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Bacteriological Quality of Raw Camel Milk in Gursum District, Somali Regional State, Ethiopia

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Abstract: A cross-sectional study was carried out from November 2015 to April 2016 at three Kebeles in Gursum district (Bombas, Golehajo and Kobijaro), Fafan zone, Somali Regional State of Ethiopia to investigate the hygienic practices and bacteriological quality of raw camel milk at farm level and milk collection centers. The study employed total bacterial count, coliform count and questionnaire survey to evaluate the hygienic practices during milking. A total of 90 farm owners (30 from each Kebele) were interviewed. For total bacterial count and coliform count 15 milk samples from farms and 15 samples from milk collection centers for each Kebele were collected. A total of 90 milk samples were processed for TBC and CC. The overall means of total bacterial count and coliform count were 5.9 $\log^{10}$cfu/ml and 1.9 $\log^{10}$ cfu/ml respectively. The present finding showed that there was significant difference ($P<0.05$) in both total bacterial count and coliform count between farms and milk collection centers. The questionnaire survey indicated that total bacterial and coliform counts were both significantly associated with level of education, milker's sex, washing of hands and udder before milking, application of teat dips, smoking and type of milk containers. It can be concluded that the quality of camel milk in the study area is not up to the standard and awareness creation on good hygienic practices and clean milk production should be provided to camel milk producers.

Key words: Gursum · Camel · Milk · Coliform Count · Total Bacterial Count

INTRODUCTION

The estimated number of camel population in the world is around 22 million. Of this, 19.58 millions are believed to be one-humped camels (Camelus dromedarius) while the remaining 2.42 million are two-humped bacterian camels (Camelus *bactrianus*). Camels live in the vast pastoral areas in Africa and Asia. The genus Camelus dromedariesmainly lives in the desert areas (arid) and Bactrian camel (Camelus bactrianus) lives in the cooler areas. More than 60% of the dromedary camel population is found in the four North East African countries viz. Somalia, Sudan, Ethiopia and Kenya [1]. The annual worldwide camel milk production is estimated to be 1, 840, 201 tons. Out of which African countries produce 1, 656 thousand tons or 90% of the world total production. Ethiopia which possesses about two million camels ranks fourth in whole fresh camel production (170, 000 tones) in Africa next to Somalia (1, 100, 000 tones), Kenya (937, 000 tones) and Mali (242, 911 tones) [2].

Camel milk is one of the most valuable food resources for pastoral people in arid and semiarid areas and public health concern associated with microbial food safety has raised [3]. Numerous epidemiological reports proved that, non-heat treated milk and raw-milk products represent one of the major factors responsible for illnesses caused by food borne pathogens in pastoral communities [4]. Camel milk has been consumed for centuries by nomadic people for its nutritional value and medicinal properties. Currently, pasteurized camel milk is produced and sold only in a few countries including Saudi Arabia, United Arab Emirates, Kazakhstan, Mauritania and Algeria [5]. The pastoralist populations have long believed that raw camel's milk is safe and even has therapeutic virtues.

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Such empirical observation was scientifically substantiated by demonstrating the stronger antimicrobial activity of camel milk as compared to that of other animal species and its ability to inhibit Gram-positive and Gram-negative pathogens of concern to food safety. Nonetheless, in pastoral communities camel milk is produced in a traditional way and is usually collected, handled and transported in poor sanitary conditions [6].

Contamination of milk takes place during milking, from the udder, milking equipment, storage equipment or milking personnel. Furthermore, contamination occurs during transportation and storage of the milk. Under any of these conditions, microorganisms get into the milk and multiply [7].The microbial load of milk is determined by the distance between the farm and the consumers, the time lapsed during transportation of milk from the farm to the consumers and the temperature of milk during storage and transportation which gives bacteria the chance to adapt and grow in this nutritious liquid. Moreover, camel herds rarely benefit from veterinary care and, hence, mastitis is common among lactating females. Therefore, the milk produced is likely to cause food-borne diseases and the natural antimicrobial factors can only provide a limited protection against specific pathogens and for a short period of time. Such risk is higher when the milk is consumed in its raw state as is commonly practiced by the local producers [6].

