Producing, Processing, Marketing and Hygiene of Cow Milk in the Supply Chain of Girar Jarso District of Oromia Regional State, Ethiopia

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Abstract

Background: Production and productivity of dairy is very low in Ethiopia. This problem is exacerbated by high contamination with microorganisms and other contaminants during production, procurement, processing and distribution. To tackle the problem, understanding the production, processing and microbial load of raw milk and measuring its hygiene quality is necessary.

Objectives: The study was conducted with the objective of assessing milk production, handlings, constraints of milk production and marketing, and its hygiene in urban and peri urban areas of Girar Jarso district of Oromia Regional State, Ethiopia.

Materials and Methods: A total of 150 respondents were interviewed using pretested questionnaire to collect data on dairy cattle management, milk production, hygienic conditions, milk production constraints and marketing. Moreover, 60 milk samples were collected and analyzed for mean aerobic mesophilic bacterial count (AMBC), total coliform count (TCC), and spore forming bacterial count (SFBC).

Results: The major feed resources were communal grazing land, crop residues, grass hay, concentrate feeds and non-conventional feed such as *atella*. The mean estimated daily milk yield/day/cow was 12.15 $\pm$ 0.26 and 2.69 $\pm$ 0.04 liters for crossbred and local cows, respectively. Average lactation lengths of local and crossbred dairy cows were 6.58 $\pm$ 0.22 and 9.19 $\pm$ 0.11 months, respectively. Shortage of feed, lack of clean water, appropriate utensils and adequate markets during fasting season were the major constraints to dairy production in the study area. The mean AMBC, TCC and SFBC for milk samples collected from producers at farm gates were 6.42 $\pm$ 0.07, 4.49 $\pm$ 0.09 and 2.59 $\pm$ 0.05 log10 cfu ml^{-1}, respectively.

Conclusion: It is concluded that dairy productivity in the study area is low and of poor quality as a result of different constraints and therefore good dairy husbandry and hygienic milk handling practices should be promoted to improve milk productivity and milk quality in the study area.

Keywords: Feed; Hygienic handling; Microbial quality; Milk yield; Production constraints.

1. Introduction

Dairy production is an important component of livestock farming in Ethiopia (Azage *et al*., 2013). Ethiopia is endowed with diverse topographic and climatic conditions favorable for dairy production that support the use of improved, high milk yielding dairy breeds, and offer relatively disease-free environments for dairy production (Berhanu, 2012). Cattle milk constitutes the larger proportion of the milk produced nationally (83%) (Pongruru and Nagalla, 2016). However, this potential has been hampered by different challenges such as lack of improved breeds, poor performance of local breeds, and shortage of feed in terms of quality and quantity (Pongruru and Nagalla, 2016).

Microorganisms may contaminate milk at various stages including production, procurement, processing and distributions. There is a steady challenge to those involved in milk production to prevent or minimize the entry and subsequent growth of microorganisms in milk (O'Connor, 1994). Therefore, an understanding of the microbial load of raw milk is important to measure its hygienic quality as high microbial load and presence of harmful pathogenic microorganisms in the milk samples are evidences of unhygienic milk production practices (Abrahamsen *et al*., 2007).

The intention of flourishing quality control is not routinely employed at individual farm level, and there is scarcity of data pertaining to the level of spoilage microorganisms and pathogens in commercially available raw cow's milk. There is a steady challenge to those involved in milk production to prevent or minimize the entry and subsequent growth of microorganisms in milk (O'Connor, 1994). Teshome *et al.* (2014) reported an average total coliform count (TCC) of 4.99 $\pm$ 0.081log cfu ml^{-1} for milk marketed in Shashemene town. Similarly, Amistu *et al.* (2015) also reported 5.42 $\pm$ 1.735 to 5.78 $\pm$ 0.985 log 10 cfu ml^{-1} in

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special zone of Oromia and Asaminew *et al.* (2011) 4.84 log10 cfu ml^{-1} for milk samples collected from Bahir Dar milk shed. According to Quality and Standards Authority of Ethiopia (Ethiopian Standards, 2008), TCC of good quality raw milk should not exceed 3 log10 cfu ml^{-1}. The presence of high TCC in milk indicates unsanitary conditions of milk production, processing and storage.

