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Assessment on Safety Status of Camel Raw Milk Marketed in Samara-Logia Town of Afar National Regional State, Northeast Ethiopia

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Abstract
A cross-sectional study was carried out to determine bacteriological quality of camel raw milk and to assess the risk factors associated with hygienic quality of camel milk marketed in Samara-Logia town, Afar, north-eastern Ethiopia from December 2013 to April 2014. One hundred thirty (130) milk samples were collected from randomly selected milk sellers and assessed by plating of total aerobic plate count (TAPC), psychrotrophic count (PC), aerobic mesophilic spore-former count (AMSC) and total coliforms count (TCC). Isolation and identification of *S. aureus* and *E.coli* was also done. The mean $\log_{10}$ counts per ml for TAPC, PC, AMSC and TCC were 6.37 log cfu/ml, 5.83 log cfu/ml, 4.69log cfu/ml and 4.87 log cfu/ml, respectively. From 130 examined milk samples, 88 (67.7 %) were found to be culture positive and yield at least one bacterium. *S. aureus* and *E.coli* were found in 56.2 % and 24.6 % milk samples, respectively. According to Kenya quality standards for whole unpasteurized milk more than 86.2 % of milk samples had TAPC at the final market exceeded the acceptable limit of 10^6 cfu/ml; (grade III or fair) quality of raw milk an indicator of poor quality and point out the potential health risk of consuming raw camel milk under the present production conditions. Result of the questionnaire survey show that milk was generally produced by the pastoral communities under unhygienic environmental conditions with the use of poor quality river water for cleaning. Hence, based on the bacteriological results coupled with the consumer's habit of raw milk consumption and cultural taboo on boiling milk, it is concluded that this milk may pose a public health hazard with different milk-borne pathogens. Therefore, in order to safeguard consumer health and to strengthen the source of income through the sale of milk by producers and sellers, there should be initiatives to lower microbiological contamination of camel milk starting from milking level to final market. To ensues safety status of camel milk, training on hygienic handling of milk for herders, other interventions that focus on provision of clean water, milk cooling facilities at milking level and efficient or organized milk transportation and storage systems are necessary.
Keywords: Bacteriological quality, Camel milk, local market, Samara-Logia

INTRODUCTION

Food safety is a significant public health issue. Unsafe food has been a human health problem since history was recorded, and many food safety problems encountered today are not new. Although governments all over the world are doing their best to improve the safety of the food supply, the occurrence of food-borne diseases remains a significant health issue in both developed and developing countries (WHO, 2006). According to World health organization (2006), each year 1.8 million people die as a result of diarrheal diseases and most of these cases are attributed to contaminated food or water. Improper food preparation can expose to most food-borne diseases. More than 200 known diseases are transmitted through food (WHO, 2006). Numerous epidemiological reports have implicated non-heat treated milk and raw-milk products as the major factors responsible for illnesses caused by food-borne pathogens (Gran *et al*., 2002 cited in Ahmed *et al.,* 2010).

According to FAO (2009), there are about 25.3 million camels in the world, of which 21.5 million are found in Africa. Somalia with 7 million heads has the largest camel population in the world followed by Sudan with 4.5 million. Ethiopia hosts about 2.4 million heads of camel which are found in the arid and semi-arid regions of the country, this number ranks the country third in Africa after Somalia and the Sudan and fourth in the world (FAO, 2010). Among other domestic ruminant, camels has the ability to produce milk of good composition and quantity for human consumption even during dry seasons and drought years when milk from cattle, sheep and goats is scarce (Yagil and Etzion,1980). McDowell (1986) stated that camel's feeding behavior, tolerance to high salt contents and ability to conserve water, make it the best of ruminants for arid and many semi-arid area.