Gursum district is an important camel milk producing area in eastern Ethiopia. Milk is produced from pastorally managed camels, under traditional conditions and camels are milked by hand. Large volumes of camel milk are produced in the district and sold daily in Gursum and Jigjiga city. However, the milk is not pasteurized, handled under poor hygienic conditions, transported long distance without a refrigeration system and sold on open markets or distributed to retailers. Thus, milk transported and handled under such conditions would have poor quality and may contain pathogenic microorganisms of public health concern.

There is no documented work undertaken so far to evaluate the microbiological quality of raw camel milk in Gursum district, which is essential source of milk for the capital city of the region. Hence, assessing the safety of camel milk along the value chain, that is, from primary production site until it reaches the final market is of paramount importance in order to devise appropriate intervention strategies aimed at improving the quality and safety of milk. Therefore, the objectives of the study were:

- To assess the bacteriological quality of raw camel milk along the value chain in Gursum district and
- To assess the hygienic level of raw camel milk in Gursum district

MATERIALS AND METHODS

Study Area: The study was conducted in Gursum districts of Fafan zone of Ethiopian Somali Regional State from November 2015 to April 2016. The district has a population of 93, 000 and the Rainfall in the study area is generally erratic and only takes place between June and September. Gursum district faces a long dry season from November to May. The altitude of the district ranges from 900-2, 400 meters above sea level and receives an annual rainfall of 500-700 mm with the mean minimum and maximum annual temperatures of 15°C and 23°C respectively. The community in this district is pastoral and agro-pastoral and there is a massive movement of camel population from one place to another place and large milk production from cows, camels and goats. The camel production system in the district is almost all traditional extensive system and the mean daily camel milk production per household in early lactation is 43.9 liters. Most milk in the district is sold down the producer – wholesaler – retailer – consumer channel, followed by the producer – milk cooperative –exporter route. Bush markets, local markets and terminal markets are the major camel milk marketing centers in the district [8].

Study Design: A cross-sectional study type was conducted from November 2015 –April 2016.

Sampling Technique and Sample Size: Gursum was selected purposively from other districts in Fafan zone due to its potential in camel milk production. A total of three potential Kebeles, namely Bombass, Golehajo and Kobijaro, were selected purposively from10 center Kebeles in Gursum district due to their high potential in camel milk production and the common practice of marketing camel milk. Using simple random sampling (lottery method), a total of 90 milk samples were collected for bacteriological quality analysis (30 samples from each Kebele). In each Kebele 15 samples from households and 15 samples from milk collection centers were collected. Approximately 25ml samples from each center Kebele were collected by using sterile bottles and the samples were transported to Jigjiga University Veterinary Microbiology Laboratory by using an insulated ice box.

Questionnaire Survey: The hygienic and sanitary practices of the householders have been evaluated by administering structured questionnaire. A total of 30 households who own female camels were interviewed from each Kebele.50% of those interviewed were owners of lactating camels of which their milk was collected for bacteriological analysis.

Bacteriological Quality Analysis: For the bacteriological quality analysis, total bacterial count (TBC) and coliform count were performed.

Total Bacterial Count: 1ml of Milk samples were diluted in 9ml of peptone water and mixed thoroughly. After preparation of serial dilutions, volumes (1 mL) of appropriate dilutions was plated by the pour plate technique in duplicate using standard plate count agar, Colonies were counted after the culture media is incubated at 37°C for 48 hours [9].

Coliform Count: Volumes (1 mL) of appropriate dilutions were plated by the pour plate technique in duplicate using Violet Red Bile Agar, After solidification of the mixture, a covering layer of the VRBG agar was added onto petri dishes to prevent spreading growth and to achieve semi-anaerobic conditions and then allowed to solidify again and the plates were incubated at 30°C for 24 hours. Pink colonies surrounded by bile precipitation were counted as coliforms [9].