There was no formal quality control system in place to monitor and control the quality of milk produced and sold in the Girar Jarso district. Therefore, studying the production practice, quality of cow milk along the milk market chain is important. Therefore, the objective of this study was to assess milk production and handling practices, marketing system, production constraints and hygienic quality of raw cow milk along the milk market chain in urban and peri-urban areas of Girar Jarso District of Oromia Regional State, Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in urban and peri urban areas of Girar Jarso District which is one of the thirteen districts of North Shewa Zone of Oromia Regional State, Ethiopia. The district is geographically located at 09°45'121"N latitude and 038°46'728"E longitude and at an altitude of 2,677 meters above sea level. The district is located at a distance of about 112 km from Addis Ababa. The mean maximum and minimum temperatures of the area are 22.13 °C and 10.26 °C, respectively and average long-term annual rainfall is 1000 mm (NSMoLF, 2016, unpublished).

2.2. Design of the Study

This study had two parts (survey and laboratory experiment). For this study, urban (Fitche town) and peri-urban (rural *Kebeles* adjacent to Fitche town) of Girar Jarso district were purposively selected based on their milk production and marketing potential.

2.3. Survey study

A two-stage sampling technique was used for this study. In the first stage, urban and peri urban areas of the district were selected purposively based on milk production potential and participation in marketing. In the second stage, two *kebeles* from urban and two *kebeles* from peri-urban areas of the district were randomly selected. The list of all milk producers was obtained from Agriculture and Rural Development Office of the District. Then the respondents were selected proportionally using random sampling techniques. In addition, 30 milk collectors (15 from urban and 15 from peri-urban areas) were selected to assess milk hygiene across the milk market chain.

2.4. Milk Sampling Techniques

A total of 60 samples of raw cow milk (250 ml) were randomly collected based on the lottery method from the previously surveyed dairy farmers at farm gate and milk collection centers during January to March 2016. Morning milk was taken from the containers of each of the producer and bulk milk samples were collected from collection centers. The cow milk samples were collected aseptically using sterile bottles and immediately kept in an ice box and transported to Dairy Technology and Microbiology Laboratory of Holetta Agricultural Research Center for analysis. The milk samples were kept in a refrigerator at 4 °C upon arrival. The samples were analyzed within 24 hours as described by American Public Health Association (APHA, 1992) and all laboratory analyses were conducted in duplicates.

2.5. Microbiological Analysis

The microbiological analysis was done through enumeration of major microorganisms namely total aerobic mesophilic bacterial count (AMBC), total coliform count (CC), and spore-forming bacterial count (SFBC). To determine AMBC, 1 ml milk sample was diluted in 9 ml sterile peptone water (Oxoid, CM0009) and serial dilutions were made in sterile peptone water diluents until the expected level of 30-300 count was obtained. One of the milk samples from a chosen dilution was placed on the sterile plate. Then, plate count agar media (Oxoid, CM0325) of 15–20 ml was poured on to the plate and thoroughly mixed with the sample and allowed to solidify for 15 minutes. Then the plates were incubated for 48 ± 2 hours at 35 °C in an inverted position. Finally, colonies were counted manually (FDA, 2003).

Total coliform Count was determined using sterile violet red bile agar (VRBA) (Oxoid, CM0107). One ml of raw milk sample was added into a sterile test tube containing 9 ml of sterile peptone water (Oxoid, CM0009). After thoroughly mixing, the sample was serially diluted up to 10^{-9} and duplicate samples (each with 1 ml) were pour plated using sterile 15–20 ml VRBA. After gently mixing, the resulting plates were allowed to solidify and then incubated at 32 ± 1 °C for 24 hours (Murphy, 1996). Following incubation, typical dark red or purplish red or pink colonies appearing on the plates, measuring 0.5 mm or more in diameter on un-crowded plates and with bile precipitation around them were counted as coliforms (FDA, 2003). To determine SFBC, milk samples were first heat treated in a water bath (Chifton, UK) at 80 °C for 10 minutes. Appropriate dilutions of the milk samples (1 ml) were plated on duplicate solid plate count agar (Oxoid, CM0325) media. Then, colonies were counted after 3 days of incubation at 30 °C (Roberts and Greenwood, 2003).

2.6. Data Analysis

The survey data were analyzed using descriptive statistics (mean and percentage) of SPSS (Statistical Package for Social Sciences) software, version 20 (SPSS, 2011). Microbiological data were subjected to analysis of variance (ANOVA), SAS procedure, version 9.0 (SAS, 2009). Tukey's Studentized Range (HSD) test was employed to detect mean differences among sample sources.