Camel milk is the key foods for pastoralists in the arid and semi-arid areas of eastern lowlands of Ethiopia where browse and water are limited (Felleke, 2003). Camel milk is traditionally prized for its anti-oxidant, anti-cancer, anti-diabetic and more generally as restorative properties in convalescent patients (Konuspayeva *et al*., 2004). Besides, camel milk is distinguished by its high content of vitamin C and niacin, and

by the presence of a powerful protector system, with relatively high levels of lysozyme, lacto peroxidase, lacto-ferine and bacteriocins produced by lactic acid bacteria (Siboukeur, 2007).

In most pastoralists, camel milk is always consumed either fresh or in varying degrees of sourness in the raw state without heat treatment, acid fermentation and kept at high ambient temperature coupled with lack of refrigeration facilities during milking and transporting (El-Ziney and Al-Turki, 2007). In Ethiopia, the Afar pastoralists have very strong beliefs regarding the health benefits attributed to camel raw milk, and it is not allowed to process the raw milk due to cultural taboo. As a result, the raw milk is often marketed and consumed by individuals (Dahl and Hjort, 1979).

Milk has been identified as a vehicle of several organisms in many occasions (Harrington *et al*., 2002). Many of these organisms are pathogen for human. Presently the most important pathogenic microorganisms are *Salmonella spp*., pathogenic *E.coli*, *Listeria*, *Campylobacter jejuni, Yersinia spp.*and *S.aureus* (Hahn, 1996; Heeschen, 1997).

According to Birhanu *et al.* (2008) camel milk is produced in traditional way by hand milking, handled and transported under low hygienic measures by pastoralists in Afar region, as in many regions around the country. Other inappropriate practices include mixing of evening and morning milk, pooling of milk from different suppliers and exposure during marketing. So that, 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. Such risk is higher when the milk is consumed in its raw state as is commonly practiced by the local producers.

Informal milk market dominates all milk sales, and consumers enjoy convenient delivery. Although most study have focused on the assessment of the hygienic quality of camel raw milk at milk producing point but the contamination is not limited to primary milk collection center, it extends to the final milk market center, which is risky for consumers. To achieve comprehensive information about the hygienic quality of the raw camel milk supplied to the consumers, it is necessary to investigate the level and factors for bacteriological contamination of camel milk, along the informal market to obtain baseline situation of marketed camel milk. The general objective of this study, therefore, was to assess the present hygienic situation of the raw camel milk in Samara-Logia town milk market. The specific objectives of this study were to investigate the bacteriological quality of the raw camel milk, to isolate and identify major food-borne pathogens; and to assess the risk factors associated with hygienic quality of camel milk marketed in Samara-Logia town.

MATERIALS AND METHODS

Description of study area

Afar is border with Oromia region in the south, Tigray region and Eritrea in the north, Djibouti and Somalia region in the east, and Amhara region in the west. The altitude of the region ranges from 1500 m.a.s.l. in the western highlands to -120 meters below sea level in the Danakil/Dallol depression. The livestock population is estimated to be about 4 Million. Afar is characterized by an arid and semi-arid climate with low and erratic rainfall. Temperature varies from 20^{o}C in higher elevations to 48^{o}C in lower elevations. Rainfall is bi-modal throughout the region with a mean annual rainfall below 500 mm in the semi-arid western escarpments decreasing to 150 mm in the arid zones to the east (Joanne *et al*., 2005). Samara-Logia town, the regional capital, is located at 600 km North-east of Addis Ababa on the main Addis Ababa to Djibouti tarmac road (Figure 1). Pastoralists of the area keep their camels far from the town and from the main road. Milking of camel is mostly done in area where the herds browse, and the milk is brought to the family then to the market.

Study population

Camel milk marketed by pastoralists to the local milk market center at Samara-Logia town and the milk supplier pastoralists who were available during each visit were utilized for this study. The local milk market center is found within the town in front of the main road. In this market, raw bulk milk of camel is available for sale to residents and passengers from different sites. Raw camel milk that was available for sale in the study period was used to determine the bacteriological quality of raw camel milk.