Data Management and Analysis: The data were entered and managed in a Microsoft Excel spreadsheet and analyzed using STATA version 20. For TBC and CC, the results were converted to log ^{10}cfu/ml and Mean+ SE was compared between farms and milk collection centers for significance difference.

RESULTS

Questionnaire survey The questionnaire survey result showed that most respondents were illiterate (82 %). All the farmers practiced traditional extensive system and all of them apply hand milking. In most of the farms (67 %) milking is practiced by females. The majority of respondents (67 %) said they wash their hands before milking, wash udder and teats before milking and use only water for washing. Few respondents (4%) claimed they applied teat dips and 24 % of the respondents said they wash their hands in between milking's. With regard to milking containers, majority of the study farms (67 %) used plastic containers and 33 % used aluminum cans. Almost all farms (96 %) practiced smoking of milking containers (Table 1 & Table 2).

The total bacterial count in the study area was found to be significantly associated ($p<0.05$) with sex of milkers, hand washing before milking, hand washing in between milking, washing teat and udder before milking, application of teat dips, type of milk storage containers and smoking of milk containers (Table 1). Similarly coliform count is significantly associated with all the above factors except sex of milkers and smoking of milk storage containers (Table 2).

Bacteriological Quality of Camel Milk: Total bacteria count (TBC) The total bacteria count ($\log_{10}$ cfu/ml) at farm level was higher in Kobjaro (6.2 ± 0.765) followed by Golehajo (5.7 ± 0.54) and Bomabas (4.9 ± 0.786). For collection centers, the TBC was highest in Kobjaro followed by Golehajo and Bomabas with results of 6.7 ± 0.629, 6.4 ± 0.725 and 5.8 ± 0.606, respectively. In all three Kebeles, there was significant difference ($p<0.05$) in TBC between milk collected from farms and milk collection centers (Table 3).

Coliform count (CC) The coliform count ($\log_{10}$ cfu/ml) at farm level was higher in Golehajo (1.7 ± 0.158) followed by Kobijaro (1.3 ± 0.349) and Bomabas (1.3 ± 0.349). For collection centers, the CC showed similar trend with 2.0 ± 0.0.44, 1.9 ± 0.56 and 1.7 ± 0.319, respectively. In all three Kebeles, there was significant difference ($p<0.05$) in CC between milk collected from farms and milk collection centers (Table 4).

DISCUSSION

The level of awareness among farmers about the economic and public health importance of zoonotic diseases in most of developing countries is low and this increases the effort required to control these diseases. One product that is commonly distributed in raw form is milk especially for pastoral people in arid and semiarid areas where camel milk is predominantly consumed [10]. Raw milk may represent an important source of food-borne bacteria. It can access to the milk through colonization of the teat canal or an infected udder (clinical and subclinical mastitis) or contamination from milk utensils or water supply used [11]. The presence of bacteria in milk has many undesirable effects on the quality and safety of milk and its products [12].

Table 1: The association of demographic characteristics with Total bacteria count (log_{10}cfu/ml) at farm level

Variables		Number	Mean ± SE	p-value
Sex	Female	30	5.3 ±0.745	0.001
	Male	15	6.2 ± 0.792	
Level of education	Illiterate	37	5.9 ± 0.711	0.000
	Primary	8	4.5 ± 0.428	
Hand washed before milking	Yes	30	5.4 ± 0.704	0.000
	No	15	6.8 ± 0.485	
Teat and udder wash	Yes	30	5.2 ± 0.555	0.000
	No	15	6.6 ± 0.400	
If yes what Material used to wash	Water only	35	5.7 ± 0.758	0.000
	Water + detergent	5	4.4 ± 0.418	
Teat dip	Yes	2	4.1 ± 0.053	0.008
	No	43	5.7 ± 0.805	
Hand washed between Milking	Yes	11	4.6 ± 0.411	0.000
	No	34	5.9 ± 0.680	
Milking storage	Aluminum	15	5.3 ± 0.486	0.000
	Plastic	30	6.9 ± 0.703	
Smoking milk containers	Yes	43	5.5 ± 0.771	0.002
	No	2	7.4 ± 0.703	

Table 2: The association of demographic characteristics with coliform count (log_{10}cfu/ml) at farm level.

