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Original Article

Marketing and Microbial Quality of Raw Camel Milk In West Hararghe Zone Oromia, Ethiopia

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ABSTRACT

The study was conducted in west Hararghe Zone of Oromia Regional State to assess raw camel milk marketing and to determine microbial quality of raw camels' milk. The research was conducted during the period of 2019-2020 using two potential districts (Mieso and Bordede). A total of 6 potential kebels were selected purposively. From each kebele 20 respondents (a total of 120 respondents) who have lactating camel and produce milk were selected randomly from the total households. In the current study, pastoralists practice informal marketing system where they sell their milk to neighbors' or the local market. Majorities of respondents in Bordede (60%) did not sale milk but in Mieso district majority of respondent's sale (58.33%) milk mainly to individual household consumers. The channel of marketing is majorly direct in which milk producers sold the milk to customers directly by themselves. The mean average price per liter in wet season was 19.92±0.282, 14.63±0.690.ETB and in dry

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season 24.7917±0.51, 23.3051±2.28 in Bordede and Mieso respectively. The price of camel milk varies mainly based on season, milk demand and supply around the study area. Majority of respondents in this study select the market place based on price of milk per litter. Long distance to market, high cost of transport, insufficient amount of milk produced and spoilage were the reasons of the producers for not selling fresh whole milk both in Bordede and Mieso district. The overall mean TBC and CC of raw camel milk samples was 5.85 ± 0.15 and 4.32±0.69 log CFU/ml, respectively. The present study showed that the quality of milk produced in the study area was poor. In general, camel milk production were practiced mostly based on traditional types and the microbiological quality of milk produced by pastoralists was poor and this calls for rigorous hygienic measures to improve microbial quality of milk. Hence, adequate sanitary measures should be taken at all stages from production to consumption.

Keywords: Camel, Marketing, Microbial quality, Milk

INTRODUCTION

In Ethiopia, fresh milk is distributed through the informal and formal marketing systems. The informal market involves direct delivery of fresh milk by producers to consumers in the immediate neighborhood and sales to itinerant traders or individuals in nearby towns (Debrah and Anteneh, 1991). Market orientation of the livestock production system especially milk would secure the livelihoods and food supply to the rapidly growing non-farming community, create employment opportunities and promote economic development in pastoral societies. But, in Ethiopia milk marketing system is not well developed particularly, market access in pastoral production system is a critical factor (Tsehay, 2002). Improving and enhancing the development of smallholder pastoralists to reach markets and involve them in marketing activities poses a pressing development challenge. Due to harsh and remoteness results in reduced production area prices increased input costs and lower returns to labor and capital. This in turn, decreases incentives to contribute in economic transaction and marks in subsistent rather than market-oriented production systems (Ahmed *et al.,* 2003).

Milk is highly nutritious food for human beings and universally recognized as a nature's nearly complete diet since it meets the complete nutritional requirements of the neonates (Benta and Abtamu, 2011). It is also a complex biological fluid and by its nature, a good growth medium for many microorganisms, because of its high water content, nearly neutral pH, and variety of available essential nutrients (Ashenafi and Beyene, 1994; Soomro *et al.,* 1996; Teka, 1997; as cited in Teshome, 2013). Therefore, the microbial content of milk is a major feature in determining its quality (Karmen and Slavica, 2008).

Camel milk production and consumption in Ethiopia was confined to the pastoral areas. In the recent past, it was introduced in the urban centers through informal