Study design and sampling

A cross-sectional study was carried out from September 2013 to April 2014 with a total of 130 milk samples to determine the bacteriological quality of raw camel milk. Simple random sampling method was applied as a sampling strategy. Accordingly, the milk samples were taken randomly from individual pastoralist that brought milk to the local milk market center and at the same time each pastoralists were interviewed using a structured questionnaire prepared in Afar language. During the study period, milk brought by one individual pastoralist was considered as a single sample unit.

Sample collection and transportation

Individual pastoralist brought the milk to the local market using plastic buckets with a lid. Small volumes of milk are usually brought in discarded packed water container and for large volume of milk they used discarded vegetable oil “jerrycans” having a capacity of 500 ml – 2 liters and 3-5 liters, respectively. From each randomly

selected individual pastoralist, 15-20 ml (Birhanu *et al*., 2008) of camel raw milk samples were collected aseptically from their utensils (plastic container) in sterile Durham bottles. Each specimen labeled, and placed in cool box with ice until transported to the Samara Regional Veterinary Laboratory. The samples were transferred in to the refrigerator immediately at +4°C and subjected to microbiological analysis within 24 hrs.

Sample processing procedure

The commonly used growth media, preparation and incubation conditions of microorganisms of interest are listed in Table 1.

Bacterial load of camel raw milk samples

In order to quantify the total aerobic plate count, aerobic mesospheric spore-former count (AMSC), psychotropic count (PC) and total coliform count of the milk samples was determined as described by APHA (1992). Before removal of the samples from its container, the content was mixed thorough vigorously. Six sterile dilution tubes with 9 ml of sterile peptone water in it were used. For each sample up to $1:10^{-6}$ dilutions were prepared. 1ml was discarded from the last dilution. Sterile pipettes were used for initial and subsequent transfers from one dilution tubes to the other.

Total aerobic plate count (TAPC) was carried out on nutrient agar plates. Starting from the most diluted one, 1 ml was taken after thorough mixing and transferred to surface of nutrient agar plates using sterile pipettes after labeling plates with sample number and dilution number. The sample on the plate was spread evenly using sterile glass spreader. The plates were then inverted and placed in an incubator at 37^0c for 24-48 hrs. Sterility of the dilution peptone water and medium was checked by incubating control plates for each sterilization lot of dilution blanks and medium used.

Total coliforms count (TCC) was determined by inoculating the sample on MacConkey agar plate, incubated at 35°C for 24 hrs. Psychrotrophic count (PC) where performed by incubation of appropriate dilutions of milk sample on nutrient agar kept at 7°C for 10 days (Wehrand Frank, 2004). For aerobic mesophilic spore-former count (AMSC), the raw milk was heat-shocked at 80°C for 10 minutes to destroy vegetative cells. After being cooled in an ice bath, the milk was immediately plated using a TAPC method on nutrient agar and incubated at 35 °C for 24-48 hrs.

Reading and interpretation of results

Reading and interpretation of results for total aerobic plate count, aerobic mesospheric spore-former count and psychrotrophic count was determined as the method described for standard plate count (APHA, 1992). For total aerobic plate count, all colonies including those of pinpoint size were counted on selected plates using automatic colony counter. If plates from two consecutive decimal dilutions yield colony counts of 30 to 300, the colony forming unit (cfu) was calculated using the following formula (APHA, 1992):

$$N = \frac{\sum C}{(N1.1) + (N2.0.1)\,D}$$

Where: $\sum C$ is the sum of all colonies on all plates counted
N 1 is the number of plates in lower dilution counted
N2 is the number of plates in next higher dilution counted
D is the dilution from which the first counts were obtained

All of the petri-dish plates containing between 30 and 300 colonies were selected. Plates with more than 300 colonies could not be counted and were designated too numerous to count (TNTC), plates with fewer than 30 colonies were designated too few to count (TFTC).

For coliforms count, after incubation of plates for 48 hrs, purple-red in color, larger and surrounded by bile acid precipitation were counted as coliforms. Results from those plates which contained between 10 and 100 colonies were recorded (APHA, 1992). Interpretation of the results was similar to that of SPC.