Variables		Number	Mean ± SE	p-value
Sex	Female	30	1.6 ±0.400	0.10
	Male	15	1.8 ±0.216	
Level of education	Illiterate	37	1.8 ±0.203	0.000
	Primary	8	1.05 ± 0.271	
Hand washed before milking	Yes	30	1.6 ±0.358	0.003
	No	15	1.9 ±0.043	
Teat and udder wash	Yes	30	1.5 ±0.348	0.000
	No	15	1.9 ±0.067	
If yes what Material used to wash	Water only	35	1.7 ±0.282	0.000
	Water + detergent	5	1.0 ±0.272	
Teat dip	Yes	2	0.8 ±0.88	0.000
	No	43	1.7 ±.316	
Hand washed between milking	Yes	11	1.1 ±0.274	0.000
	No	34	1.8 ±0.164	
Milking container	Aluminum	15	1.6 ±0.360	0.005
	Plastic	30	1.9 ±0.039	
Smoking milk containers	Yes	43	1.6 ±0.358	0.147
	No	2	2.0 ± 0.014	

Table 3: Mean variation in Total bacteria count (log_{10}cfu/ml) among milk samples collected

Kebelle	Source	Number	Mean ± SE	p-value
Bombas	Farm level	15	4.9 ±0.786	0.002
	Collection center	15	5.8 ±0.606	
Golehajo	Farm level	15	5.7 ±0.54	0.009
	Collection center	15	6.4 ±0.725	
Kobijaro	Farm level	15	6.2 ±0.765	0.04
	Collection center	15	6.7± 0.629	

Table 4: Mean variation in Coliform count (log_{10}cfu/ml) among milk samples collected

Kebelle	Source	Number	Mean ± SE	p-value
Bombas	Farm level	15	1.3 ±0.349	0.003
	Collection center	15	1.7 ±0.319	
Golehajo	Farm level	15	1.7 ±0.158	0.000
	Collection center	15	2 ±0. 044	
Kobijaro	Farm level	15	1.3 ±0.349	0.000
	Collection center	15	1.9 ± 0.056	

Milk contaminated by high levels of bacteria usually becomes unsuitable for human consumption and further processing [13].

High total bacterial counts in raw milk mainly reflect the poor hygienic condition under which the milk was handled, including the storage temperature and poor health of milking animals [14]. The present study showed washing of hands and udder before milking showed significantly ($p<0.05$) lower total bacterial and coliform count at farm level. This is mainly because dirty hands and udder are sources of contamination at milking as evidenced by Almaz *et al*. [15], Jayarao *et al.* [16] and Marth and Steele, [17]. Education is an important entry point for empowerment of the rural communities and also an instrument to sustain development. This could have significant importance in identifying and determining the types of development and extension the service approaches. The role of education is obviously affecting households income, adapting technologies, demography health and as a whole the socio-economic status of the family. As this study showed, milk samples collected from primary level educated householders has significantly ($p<0.05$) lower TBC and CC than illiterate householders. The differences in the education levels between households might be the reason for the poor management and practices which led to increase number of bacterial colony with enhanced growth of bacteria in the milk result in degradation of milk quality [18].

Equipment used for milking, processing and storage determine the quality of milk and milk products. According to the present study householders that used aluminum cans had significantly ($p<0.05$) lower TBC and CC than households which used plastic jars/jerry cans. The use of plastic and traditional containers can be potential source for the contamination of milk by bacteria, because they may contain many crevices, cracks and corners that cannot be easily cleaned and allow the multiplication of bacteria on milk contact surfaces during the interval between milking. There may be difficulty of removing all milk residues from traditional containers that are porous by nature with the common cleaning systems [19].