marketing. Other communities have taken up the consumption of camel milk. But there are no adequate hygienic practices in the camel milk production and processing, even if there is no quality standards set for camel milk in Ethiopia (Abdurahman, 2006;Semereab and Molla, 2001) the milk is traditionally consumed predominantly in its raw or fermented form without any heat treatments (Eyassu, 2007;Yohannes *et al*., 2007; Yagil, 1982 and Farah, 1996). So non-heat treated milk and raw-milk products is the major factors which responsible for illnesses caused by food borne pathogens (De Buyser *et al.,* 2001). Information on raw camel milk marketing and microbial quality of raw camel milk in Ethiopia is very sparse. Only very few published research report were available, but it is not representing all the arid and semi-arid area of the country and current situations. Therefore, detail investigation of microbial quality and marketing of milk is very important to identify existing hygiene and marketing related problems in the study area and improve milk production and marketing. In addition, periodical assessment of milk quality is required to offer safe and good quality milk for the consumer. Therefore, the study was conducted on assessment of marketing of raw camel milk and evaluation of microbial quality in West Hararghe Zone Oromia, Ethiopia with the following objectives

- To assess camel milk marketing practice in the study area
- To determine microbial quality of raw camels' milk in the district

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in West Hararghe Zone of Oromiya National Regional State, Ethiopia. West Hararge is one of the Zones in the Ethiopian Region of Oromiya. West Hararghe takes its name from the former province of Hararghe. West Hararghe is bordered on the south by the Shebelle River which separates it from Bale, on the southwest by Arsi, on the northwest by the Afar Region, on the north by the Somali Region and on the east by East Hararghe. Chiro is the town of West Hararghe Zone and 325 km far from the capital city of Ethiopia, Addis Abeba(CSA, 2015).

Sampling Procedures and Data collection

Before commencing the actual study, preliminary survey was conducted to gather information relevant to the study. Both primary and secondary data were collected. Primary data sources were the household heads in the respective districts whereas the secondary data were collected from Bordede district Agricultural Office and Mieso district Agricultural Office.

The sampling procedure was purposive sampling as strictly random sampling procedure might not be possible due to mobile, scattered and less accessible nature of pastoral communities.

Two districts were selected purposively, from each district 3 kebeles were selected purposively based on camel production, accessibility of the kebele's, area coverage and representativeness for the study areas. The target sampling population was the households who have lactating camel herds in the selected kebeles. The sample size was decided to be 120 household heads (i.e 20 households from each kebeles) taking into consideration the limited resources and time available to conduct the study.

To examine the microbial quality of the milk, four kebeles were selected based on road accessibility and nearest from the selected six kebeles., From each kbeles', ten households who have lactating camel were selected randomly. Then 10 milk sample from camel teat,10 milk samples from milking bucket of producers and 10 milk sample from market were collected from each district (i.e a total of 60 milk samples).

Information was collected using semi-structured questionnaire. For conducting the field survey, six enumerators who have the knowledge about the area and well acquainted with the culture and local language were recruited and "trained" on the methods of data collection and contents of the interview.

Sampling of Milk

About 25 ml of fresh whole milk samples were collected from three sampling points (directly from camel teat, from traditional milking buckets of the producer and from the market) by using sterile screw caped universal bottle. All samples were securely capped, labeled with permanent markers and kept below 10 °C in a cool box that had cooling elements. The samples were transported to the laboratory and analysis started immediately. The microbiological analysis of the samples was done at the Microbiology Laboratory.

Microbiological Tests

The bacteriological tests considered for determination of the bacterial load in raw milk samples were total bacterial count (TBC) and coliform count (CC). For these two procedures standard plate count agar (Oxoid, UK) and violet red bile agar (HiMedia, India) were used, respectively. Peptone water was used for serial ten-fold dilutions.

Data management and analysis

Data collected from Survey was summarized on Microsoft excel sheet and analyzed using descriptive statistics (mean and percentage) by using SPSS (statistical package for social science, version 20). The TBC and CC count data were transformed to log values before subjected to statistical analysis and the results were presented as mean ± standard deviation (SD). The log transformed values were analyzed using the General Linear Model (GLM) for least square mean in Statistical Analysis Software (SAS) version 9.0 (2004).