Isolation and identification of bacterial agent

A loop full of the sample was streaked onto blood agar base enriched with 7 % heparinized sheep blood and on MacConkey agar. The plates were aerobically incubated at 37 ^{0}C and examined for bacterial growth after 24 and 48 hrs. From culture positive plates typical colonies were subjected to Gram's stain to study staining properties and cellular morphology. Pure cultures of a single colony type from the blood agar were transferred on to nutrient agar. From this, a single pure colony was subjected to a biochemical tests and selective media that aided final identification of bacteria were conducted following standard methods (Carter, 1984; Quinn *et al*., 1999).

S. aureus was identified based on haemolysis pattern on blood agar, catalase, coagulase test and growth pattern on Mannitol salt agar. *E.coli* was identified based on Gram's stain reaction, growth characteristics on MacConkey agar, oxidase test, and reaction pattern on IMVIC test. Pure cultures of a single colony type from the nutrient agar was plated on eosine methylene blue agar (modified) Levine (EMB) and incubated at 37°C for 24 hrs.

Data management and analysis

All data obtained through microbiological analysis and questionnaire survey were entered into Microsoft Excel spread sheet. Statistical data analysis was carried out using SPSS software (Version 20, SPSS Inc., Chicago).The

microbial counts were first transformed to logarithm of colony forming units per milliliter of sample (log cfu /ml) and the results were presented as the geometric means and other descriptive statistics.

RESULTS

Bacterial counts

The mean of total aerobic plate count in collected sample was 6.37 log cfu/ml with about 86.2 % the samples having standard plate count greater than 10^6cfu/ml (Table 2 and 3). The mean count of total coliforms was 4.87 log cfu/ml with range from 4.16 to 5.61 log cfu/ml (Table2). About 63.8%of the samples had coliform count greater than 5 x 10^4cfu/ml (Table 3). The count of psychrotrophic bacteria of camel milk was varied between samples. About 76.9 % of the milk samples had a PC of greater than 5 x 10^5cfu/ml (Table 3), with a mean value of 5.83 log cfu/ml (Table 2). In terms of residual spore forming bacteria (aerobic mesophilic spore-former), about 100% of the samples had greater than 10^4cfu/ml aerobic mesophilic spore-formers (Table 3), with mean value of 4.69 log cfu/ml (Table 2).

Bacterial species isolated

Out of 130 milk samples, 88 (67.7 %) of the samples yield at least one bacterial species. 56.2 % were culture positive for *S.aureus* and 24.6 % for *E.coli.* Among the identified bacterial isolates *S.aureus* was the predominant isolate (56.2 %, n= 73) from the samples. *E.coli* was the second predominant bacteria constitute (24.6 %, n= 32) of isolates.

Questionnaire survey

A total of 130 milk supplier pastoralists in the local market were interviewed randomly using structured questionnaires based on their engagement on production, trade and availability. The respondents' views were briefly summarized below (Table 4). According to the response by the interviewees in the local markets100 % do not clean the barns at all which leads to poor quality milk production, and 92.3 % do not wash udder or teats before milking. All respondent do not wash hands before and after milking every camel. Moreover, 54.6% use water from river (running water) for washing milking, storage equipments and milker's hand. During the time of milking, 76.9% exercised randomly milking techniques rather than sequentially (starting from healthy camel and proceed to mastitic or any sick camel). At the beginning of milking discarding of the first few drops of milk was not be practiced by 113 % of milkers, 73.1 % of pastoralist brought pulled (mixed) camel milk to the market for sale which is left over from household consumption. All the interviewed pastoralist cannot applied cooling of milk after milking or after long distance transportation. Under these problems, 100 % of the respondents involved in the local milk market reported for which milk is never boiled for cultural reasons and they believed that camel milk had medicinal value when drank in raw state. Due to this belief, any heat treatment of milk before drinking is not exercised. In addition, 86.9 % of producers or consumers are not aware about public health hazards of drinking raw milk.