The numbers of microorganisms (colony forming units) per milliliter of milk samples were expressed using the following mathematical formula (FDA, 2003):

$$N = \frac{\sum C}{(n1 * 2) + (0.1 * n2)} * d$$

Where,

N = Number of colony forming units per milliliter of milk

$\sum C$ = Sum of all colonies counted on plates

n1 = Number of plates in the first dilution counted

n2 = Number of plates in the second dilution counted

d = Dilution factor of lowest dilution used

Microbial count data were first transformed to logarithmic values ($\log_{10}$) before statistical analysis. The $\log_{10}$ transformed values were analyzed using the General Linear Model (GLM) procedure of analysis of SAS software.

$Y_{ij} = \mu + L_{i+} S_j + e_{ij}$; where, Y_{ij} = the dependent variables; μ =overall mean; L_i = location effect (peri-urban and urban); S_j = collection sites (farm gate and collection center) and e_{ij} = random error.

3. Results and Discussion

3.1. Household and Farming Practices in the Study Area

The majority of the respondents (80%) in the study area were married and male-headed households (Table 1). The educational levels of household heads varied between urban and peri-urban areas. About 60% of the household heads in urban areas completed high school education and above, whereas the majority of the household heads (56.7%) in peri-urban areas never went to school. Low level of education may have a direct impact on milk production, quality and safety of milk and milk products. Education is perceived as one of the prerequisites for the development of market oriented dairy farming and understanding determinants of market channel choices among smallholder dairy farmers (Zewdie, 2010).

Table 1. Marital and educational status and farming system of respondents in the study area.

Variable	Category	Urban (N = 60)		Peri urban (N = 60)		Overall mean (N = 120)	
		N	%	N	%	N	%
Marital status	Single	7	11.7	1	1.7	8	6.7
	Married	47	78.3	50	83.3	97	80.8
	Divorced	5	8.3	8	13.3	13	10.8
	Widowed	1	1.7	1	1.7	2	1.7
Educational status	Illiterate	12	20.0	34	56.7	46	38.3
	Read and write	3	5.0	12	20.0	15	12.5
	Elementary school	0	0	4	6.7	4	3.3
	Junior school	9	15.0	5	8.3	14	11.7
	High school	20	33.3	3	5.0	23	19.2
	Above high school	16	26.7	2	3.3	18	15.0
Farming system	Livestock only	51	85.0	6	10.0	57	47.5
	Mixed crop-livestock	9	15.0	54	90.0	63	52.5

Note: N = Number of respondents.

Mixed crop-livestock farming system was found to be the major practiced farming system as reported by 90% of the respondents in peri-urban area of the study district (Table 1). On the contrary, intensive livestock rearing was the sole farming activity in urban areas, which could be attributed to shortage of land. Among the livestock species, cattle are the most important component of the mixed crop-livestock farming system.

3.2. Dairy Cattle Management

3.2.1. Feed resource and feeding

Communal grazing land (64%), crop residues (of barley, teff, wheat and oat straw) (90.8%), grass hay (100%), concentrate feeds (64%) and non-conventional feed (*atella*) were the major feed resources of dairy cattle in the study area (Figure 1). In line with this result, Kibru *et al.* (2015) reported that communal gazing, private grazing and stall feeding were major feeding system in Aleta Chuko district, Southern Ethiopia. About 82% of dairy producers in urban area of the district were using purchased concentrate feed as supplement. However, only 47% of the respondents were using purchased supplement feeds in the peri-urban areas.

Hay making was the most commonly used means of feed preservation technique in the study area. This was used to mitigate livestock feed shortage during dry periods of the year and to avoid wastage of feed in times of surplus production during rainy season. In urban areas, grazing land was hardly available except in the backyards and some open communal fields. As a result, the majority of the cattle are kept indoor and fed on purchased hay, crop residues, concentrate and non-conventional feeds (Figure 1).