Standard European Union (EU) microbiological limits (TBC $\leq 1 \times 10^5$ CFU/ml and CC $\leq 10^2$ CFU/ml) for acceptable level of bacterial contamination in cow milk (EU Regulation (EC) No 853/2004 of the European Parliament) were used to qualify contamination in raw camel milk samples. Duncan multiple Range test mean (DMRT) comparisons were used to see the mean difference between sampling sources and confidence level were held at 95% and statistical analysis were considered significant at $P<0.05$.

The following model was used for the analysis of microbial quality of milk:

$Yij = \mu + \beta i + eij$

Where,

Yij = individual observation for each test

μ = the overall mean

β = the i^{th} milk source effect (i=1, 2, 3)

eij = the error term

RESULTS AND DISCUSSION

Household Characteristics and Responses

Most of the respondents in Bordede (53.33%) and Mieso (46.67%) district were illiterate and the remaining got only primary school education and Kuran (Table 1). This proportion is lower than the report of Solomon (2010) and Yohannes (2006) who reported that 95% in Borena and 82% in Jijiga, were illiterate, respectively. Similarly, the study conducted by Abdisa *et al*. (2017) indicated that most of the respondents in Yabello district were illiterate (79.6%) and the remaining (20.4%) got only primary and high school education.

Table 1: Educational status and marital status of the respondent (N=120)

Variables	Bordede (N=60) %	Mieso (N=60) %	Overall mean (N=120)
Educational status of HH (mean)			
Illiterate	53.33	46.67	50
Read and write	46.67	53.33	50
Marital status of HH			
Married	71.67	85.00	78.34
Single	23.33	8.33	15.83
Polygamous	5.00	6.67	5.84

N= number of Respondents; HH= Household

Milk Marketing

Milk selling in the study area

As shown in Table 2 majorities of respondents in Bordede (60%) did not sale camel milk but in Mieso district majority of respondent's sale milk (58.33%). In the current study, respondents practice informal marketing system where they sale their milk to

neighbors', the local markets or to local retailers. Camel milk was one of the income sources for pastoralists in the study area. Most respondents preferred camel milk than milk of other animals because they believe that camel milk has a medicinal value, best quality, nutritious, easily digestible, whitens a tea more than other milk types (according to the respondents, it has twice as much whitening concentration compared with other milk types).

As indicated by the study some of the respondents did not sale all milk go to the market. After that either they take back to the home and used for family consumption or sale at low price. The majority of respondents sold their milk to household consumers. Similar to the current result, Mebrahtu *et al. (*2017) indicates that majority of respondents sold their milk to household consumers in Afar regional state.

Table 2: Sale of milk in the study area

Variables	Bordede (N=60) %	Mieso (N=60) %	Overall mean (N=120)
Do you sale camel milk?			
Yes	40	58.33	49.17
No	60	41.67	50.84
Consumers			
Household consumer	75	77.14	76.07
Café	25	22.86	23.93
Did you sell all milk go to the market always			
Yes	58.33	57.14	57.74
No	41.67	42.86	42.27
If no what do you do			
Back and consume	60	66.67	63.34
Sale at low price	40	33.33	36.67

N=number of respondents

Seasonal price of camel milk, market place and transportation means

The survey result in Bordede indicates that, the range of milk price in wet season was 19-20 ETB (19.92±0.282 on average), while 23-25ETB (24.7917±0.51) in dry season. In Mieso, 13-15 birr (14.63±0.690) in wet season, while 20-25 birr (23.3051±2.28) in dry season (Table 3).The survey result of Omer (2019) shows that the mean average price of milk per liter in wet season was 12.05±2.14 and in dry season 22.55±2.51 ETB in Degahbour Woreda, Jarar Zone.

According to the result of the current study the lowest price occurs in wet season, because of more supply of milk to markets due to high availability of feed and high number of milking camels in wet season. Whereas maximum price occurs during dry season when there is low supply of milk in the market as a result of fed shortage and low number of milking camel. In the dry seasons since the supply of camel milk is

low and the demand for it is high. As shown in Table 3 the respondents were used drought animal, household labor and vehicle as means of transportation during milk marketing, which were accounts 44.47%, 40.06% and 15.48%, respectively.