According to the local understanding, smoking of milk containers imparted special taste and flavor to the milk and disinfected the containers, thus reducing the numbers of microorganisms and thereby extending the shelf life of milk. The pastoralists believed that if not properly fumigated, milk would spoil regardless of hygiene measures taken. Their claims were evidenced by the present study where the TBC in farms that smoked their containers was significantly lower than farms that did not smoke their containers. This finding agreed with previous works of Ashenafi and Beyene [20] and Kera et *al*. [21].

So far there are no Microbiological standards concerning camel milk. Therefore, Standard European Union (EU) microbiological limits (TBC $\leq 1 \times 10^5$ CFU/ml and CC $\leq$ 102 CFU/ml) for acceptable cow milk (EU, 2004) were used to assess the quality of camel milk in this study. This study revealed that the overall mean count of total bacterial count (TBC) was 5.9 $\log_{10}$ cfu/ml. The current findings in agreement with the finding of Semereab and Molla [22] in Afar Region of Ethiopia and Al Mohizea [23] in Riyadh, Saudi Arabia and Kaindi D. *et al*. [24]and Omer and Eltinay [25]in United Arab Emirates.

A significant ($p<0.05$) increase in TBC from 5.6 $\log_{10}$ cfu/ml to 6.3 $\log_{10}$ cfu/ml was observed along the chain as the milk was transported from the production site (milking level) until it reached the milk collection centers, respectively . These finding is comparable with other findings by Farah *et al.* [26], Younan and Abdurahman [27]. The TBC and CC reported in the present study was still higher given that householders practiced washing hands and udder before milking. This shows that the practicing of hygienic practices was inappropriate. The water used for washing may not be clean and the milk was not properly transported and stored at milk collection centers. Water used for washing at milking level and milk collection centers could be one factor. Since there was shortage of water in the study area, the householders and milk collectors were not giving care to the source of the water. The lactating camel's health could also be one factor since camels in the study area were not treated regularly. The contamination could be attributed to improper handling of milk during milking, transportation; temperature of the area, storage at the different stages from production site until the final market and hygienic standard of both milk containers and workers. These claims were well supported by Ahmed *et al*. [28] and Soler *et al*. [29].

Coliform bacteria are a commonly used as indicators of sanitary quality of foods and water. They are rod-shaped Gram-negative, non-spore forming organisms. Coliforms can be found in the aquatic environment, in soil and on vegetation; they are universally present in large numbers in the feces of warm-blooded animals. While coliform themselves are not normally causes of serious illness, they are easy to culture and their presence is used to indicate that other pathogenic organisms of fecal origin may be present [30].

The present findings indicated an overall mean coliform count of 1.9 $\log_{10}$ CFU/ml. This value appears to be the acceptable level of coliform count (1.69-2.00) according to European Union standard [31]. The figure from the present study is much lower than the finding in Afar Region, Ethiopia by Semereab and Molla [22].

CONCLUSION

The study revealed that camel milk contamination in the study area occurs along the chain as the milk was transported from the production site (milking level) until it reached the milk collection centers in all three Kebeles. The hygienic level of milk was affected by various characteristic and practices of milkers like sex, washing hands and udder, application of teat dip, type of milk containers and smoking of milk containers. There were high total bacteria and coliform count both at farm and collection centers which is not an acceptable. It can be concluded from the study that the awareness of the households about clean milk production is low and the hygienic practices being practiced in the study area are not up to the standard.

Based on the above concluding remarks, the following recommendations are forwarded:

- Rigorous training should be given to camel milking persons about good hygienic practices and clean milk production
- As the present study focused on microbial quality, subsequent studies should focus on isolation and quantification of specific pathogenic organisms to evaluate the safety of camel milk supplied to consumers.
- Awareness should be given to the public about the danger of consuming raw milk.

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