DISCUSSION

Camel milk is the key foods for pastoralists in the arid and semi-arid areas of eastern lowlands of Ethiopia. It is traditionally prized for its anti-oxidant, anti-cancer, anti-diabetic and more generally as restorative properties in convalescent patients. Milk has been identified as a vehicle of several organisms in many occasions. Because of the poor hygienic production of 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. Such risk is higher when the milk is consumed in its raw state as is commonly practiced by the local producers.

In the present study the mean of total aerobic plate count in collected sample was 6.37 log cfu/ml with about 86.2 % the samples having standard plate count greater than 10^6cfu/ml. TAPC value in this study was does not agree with those reported from Saudi (i.e., 5.4 log cfu/ml in average) by Al Mohizea (1994) and Ethiopian (5.6 log cfu/ml) by Semereab and Molla (2001) for camel milk. It is worth to mention that there are no microbiological standards concerning camel milk. Therefore, the microbiological limit value for cow milk was used to assess the quality of camel milk (El-Ziney and Al-Turki, 2007).According to the Kenya quality standards for whole unpasteurized milk (KEBS, 2007), 86.2 % of milk samples at the final market exceeded the acceptable limits of 10^6 cfu/ml (grade III or fair) which indicates poor quality milk and a threat to human health.

In this study, the mean count of total coliforms was 4.87 log cfu/ml with range from 4.16 to 5.61 log cfu/ml. About 63.8%of the samples had coliform count greater than 5 x 10^4cfu/ml. Similar finding was reported by Tola (2002) from Southern Ethiopia raw cow's milk sampled from smallholder producers contained coliform counts of about 4.46 log cfu/ml.The occurrence of total coliforms, in our study, was higher than reported for Afar by Semereab and Molla (2001) which were 3.472 x 10^3cfu/ml and 6.95 x 10^3cfu/ml for milk sampled from udder and milking bowl. Similarly, high coliform counts were observed in Moroccan camel milk (Benkerroum *et al*., 2003) which was 10^7cfu/mlon average. However, existence of coliforms may not necessarily indicate a direct fecal contamination of milk, but is an indicator of poor sanitary practices during milking and further handling processes (Frazier and Westhofi, 1988).

The count of psychrotrophic bacteria of camel milk was varied between samples. About 76.9 % of the milk samples had a PC of greater than 5 x 10^5cfu/ml, with a mean value of 5.83 log cfu/ml (Table 2). The results of psychrotrophs are higher than the mean counts of PC camel milk at final market in Kenyawhich was l0 ^{5} cfu/ml (Kindi *et al.,* 2011) andcamel milk in the Qassim region in Saudi Arabia with mean count of 3.8 log cfu/ml (El-Ziney and Al-Turki, 2007).Further, no information in the literature documented the content of psychrotrophs in camel milk. Psychrotrophic bacteria are important because, many of them produce extracellular thermo-stable, proteolytic and lipolytic enzymes which can survive heat treatments (i.e. pasteurization) thus affecting the shelf-life and quality of milk & milk products (Collins, 1995).

In terms of residual spore forming bacteria (aerobic mesophilic spore-former), about 100% of the samples had greater than 10^4cfu/ml aerobic mesophilic spore-formers (Table 3), with mean value of 4.69 log cfu/ml (Table 2). Comparing to previous studies, relatively higher AMSC have been recorded in this study. These result does not agree with from Saudi (i.e. 2.1 log cfu/ml in average) and New York state (i.e. 1.7 log cfu/ml as a mean) camel milk by El-Ziney – Al-Turki (2007) and cow milk by Boor *et al*. (1998), respectively. No data in the literature reported the level of this group of organisms in raw camel's milk. Spore-forming bacteria are known to, apart from causing spoilage, cause food-poisoning by producing heat labile enterotoxins (Eley *et al*., 1992; Graaf *et al*., 1997).