Similar to the current study the result of Omer (2019) shows that majority of the respondents were using animal, household labor and vehicle as means of transportation, which accounts 58.7%, 38.7% and 2.6% respectively. Based on the current survey result there were limitation of transport, although camel and human back were major means of transportations. The closer the market, less time it takes to travel, less milk spoilage would be incurred. This may reduce losses of energy, time and producers would get fair price for their milk. Majority of the respondents in the study area sale their camel milk at nearby market.

Majority of respondents both in Bordede and Mieso district select the market place based on price of milk per litter. The result of the current study agrees with Mohamed (2014) the criterion mostly used in selecting milk marketing out let was price of milk per liter. The survey result of Ayanel (2019) shows that the most criteria of camel milk marketing selection were distance of market (40.6) and market reliability (46.5%) and this result disagree with the current result. Choice of market outlet is the farmers decision on where to or not to sell their farm produces. Before choosing a market outlet, farmers consider the costs associated with transportation, profits, level of trust among the available channels and familiarity of the markets (Ahmed *et al.*, 2016).

Table 3: Seasonal price of milk, transportation means and market place

Variables	Bordede (N=60)	Mieso (N=60)	Overall mean(N=120)
Price of milk (Mean±SD			
Price per liter in wet season	19.92±0.282	14.63±0.690	16.78±2.679
Price per liter in dry season	24.7917±0.51	23.3051±2.28	23.3051±2.27622
Means of transportation for milk marketing (%)			
On foot	45.83%	34.29%	40.06
On animal	37.5%	51.43%	44.47
On car	16.67%	14.29%	15.48
Selling place of camel milk (%)			
Farm gate	37.5%	22.86%	30.18
Nearby market	62.5	77.14%	69.82
Criteria in selecting market place%			
Price of milk	50	85.71	67.86
Distance of market	29.17	14.29	21.73
Market reliability	16.67	0.00	8.34
Long term contact	4.17	0.00	2.09

N=number of respondents

Milk supply changes in the study area

As shown in Table 4 there was supply change of milk in the market both in Bordede and Mieso district. The main reasons for supply changes were number of milking camel, feed shortage and drought. In wet season the supply of milk was high but in dry seasons since the supply of camel milk is low and the demand for it is high. High milk supply during wet season was due to the increase of milking camel and feed availability and the inverse is true during dry season.

Table 4: Milk supply variation and the reasons for that variation

Variables	Bordede (N=60) %	Mieso (N=60) %	Overall mean (N=120)
Does the supply of milk in the markets vary			
Yes	91.67	88.57	90.12
No	8.33	11.43	9.88
Reasons for supply changes			
No. of milking camel	45.45	48.39	46.92
Price change	18.18	16.13	17.16
Feed shortage	27.27	22.58	24.93
Drought	19.09	12.90	11.00

N=number of respondents

Milk marketing constraints

The reasons for not selling raw milk in the study areas are indicated in Table 5. Long distance to market, high cost of transport, insufficient amount of milk produced, spoilage and cultural limitation were the reasons of the producers for not selling fresh whole milk both in Bordede and Mieso district. For example, the long distance to market of households in Dire-kalu rural *kebele* in Mieso decreases their participation in milk marketing. Cultural taboo was indicated as a limiting factor for milk marketing by only 8.33% and 8 % of the respondents in Bordede and Mieso district respectively.