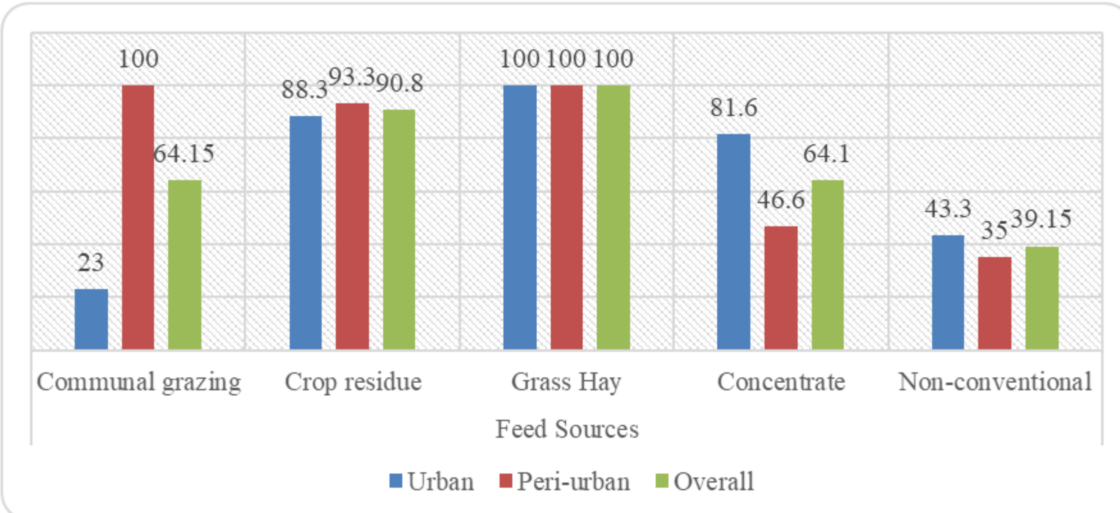

Figure 1. The major feed resources available in the study area (%).

3.2.2. Dairy cattle breeding

About 38% of the respondents were used artificial insemination (AI) to breed dairy cows. However, nearly 24% and 20% of the respondents depended on natural mating system using genetically improved bulls and combination of both methods, respectively (Table 2). In the absence of AI and improved bull services, some of the farmers were compelled to use (17.2%) local bulls. Both AI and veterinary services were delivered by the District Livestock Agency in both urban and peri urban areas. The AI service was delivered at the cost of 12.00 Birr per service and respondents reported that the price was affordable.

Similarly, a study conducted by Kibru *et al.* (2015) indicated that the majority of the farmers (91%) practiced natural mating system using local bulls available in the area while some of the farmers used both natural and artificial mating system (7%) and only 2% of them used AI in Aleta Chuko District of Southern Ethiopia. The present finding agreed with the findings of Zewdie (2010) who reported that AI, crossbred and local bulls were the most commonly used methods to breed dairy cows in the central highlands of Ethiopia.

Table 2. Breeding system used and available services in the study areas.

Variables		Urban (N = 60)		Peri urban (N = 60)		Overall mean (N = 120)	
		N	%	N	%	N	%
Breeding system	AI	33	55	13	21.7	46	38.3
	Local breed bull	2	3.3	19	31.7	21	17.6
	Crossbred bull	13	21.7	16	26.6	29	24.1
	AI and crossbred bull	12	20	12	20	24	20
Available breeding Service providers	Government (AI)	39	65	14	23.3	53	44.1
	Own bull	0	0	17	28.3	17	14.1
	Neighbors' bull	21	35	29	48.4	50	41.8

Note: AI = Artificial insemination and N = Number of respondents.

3.3. Family Labor Division for Dairy Production

Members of the households have a range of responsibilities for different dairy farm operations. Milking, cleaning of milk containers and barns, animal health management, milk processing and marketing, heat detection and feeding of dairy animals was the major dairy farm activities identified. Wives were highly engaged in milking and cleaning of milk containers and barns while husbands were mainly responsible for marketing of milk, feeding, heat detection and animal health management (Table 3) in the urban area of the district. Children assist in herding activities after and before school times.

In the peri-urban area of the district, husbands were most often involved in feeding, watering, health management, milking cows and milk marketing. Money earned from sale of milk was exclusively controlled by the husband. Kibru *et al.* (2015) reported that milking, milk processing, barn cleaning and sale of dairy products were mainly performed by wives while live animal marketing and stall feeding were performed by husband in Aleta Chuko district, southern Ethiopia.

Table 3. Family labor division for milk production related activities in the study area.