Bacteriological examination was conducted on all of the milk samples collected from the local market, where milk was available commercially for direct consumption, to isolate and identify the major bacteria that can cause food poisoning. Out of 130 milk samples, 88 (67.7 %) of the samples yield at least one bacterial species.56.2 % were culture positive for *S.aureus* and24.6 % for *E.coli.* Among the identified bacterial isolates *S.aureus* was the predominant isolate (56.2 %, n= 73) from the samples. The existence rate of *S. aureus* in the present study was relatively high compared to the finding by Samarab and Molla (2001) who reported 15% isolation rate of *S. aureus* from composite camel udder milk. An overview of the annual reports of food-borne diseases from seven countries indicated that milk and milk products implicated in 1-5% of the total bacterial outbreaks. *S. aureus* was by far the most frequent pathogen associated with these outbreaks (85.5%), followed by *Salmonella* (10%) (De Buyser *et al*., 2001). High isolation rate in this study may be of great concern to human health since some strains of *S. aureus* are capable of producing enterotoxin.

E.coli was the second predominant bacteria constitute (24.6 %, n= 32) of isolates from the present study. This may be associated with environmental contamination of milk after milking. Fekadu (1986) reported that the presence of coliform organisms in milk indicates unsanitary conditions of production. Hence their presence in large number is indication of the product was potentially hazardous to the consumer's health, since *E.coli* and *Staphylococcus* species are associated with food-borne intoxications through production of enterotoxins (Donkor *et al*., 2007).

Generally, the organisms identified in the milk samples are potential food-born pathogen, and the practice of pooling milk from different sources by pastoralist and the absence of bactericidal treatment could increase the risk posed by such organisms. These have been implicated in milk and other food related infections (Soomro *et al*., 2002; Sivapalasingams *et al*., 2004; Oliver *et al*., 2009).

A total of 130 milk supplier pastoralists in the local market were interviewed randomly using structured questionnaires based on their engagement on production, trade and availability. The respondents' views were briefly summarized below (Table 4). According to the response by the interviewees in the local markets100 % do not clean the barns at all which leads to poor quality milk production, and 92.3 % do not wash udder or teats before milking. All respondent do not wash hands before and after milking every camel. Moreover, 54.6 % use water from river (running water) for washing milking, storage equipments and milker's hand. During the time of milking, 76.9 % exercised randomly milking techniques rather than sequentially (starting from healthy camel and proceed to mastitic or any sick camel). At the beginning of milking discarding of the first few drops of milk was not be practiced by 113 % of milkers, 73.1 % of pastoralist brought pulled (mixed) camel milk to the market for sale which is left over from household consumption. All the interviewed pastoralist cannot applied cooling of milk after milking or after long distance transportation. Under these problems, 100 % of the respondents involved in the local milk market reported for which milk is never boiled for cultural reasons and they believed that camel milk had medicinal value when drank in raw state. Due to this belief, any heat treatment of milk before drinking is not exercised. In addition, 86.9 % of producers or consumers are not aware about public health hazards of drinking raw milk.

In general, results of the questionnaire survey and frequent observations in the study area show that milk was generally produced by the pastoral communities under unhygienic environmental conditions with poor quality river water. Pastoralists were used to sell the milk under poor environmental hygiene in the town along the road side through which a number of vehicles and passengers on foot pass, coupled with no shade to protect the milk from sun rays. It was transported to the market long time using unclean plastic containers. In addition, milk of the domestic animal species, particularly milk of camel in these pastoral communities is consumed in its raw state. This tradition therefore poses a lot of dangers to all consumers in relation to milk-borne diseases

(Lingathurai and Vellathurai, 2010; Lues *et al*., 2003). Therefore, consumption of raw camel milk at the current status poses potential public health risk as was reported in other studies (Farah *et al.*, 2007). Furthermore, poor safety and quality of the milk as a result of poor hygiene may greatly discourage consumers' demand.