This result is contrary to the report of Fita *et al*., (2005) in east Showa zone of Oromia, that among the many reasons reported by farmers, insufficient amount of milk production and cultural restriction were the most common hindering factors. Tola (2002) also reported that, about 21.3 % and 19 % of the women in Eastern Wollega did not sell fresh milk due to scarcity and cultural restriction, respectively. Lack of quality control of milk, lack of cooling and storage facilities at milk vending sites, poor quality of milk supplied from rural areas, inappropriate milk handling and storage vessels and spoilage of milk due to lack of preservation and processing facilities are constraints related to milk marketing (Eyassu and Doluschitz, 2014). Similarly, Lumadede *et al*. (2010) reported that seasonality of milk production, milk

spoilage, lack of milk collecting facilities and processing, poor hygienic standards are major challenges in raw milk marketing. Seasonal variation in camel milk production in pastoral production systems is great and it is believed that some surplus milk is wasted during the rainy seasons when production is high (Agrawal *et al*., 2013). Similar to the current study Hussen (2007) reported that milk sale was highly affected by small milk quantity (73%) followed by distance to market (38 %) and cultural taboo as a limiting factor for milk market participation in Mieso district.

The result of Omer (2019) indicates that lack of transportation, poor infrastructure, price, and poor milk handling (traditional) technologies were main challenges remarked in difficulties of fresh milk marketing in Degahbour Woreda, Jarar Zone and this result agree with the current study. In the current study the respondents stated that, during the wet season a large amount of milk surplus wasted due to lack of transportation. This result agrees with previous literature, Ahmed (2002) lack of road infrastructure to transport milk from pastoralist areas (remote areas) was the major constraints in Afder zone.

This all were caused by remoteness of the area from market sites. Generally, the fact that there is low limited cultural taboo both in Bordede and Mieso in milk marketing is an opportunity to develop market-oriented dairy development in the area. Moreover, the other limiting factors can be alleviated by providing appropriate technologies for enhancing utilization of available feed resources, range management system and improved animal health and reproductive management to increased milk production throughout the year. Distance to the market can be dealt with by using animals or by introducing animal drawn carts for milk collection and transport from remote areas. This all needs government intervention to develop infrastructure for input supply, enhanced use of animal power, capacity development and training to enhance the skills of producers in milk production and marketing.

Table 5 : Reasons for non-participation in milk marketing based on the response of producers in different kebeles of Bordede and Mieso district (%)

District	Reasons for non participation in milk marketing					
	long distance to market	high cost of transport	cultural limitation	Spoilage	Low milk production	Total
Bordede (N=60)	33.33	27.78	8.33	13.89	16.67	100
Mieso (N=60)	32	24	8	16	20	100
Total(N=120)	32.67	25.89	8.17	14.95	18.34	100

N= number of respondents

Milking Practice and Hygenic Conditions

Udder and hand washing

In the study area, all of the respondents practice hand milking. Majority of respondents in Bordede (76.67%) and Mieso (96.67%) reported that they did not wash hands before milking (Table 6). Dipping of milker's fingers into the milking vessel and moistening teats of the camels to facilitate milking was practiced in the study area. This practice may allow microbial contamination of the milk from the milker's hand and thus should be discouraged. The milker is an important source of milk contamination. Therefore, keeping good personal hygiene and milkers should be in good health during milking operation (Zelalem, 2010).

To ensure clean milk production cleaning of the udder before milking is one of the most important hygienic practices. But in this study, all of the respondents did not practice udder washing during milking both in Bordede and Mieso district. The producers believed that during calf suckling for milk let-down, the teat get washed by the saliva of calf and therefore it is not as such important to wash the teat before milking. Traditionally calves are allowed to suckle their dam before (to initiate milk let-down) and after milking (to drain whatever is left in the udder).

Similarly, Bereda *et al.* (2013) reported that all respondents did not practice udder washing before milking in Gurage Zone, Ezha district. In contrary Welearegay *et al.* (2012) reported that 82.5% of the small size farm owning households in Hawassa city practice pre milking udder washing. In Shashemenia town 71.79 % of the household milk producers wash the teats and udder of the cows before milking **(**Teshome, 2013).In addtion the other study conducted by Megersa *et al*. (2011) reported that 58% of small dairy farms and 85.7% of medium dairy farms in Bishoftu town cleaned the udder of the cow with warm water.

