective sanitary measures are taken starting from the point of milk withdrawn from the cow until it reaches the consumers [37]. From the findings of this study, it is concluded that; the milk produced by at MU-CVM and Kalamino dairy farms generally had higher TBPCs according to the international acceptable limits. Although, the mean TBPCs in the study farms were lower than previous reports, it calls for immediate action to improve the hygiene and sanitary measures at different critical points where milk could get contaminated. Majority of raw milk samples from distribution center containers for consumers had higher TBPCs, hence, its keeping quality would be lower and some of the pathogens present in the milk have public health significance.

Based on the findings of the present study, the following recommendations are made:

- a. Raising the awareness of farm workers on good hygiene and sanitary measures could significantly reduce the contamination level
- b. Ensuring proper transportation and storage of the milk, and reducing the milk storage time, at milk distribution centers should be considered.
- c. Routine assessment of milk quality by the farms should be performed on a regular basis to ensure the supply of good quality milk to consumers.

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