Activities	Location	Responsibility sharing among family members (%)			
		Men	Women	Children	Hired Labor
Feeding and watering of dairy animals	Urban	8.3	31.7	33.3	26.7
	Peri urban	28.3	8.4	53.3	10.0
	Overall mean	18.4	20.0	43.3	18.3
Barn cleaning	Urban	0.0	45.0	36.7	18.3
	Peri urban	1.7	66.7	20.0	11.6
	Overall mean	0.9	55.8	28.3	15.0
Cleaning of milk container	Urban	15.0	38.3	25.0	21.7
	Peri urban	0.0	71.7	21.7	6.6
	Overall mean	7.5	55.0	23.4	14.1
Milking of cow	Urban	20.0	38.4	8.3	33.3
	Peri urban	6.7	70.0	5.0	18.3
	Overall mean	13.4	54.2	6.6	25.8
Milk marketing	Urban	41.7	15.0	40.0	3.3
	Peri urban	40.0	16.6	36.7	6.7
	Overall mean	40.9	15.8	38.4	4.9

3.4. Daily Milk Yield and Lactation Length

The overall average number of lactating crossbred and local breed cows owned per household in the study area were 1.92 ± 0.12 and 1.86 ± 0.15, respectively (Table 4). The number of lactating crossbred cows varied significantly ($P < 0.05$) between urban and peri urban areas of the study district. The difference could be attributed to relatively better access to AI service and market opportunities of the urban farmers. The mean estimated daily milk yield/liter/cow obtained from crossbred cows (12.15 ± 0.26) was four times higher than that of the local cows (2.69 ± 0.04). The current report on milk yield of local cows was slightly higher than the earlier report by Asaminew *et al.* (2011) (average of 2 liter/day/cow) and Zewdu (2004) (1.8 liters/day/cow) in the first and second lactations in North Gonder Zone.

The overall average lactation length of local and crossbred cows was 6.58 ± 0.22 and 9.19 ± 0.11 months, respectively. The average lactation length of the local cows and crossbred cows observed in this study is only slightly shorter than that reported by Debir (2016) in Sidama Zone, Southern Ethiopian which were 7.38 ± 10 and 9.79 ± 11 months for local and crossbred cows, respectively.

Table 4. Daily milk yield and lactation length of crossbred and local cows in the study area.

Variable		Urban		Peri-urban		Overall mean		SL
		N	Mean± SE	N	Mean± SE	N	Mean± SE	
Number of lactating cows	Local breed	6	1.16 ± 0.66	37	1.973 ± 0.17	43	1.86 ± 0.15	ns
	Crossbred	59	2.12 ± 0.85^{a}	41	1.63 ± 0.12^{b}	100	1.92 ± 0 .12	*
Milk yield of cows (liters/day)	Local breed	6	2.83 ± 0.16	37	2.66 ± 0.20	43	2.69 ± 0.04	ns
	Crossbred	59	13.14 ± 0.34^{a}	41	11.52 ± 0.35^{b}	100	12.15 ± 0.26	**
Lactation length (months)	Local breed	6	6.14 ± 0.26^{a}	37	6.66 ± 0.11^{b}	43	6.58 ± 0.22	*
	Crossbred	59	9.28 ± 0.13^{a}	41	9.04 ± 0.21^{b}	100	9.19 ± 0.11	*

Note: N = Number of respondents. Means with different superscripts in the same rows for the same parameter are significantly different at P < 0.05; ns = non-significant; SL = significance level.

According to the report of NSMoLF (2016), the total numbers of households using local cows for milk production were about 13,566 with about 2998 households using crossbred dairy cows. A total of 34,638,240 and 23,160,480 liters of milk were produced per annum from crossbred and local cows, respectively. High proportion of households in the district (80%) is engaged in selling raw milk.

3.5. Milk Hygienic Practices

3.5.1. Dairy cattle housing

Almost all of the respondents (99.2%) had separate barn for dairy cattle. Most of the cattle houses had roofs made of corrugated iron sheet. Some of the households also used crop residue and grasses for thatching roofs (Table 5).

Table 5. Daily milk yield and lactation length of crossbred and local cows in the study area.

Variable		Urban (N = 60)		Peri-urban (N = 60)		Overall mean (N = 120)	
		N	%	N	%	N	%
House type	Separate house	60	100.0	59	98.3	119	99.2
	Inside family house	0	0.0	1	1.7	1	0.8
Floor material	Concrete/cement	37	61.7	3	5.0	40	33.4
	Mud/earthen	0	0.0	20	33.4	20	16.6
	Stone	23	38.3	37	61.7	60	50.0
Type of roof	Tin/corrugated iron	52	86.7	27	45.0	79	65.8
	Thatched	8	13.3	23	55.0	41	34.2

Note: N = number of respondents.