Table 6: Pre-milking udder preparation in the study areas

Variables	Bordede (N=60)%	Mieso (N=60)%	Overall mean (N=120)
Milking procedure			
Washing hands	23.33	3.33	13.33
Do not wash hand	76.67	96.67	86.67
Udder washing before milking	-	-	
Do not wash udder	100	100	100
Use of towel			
Use of towel	-	-	
No use of towel	100	100	100

N=number of respondents

Milking in dry condition significantly reduces bacterial count. It is because no surplus water remains on the surface of the udder to drip into the milk and due to less chance

of discharge dirt and bacteria from udder, teats and hands into milk (Islam *et al*., 2009). Wallace (2009) reported that thorough cleaning of the udder followed by drying with a clean cloth was effective in reducing the number of bacteria in milk contributed from soiled teats. But, in the current study, all of the respondents did not use towel for udder drying during milking (Table 6). The use of individual towel and following essential cleaning practices during milking is important for the production of quality milk (Zelalem, 2010).

Containers used for milking and transportation of milk

Table 7 shows the different containers used for milking and transporting of milk during marketing in the study area. Gourd and plastic containers were the major containers that used for milking in the study area. Gourd or locally called Gorboo were two types in the study area. The first one is made from wood and the second one is made from grass sewed by women. The respondents used plastic containers for both milking and transporting of milk during marketing. Producers need therefore pay particular attention for the type as well as cleanliness of milk equipment. Milking equipment should be easy to clean. Aluminum and stainless-steel equipment are mostly preferred.

About (35%) of the respondents in the study area used Gourd for milking. As reported by Yigrem *et al.* (2008) in Shashemenia - Della area, about 92% of urban producers used plastic milk utensils and about 43.3% of the rural producers used clay pot and plastics, while few (12.5%) farmers used locally made grass utensils. In Jikawo woreda of Nuer zone, Gambella region, farmers used different types of milk handling equipment for milking and storage such as traditional milking equipment (gourd) with different types and size for churning, milking and storing of milk and milk product, plastic jar, jug and nickel (Yien, 2014). Bereda *et al*. (2013) reported that all farmers in Ezha district of Gurage Zone used plastic jars as milking utensil.

Table 7: Containers used for milking in the study areas

District	Container				
	Clay pot	Stainless steel	Plastic	Gourd (Gorboo)	Total
Bordede (N=60) %	15	18.33	21.67	45	100
Mieso (N=60) %	21.67	23.33	30	25	100
Total (N=120)	18.34	20.83	25.84	35	100

N= number of respondents

Smoking of milk vessels and smoking plants

Washing of milk handling vessels with plant leaves as well as smoking them with tree stems is common in different parts of Ethiopia (Haile *et al*., 2012). The plants that are used for smoking milk vessels are indicated in Table 8.

Ejersa (Olea Africana) and Hulunk were the most frequently used plant species for smoking milk vessels in the study areas. The procedure for smoking milk vessels in this study area were turned upside down on a burning plant to make sure entrance of smoke in to the milk vessel and fumigate well until the utensil is sufficiently smoked. 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. This report is consistent with the report of Tassew (2007) and Derese (2008) who reported similar practices in Bahir Dar milk shed area and East Shoa Zones of Oromia region, respectively. Similar to this study, about 43.2% of the producers in Hawassa used different plants such as (Eucalyptus globules, Ocimum hardiense, Rutachalepensis, Cymbopogan martini and Agave sisalena) to fumigate before and after use of milk and milk products (Welearegay *et al*., 2012).