CONCLUSION AND RECOMMENDATIONS

This study has shown that the quality and safety of milk produced in Samara-Logia was poor. This was evident from the high values of TAPC, TCC, AMSC, PC and a significant number of samples were highly contaminated with potentially pathogenic bacteria in the milk. Furthermore, pooling of different milk batches along the value chain might have led to an increased contamination of the milk. This coupled with the unhygienic cleaning of milking, storage and transport equipment together with unhygienic milk handling throughout the milk value chain, and poor personal hygiene of the milkers under high environmental temperature as well as the lack of cooling facilities resulted in increased bacterial contamination of the milk. In these area, no boiling of camel milk is exercised because, the consumers are not aware about hazard of consuming raw milk. Based on the high bacteria count and presence of potential pathogenic organisms, one may conclude that this milk may pose a public health hazard with different milk-borne pathogens. Therefore, training and extension to raise awareness among Afar pastoralists about adequate sanitary measures from production to consumption, accelerated transport from production to market, and consumer consciousness about the hygienic quality of milk and the risk arising from contaminated milk and milk products. Moreover, proper use of effective bactericidal treatment should be developed to improve the hygiene of marketed milk and public health concerns. Public awareness on reducing public health risks of raw milk consumption in the pastoral communities. Further research is needed regard to milk hygiene and safety status, and designing the improvement strategy in safety status of camel milk along the value chain.

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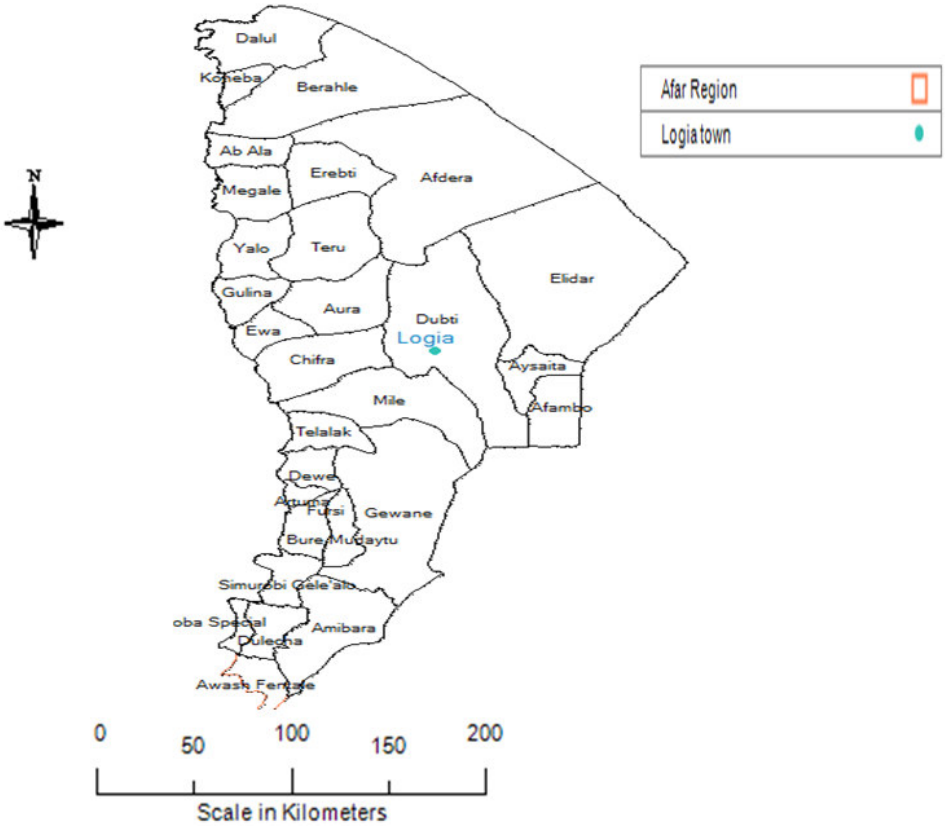