In the urban area, dairy producers built the floor with concrete and stone whereas 95% of the respondents in peri urban area used stone and earthen floor as bedding material. In contrast to this finding, Abebe *et al.* (2012), Berhanu (2012) and Kibru *et al.* (2015) reported that cattle share the same house with the family member during the night time in the southern Ethiopia. Asaminew (2007) also found that some of the households keep cattle in the same room with family members at Bahir Dar Zuria and Macha districts. In line with the findings of this study, Mustefa (2012) reported for Sululta and Welmera districts that about 94% of the dairy herd owners used earthen and stone floors.

3.5.2. Dairy animal health

The major dairy cattle diseases reported in the study area were anthrax (*Abba Sangaa)*, foot and mouth disease (FMD) (*Manse)*, pasteurollosis (*Gororsiisaa),* blackleg (*Abba Gorbaa*), mastitis (*Muchaa Dhiitessaa*) and metabolic disorder due to imbalance feeding rations (*kirkirsiisaa*). Most of dairy herd owners (93%) encountered cow udder infection.

Table 6. Udder health problems of dairy cattle and treatments practiced in the study area.

Variable		Urban (N = 60)		Peri-urban (N = 60)		Overall mean (N =120)	
		N	%	N	%	N	%
Encounter Udder problem	Yes	16	26.7	14	23.3	30	25.0
	No	44	73.3	46	76.7	90	75.0
Milk animals with udder problem	Yes	16	100.0	11	84.6	27	93.1
	No	0	0.0	3	15.4	3	6.9
Milk from infected udder	Dispose	11	68.7	3	27.3	14	51.8
	Use as animal feed	5	31.3	8	72.3	13	48.1
Udder disease treatment	Veterinary treatment	15	93.8	12	92.3	27	93.1
	Veterinary and Traditional treatment	1	6.2	2	7.7	3	6.9

Note: N = Number of respondents.

As a result, milk obtained from infected udders was either discarded (52.8%) or fed to animals (48%) (Table 6). In agreement with the current finding, Zewdie (2010) reported occurrence of anthrax, FMD, blackleg and mastitis as major diseases in the central highlands and central Rift Valley of Ethiopia. The same author also stated that these diseases usually occurred during the short rainy season (March to May) when animals are in poor body condition due to inadequate feed availability in the preceding dry period. About 93% of dairy herd owners reported udder infection but they had access to veterinary services for udder infection from the nearby government veterinary clinics. Milk produced from infected udders of milking cows were either discarded (52.8%) or fed to animals (48%).

3.5.3. Milking and milk hygienic practice

In the study area, milking was practiced twice a day, in the morning and the evening. About 87.5% of the respondents used a wide-necked plastic vessel for milking whereas only 12.5% of the respondents used an aluminum milking can (Table 7). Similar studies by Teshome *et al.* (2014) and Teklemichael (2012) reported that 84.62% of the surveyed small-scale milk producer in Shashemane town and 75% of the surveyed farmers in Dire Dawa town, respectively used plastic utensils. This might be due to the fact that aluminum made vessels are very expensive, not affordable and are hardly available for most the farmers in the local markets.

Table 7. Milk hygiene practices during milking in the study area.

Variable		Urban (N = 60)		Peri-urban (N = 60)		Overall mean (N = 120)	
		N	%	N	%	N	%
Utensil used for milking	Wide necked-aluminum can	10	16.6	5	8.3	15	12.5
	Wide-necked plastic can	50	83.4	55	91.7	105	87.5
Cleaning cow's shed before milking	Yes	28	46.7	23	38.3	51	42.5
	No	32	53.3	37	61.7	69	57.5
Wash hand before milking	Yes	59	98.3	55	91.7	114	95.0
	No	1	1.7	5	8.3	6	5.0
Wash udder before milking	Yes	34	56.7	18	30.0	52	43.3
	No	26	43.3	42	70.0	68	56.0
Use of towel while cleaning udder	Individual towel	10	16.7	4	6.6	14	11.7
	Collective towel	17	28.3	5	8.3	22	18.3
	Not at all	33	55.0	51	85.0	84	70.0

Note: N = Number of respondents.

Milking was usually done under poor hygienic conditions where milking rooms were contaminated with cow dung and urine. More than half of the sample households (57.5%) did not clean barn before milking. The influence of dirty cows on total bacteria counts depended on the extent of soiling of teat surface and cleaning procedures, followed immediately before milking (Teshome *et al.*, 2015). About 43% of the respondents washed udder of milking cows before milking; however, 70% of these respondents did not use towel to dry up the udder after washing. Only 22% of the respondents used common towel to dry up udder after washing. Haile *et al.* (2012) and Amistu *et al.* (2015) also reported that 70–82.5% of smallholder farmers in Ethiopia did not practice drying up of udders using individual towel. The results of this study are consistent with the findings of Teshome *et al.* (2015) who reported that 71.79% of the household milk producers washed the teats and udder of the cows before milking, but without using detergents for cleaning udder and teats.