Table 8: Plants used for smoking milking containers and its purpose in the study area

Variables	Bordede (N=60) %	Mieso (N=60) %	Overall mean (N=120)
Plants used for smoking milking container			
Hulunko(Unidentified)	56.67	50	53.34
Kortatuma(unidentified)	1.67	-	0.84
Woyera(*Olea Africana)*	41.67	50	45.84
Purpose of smoking materials			
Increases flavor	56.67	50	53.34
Increase shelf life	21.67	28.33	25
to reduce multiplication of bacteria	21.67	21.67	21.67

N=number of respondents

Microbiological Quality Of Raw Camel Milk

Total bacterial count

As shown in Table 9 the mean±SD of total bacterial count was varied from 5.53±0.12 to 6.18±0.23 for sample collected from Bordede and 5.51±0.12 to 6.09±0.12 for sample collected from Mieso from udder to market respectively. Sample collected from market was significantly higher than milk samples collected from milking bucket and udder at ($P<0.05$). But there were no significant different ($p>0.05$) in TBC of milk samples collected from udder, milking container and market between district(5.53 to 5.51),(5.83 to 5.92) and (6.18 to 6.09) respectively in Bordede and Mieso respectively. The overall mean TBC of raw camel milk samples was 5.85 ± 0.15 *(log10cfu/ml).* Similarly, the study conducted by Abdirahman *et al. (*2017) shows that the overall

mean total bacterial counts of milk sampled from pastoralists in Gurusum district were 5.9 log10cfu/ml.

The mean raw camel milk TBC observed in this study agrees with those reported by (EU, 2004) (5.0 log CFU/ml), (Semereab and Molla, 2001) (5.6–5.0 log CFU/ml), (Mohizea, 1994) (5.4 log CFU/ml), (RH and AH, 2008) (5.22 log CFU/ml) and (Younan, 2004) (3.0–5.0 log CFU/ml). So far there are no Microbiological standards concerning camel milk. Therefore, Standard European Union (EU) microbiological limits (TBC 1 × 10^5 CFU/ml and CC 10^2 CFU/ml) for acceptable cow milk (EU, 2004) were used to assess the quality of camel milk in this study.

The current mean TBC was higher than the range of EU acceptable limits for raw milk intended for direct human consumption and processing. This might be due to the differences in initial contamination originating from the udder surface, quality of water used for cleaning milking utensils and the time lapse from production to marketing.

Milk collected directly from udder and milking bucket was found with relatively better bacteriological quality than the milk collected from market. This might be due to the traditional methods of distribution and transportation of milk including; use of easily contaminated and hard to clean container, long transit time to markets with frequent opening of containers for retail or milk transfer.

It was indicated that the total bacterial count in milk of developing countries falls between 5.30 to 5.88 log10 cfu/ml (Febrhadt and Micholes, 2004). Therefore, mean result of current study (5.84log10 cfu/ml) is found between the developing country's ranges. The total bacterial count obtained in this study is generally high compared to the acceptable level of 1 x 10^5 bacteria per ml of raw milk (O'Connor, 1994).

Table 9: Mean (±SD) of TBC (log10cfu/ml) collected from different milk source of the study sites

Sample source	Study district		
	Bordede (N=30)	**Mieso (N=30)**	**Mean**
Udder (N=20)	5.53^{c}±0.12	5.51^{c}±0.12	**5.52^{c}**
Milking bucket (N=20)	5.83^{b}±0.10	5.92^{b}±0.16	**5.88^{b}**
Market (N=20)	6.18^{a}±0.23	6.09^{a}±0.12	**6.14^{a}**
Mean	**5.85**	**5.84**	**5.85**

Means with different superscript letters in column are significantly different, P < 0.05; N = number of observations; TBC = total bacterial count; CC = Coliform count; cfu = colony-forming units

Coliform count

The mean±SD of coliform count was varied from 3.82±0.86 to 5.35±0.83 for sample collected from Bordede and 3.70±0.74 to 4.93±0.67 for sample collected from Mieso from udder to market respectively and sample collected from market was significantly higher than milk samples collected from milking bucket and udder at(P<0.05) (Table

10). But there was no significant different ($p>0.05$) in CC of milk samples collected from udder, milking container and market between district (3.82 to 3.7), (3.88 to 4.24) and (5.35 to 4.93) respectively in Bordede and Mieso respectively.