Figure 1: Map showing Afar national regional state and study area (Joanne *et al*., 2005)

Table 1. Growth media, preparation and incubation conditions of microorganisms of interest

Growth media	Media preparation	Incubation	Cultivated organisms
Nutrient agar	Autoclaved at 121^{0}C for 15 min	37 ^{0}c for 24-48 hrs	Total Aerobic bacteria (TAPC)
Nutrient agar	Autoclaved at 121^{0}C for 15 min	7°C for 10 days	Psychotropic bacteria (PC)
MacConkey agar	Autoclaved at 121^{0}C for 15 min	35°C for 24 hrs	Coliform bacteria(TCC)
Nutrient agar	Autoclaved at 121^{0}C for 15 min	Milk heat-shocked at 80°C for 10 min and incubate at 35 °C for 24-48 hrs	Aerobic mesophilic spore-former bacteria (AMSC)
Mannitol salt agar	Autoclaved at 121^{0}C for 15 min	37°C for 24 hrs	*S. aureus*
Eosine methylene blue agar (Levine)	Autoclaved at 121^{0}C for 15 min	37°C for 24 hrs	*E.coli*

Table 2. Selected statistical values (logcfu/ml) of total aerobic plate count (TAPC), psychotropic count (PC), aerobic mesophilic spore-former count (AMSC) and total coliform count (TCC) of the raw camel's milk in local market of Logia town

Bacterial counts	Minimum	Maximum	Mean	SD*
TAPC	5.55	6.77	6.37	0.28
PC	5	6.36	5.83	0.19
AMSC	4	4.98	4.69	0.21
TCC	4.16	5.61	4.87	0.39

* SD = Standard deviations

Table3. Frequency distribution of the bacterial counts of camel's raw milk

Bacterial counts	Frequency of sample counts (cfu/ml), %					
	10^4 –5x10^4	5x10^4-5x 10^5	5 x10^5 - 10^6	10^6-2x 10^6	2 x 10^6-5x 10^6	>5x10^6
TAPC	-	3 (2.3 %)	15(11.5%)	27(20.7%)	69(53.2%)	16(12.3%)
PC	-	30(23.1%)	70(53.8%)	30(23.1%)	-	-
AMSC	52(40 %)	78 (60 %)	-	-	-	-
CC	47(36.2%)	83 (63.8%)	-	-	-	-

Table 4. Milkowners' awareness about milk hygiene practices, handling and habit of consuming milk in the production and local market

Risk factors	Categories	Number of respondent	Percent (%)
Mastitis status	Yes	26	20
(Udder problem)	No	104	80
Hand washing before & after	Milking all camel	6	4.6
	Milking every camel	124	95.4
Milking order	Sequentially	30	23.1
	Randomly	100	76.9
Udder hygiene	Yes	10	7.7
	No	120	92.3
Milking equipment hygiene	Cleaning with water	45	34.6
	Cleaning with smoke	58	44.6
	Cleaning with soap	8	6.2
	Cleaning with ash	19	14.6
Storage equipment hygiene	Cleaning with water	40	30.7
	Cleaning with soap	7	5.4
	Cleaning with ash	19	14.6
	Cleaning with towel	1	0.8
	Cleaning with water and smoke	63	48.5
Awareness of raw milk health	Yes	17	13.1
risk	No	113	86.9
Distance from milk source to	Five to six hours	17	13
market	Two to four hours	24	18.5
	One to two hours	89	68.5
Milking equipment sharing	Yes	40	30.8
Habit of drinking milk	No	90	69.2
Foremilk stripping	Raw	130	100
	Boiled	0	0
	Yes	17	13.1
	No	113	86.9
Cooling of milk	Yes	0	0
	No	130	100
Source of water	Tap water	23	17.7
	Untreated ground water	36	27.7
	River	71	54.6
Barn cleaning	Yes	0	0
	No	130	100
Milk condition	Single	35	26.9
	Pulled	95	73.1