3.6. Milk Handling Practices at Collection Center

Milk collection in the study area usually takes place in the morning time for both evening and morning milk. Milk was usually sold only in the morning times and hence milk producers store the evening milk in cold water to keep milk temperature lower until the next morning to reduce microbial multiplication. About 86.7% of milk was directly collected from dairy producer, while 13.3% of milk collectors buy milk from milk venders. All dairy farmers deliver milk to milk collection center by themselves (Table 8).

The majority of milk collectors in the study area practiced milk quality test (Table 8). The common quality tests in the study areas were lactometer reading and alcohol test. However, 6.6% of milk vendors did not apply milk quality test. The major dairy processing plants (96.7) such as Lame Dairy PLC (Shola Milk Enterprise), MB PLC (Family Milk), Sebeta Agro-industry (Mama Dairy) and Elemtu Integrated Milk Industry were the formal customers that buy milk from those private milk collectors in the study area. Hotels and restaurants in Fitche town were also customers of the milk collectors. The equipment used to store and transport milk at collection centers was plastic container (80%) and only 20% of the collectors used stainless steel.

Table 8. Milk handling practices at collection centers of the study area.

Variable		Urban (N = 15)		Peri-urban (N = 15)		Overall (N = 30)	
		N	%	N	%	N	%
Source of milk	Farmers	12	80.0	14	93.3	26	86.7
	Milk vender	3	20.0	1	6.7	4	13.3
Mode of delivery	Farmer deliver the milk	15	100.0	15	100.0	30	100.0
Milk quality test methods upon delivery	Organoleptic test	42	6.7	74	6.7	11	36.7
	Lactometer and alcohol test	11	73.3	6	40.0	17	56.7
	No test	0	0.0	2	13.3	2	6.6
Type of costumer	Milk processing plant	14	93.3	15	100.0	29	96.7
	Hotel and restaurant	1	6.7	0	0	1	3.3
Milk transportation utensils	Stainless steel	5	33.3	1	6.7	6	20.0
	Plastic water bottles	10	66.7	14	93.3	24	80.0
Milk cooling facility	Yes	3	20.0	0	0	3	10.0
	No	12	80.0	15	100.0	27	90.0

Note: N = number of respondents.

3.7. Milk Marketing

Out of the total milk produced per day, the biggest share was supplied to the market. Producers also processed milk into butter and cottage cheese (Table 9). The total milk (TM) produced per day per household was significantly ($P < 0.05$) higher for urban (24.63 liters) than that of the peri urban (16.86 liters) households. All dairy producers who sell milk in the study area entered contractual agreements with milk collectors to deliver milk on daily bases and to collect milk money every fortnight.

Table 9. Quantity of milk produced, processed, consumed and marketed in the study area.

Variable	Urban	Peri urban	Over all mean
	Mean ± SE	Mean ± SE	Mean ± SE
TM produced/HH/day (liters)	24.63 ± 1.67^{a}	16.86 ± 1.32^{b}	20.75 ± 1.19
TM processed HH/day (liters)	2.33 ± 0.22	1.26 ± 0.19	1.80 ± 0.15
TM consumed HH/day (liters)	1.72 ± 0.10	0.97 ± 0.09	1.35 ± 0.77
TM sold/HH/day (liter)	20.57 ± 1.51^{a}	14.77 ± 1.19^{b}	17.67 ± 0.99
Time to arrive at market place (in min)	12.15 ± 1.07^{b}	20.61 ± 1.68^{a}	16.38 ± 1.6

Note: TM = Total milk and HH = house hold. Means with different superscripts in the same rows are significantly different (P <0.05).

Private milk collectors and cooperatives/union buy milk from the producers on credit basis. Establishment of milk groups and milk-collection centers gave dairy farmers a broader choice of milk marketing instead of being dependent on local traders and neighborhood buyers. Thus, one entry point for intervention to improve the dairy sector could be the formation of new dairy cooperatives as well as strengthening the existing dairy cooperatives (Birhanu, 2013).