The overall mean CC of raw camel milk samples was 4.32±0.69 log CFU/ml (table 10). The mean CC observed in the current study is higher than the value of 2.83 log CFU/ml reported for milk samples collected from camels in central and southern regions of United Arab Emirates (Younan, 2004) and the value of 1.9 log CFU/ml reported for milk samples collected from camels in Gurusum district Somali regional state. However, it was lower than that reported by (Benkerroum *et al.*, 2003) 6.85 log CFU/ml in Morocco and (Benyagoub *et al.*, 2013) in south west Algeria (6.75 log coliform CFU/ml).

The overall value of coliform counts observed in the current study was higher when compared with the recommended values given by the American Public Health Association and EU (<100 CFU/ml). Mean CC increased in camel milk shows significant ($p<0.05$) increase from udder to milking bucket to market 3.76, 4.06 and 5.14 log CFU/ml respectively. This might be due to milk contamination at different levels while milk was passing through different stages of production.

Table 10: Mean (±SD) of CC (log10cfu/ml) collected from different milk source of the study sites

	Study district		
Sample source	**Bordede (N=30)**	**Mieso(N=30)**	**Mean**
Udder (N=20)	3.82^{c}±0.86	3.70^{c}±0.74	**3.76^{c}**
Milking bucket (N=20)	3.88^{b}±0.46	4.24^{b}±0.44	**4.06^{b}**
Market (N=20)	5.35^{a}±0.83	4.93^{a}±0.67	**5.14^{a}**
Mean	**4.35**	**4.29**	**4.32**

Means with different superscript letters in column are significantly different, $P < 0.05$; N = number of observations; TBC = total bacterial count; CC = Coliform count; cfu = colony-forming units

CONCLUSION AND RECOMMENDATIONS

The marketing system identified in the study area was mostly informal marketing system, in which the producers sell their milk and milk products to neighbors or the local market. It is well known that camel milk is one of the most reliable income sources to the pastoralist in the harsh area. The milk produced was sold mostly to individuals and some to cafes and restaurants. Price of milk per liter was used mainly as the milk marketing out let selection criterion while distance of market place also determined the criterion used to some extent. It was also revealed that the main means of transport used in transporting milk for sale was on animal and on foot delivery. The most important problems experienced in camel milk marketing were long distance to market, high cost of transport, insufficient amount of milk produced and spoilage. Therefore, solving feed and water problems, improving animal health and breeding

services, and commercialization of the activity by creating market chain, marketing facilities, infrastructure and establishing milk selling cooperatives will help in future development of the sector.

Results from the present study clearly indicated that the microbial quality of raw camel milk at various levels of milk source in Bordede and Mieso districts was poor. Significant differences were observed in bacteriological quality in milk samples along the milk source in which high degree of contamination occurred at market place than at farm level. The total bacterial count and total coliform count obtained in the present study was higher than acceptable limits. The presence of these bacteria not only indicates the poor hygienic conditions in which milk is produced and marketed but also, they could be pathogenic. Hence, adequate sanitary measures should be taken at all stages from production to consumption. These measures include proper handling of the camel, personnel hygiene, hygienic milking and storage equipment, improving milk and milk handling environment among others should be implemented and the work on the determination of camel milk standards in Ethiopia should be initiated.

Based on the findings of this study the following recommendations are forwarded

- Poor infrastructure, lack of transportations and poor milk handling were the main milk marketing problems in the study area, therefore proper intervention on infrastructure, transportation and providing producers with the necessary equipment and materials for milk handling, processing and storing could help to solve these problems.
- Provision of training to the pastoralists is crucial so as to improve their knowledge and skills on the management of their animals, on proper milking procedures, on hygienic conditions during milking and on production of quality milk.

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