3.8. Constraint of Milk Production, Quality and Marketing

The major constraints affecting dairy production in the study area were shortage of feed, lack of land, lack of productive dairy breeds, lack of clean water and presence of poor animal health services (Table 10). The current finding was in line with the result of Tsegaye *et al.* (2015) who reported feed shortage, animal health as well as water and labor scarcity problems being the major challenges which affect dairy cattle production and productivity in selected district of Sidama Zone, Southern Ethiopia. Moreover, limited awareness on hygienic handling, lack of appropriate materials used for milking and milk handling, shortage of capital and hygiene of the milker were found to be the other important constraint to the dairy sector. With regard to market related problems, majority of the respondents reported the absence of adequate milk markets during fasting seasons, high feed prices, and low milk and milk product prices. On the other hand, price regulatory mechanisms were not in place to make such important food item easily available with an affordable price to the large segment of the consumers.

Table 10. Milk production, quality and marketing constraint in the study area.

Production constraints	1st	2nd	3rd	index	Rank
Poor quality and quantity feed	80	38	2	0.45	1st
Lack of land	37	63	0	0.34	2nd
Lack of productive dairy breeds	0	0	61	0.09	3rd
Lack of clean water	0	20	16	0.08	4th
Poor animal health	0	20	8	0.04	5th
Milk and milk product quality related constraints	1st	2nd	3rd	index	Rank
Limited awareness on hygienic milk handling	56	55	0	0.37	1st
Lack of appropriate utensils for milking and milk handling	46	49	9	0.33	2nd
Shortage of capital	16	34	8	0.17	3rd
Poor hygiene of the milker	6	23	32	0.13	4th
Marketing related constraints	1st	2nd	3rd	index	Rank
Lack of adequate markets during fasting season	62	16	37	0.39	1st
Increased feed prices	35	59	13	0.36	2nd
Low price of milk and milk products	23	26	11	0.20	3rd
Discarding of milk delivered to milk collector	0	8	19	0.05	4th

Note: Index = the sum of (3 times first order + 2 times second order +1 times third order) for individual variables divided by the sum of (3 times first order + 2 times second order +1 times third order) for all variable.

3.9. The Microbial Quality of Raw Cow Milk in the Study area

The mean value of aerobic mesophilic bacterial count (AMBC) of raw milk samples collected from producers (6.42 ± 0.07) was significantly ($P < 0.05$) lower than that of the milk collectors (7.49 ± 0.10) (Table 11). However, significantly ($P < 0.05$) lower bacterial counts of raw milk were observed in both sampling sources of urban areas of the district. The differences in the overall mean of bacterial counts observed in the study area might be attributed to the time elapsed after milking which is longer for collection centers. Similar values of AMBC 7.28 log10 cfu ml^{-1} was report by Haile *et al.* (2012) for milk samples collected from different farm sizes in Hawassa, Southern Ethiopia. Solomon *et al.* (2013) also reported 7.08 $\log_{10}$ cfu ml^{-1} for raw milk samples obtained from the selected large-scale dairy farms in Debre-Zeit town.

Table 11. Bacterial counts of raw cow milk produced and marketed in study area.

Parameters	Milk Sampling sources	Location		Overall mean
		Urban	Peri-urban	
AMBC	Farm gate	6.22 ± 0.10^{c}	6.62 ± 0.13^{b}	6.42 ± 0.07
	Collection center	6.99 ± 0.15^{b}	7.99 ± 0.15^{a}	7.49 ± 0.10
TCC	Farm gate	3.87 ± 0.13^{d}	5.10 ± 0.13^{c}	4.49 ± 0.09
	Collection center	6.96 ± 0.18^{b}	7.13 ± 0.18^{a}	7.05 ± 0.10
SFBC	Farm gate	2.42 ± 0.74^{d}	2.77 ± 0.10^{c}	2.95 ± 0.05
	Collection center	3.27 ± 0.10^{b}	4.13 ± 0.10^{a}	3.7 ± 0.07

Note: AMBC = Aerobic Mesophilic Bacteria Count; TCC= Total Coliform Count and SFBC = Spore Forming Bacteria Count. Means in all columns and rows bearing with different superscripts letters for the same parameter are significantly different from each other ($P < 0.05$).

However, the results obtained in this study are lower than the findings of Haile *et al.* (2012) and Teklemichael (2012) who reported a total bacterial count of 9–10 $\log_{10}$ cfu ml^{-1}. According to Quality and Standards Authority of Ethiopian (Ethiopian Standards, 2009), good quality milk should not contain a total bacterial count of more than 5 $\log_{10}$ cfu ml^{-1} which indicated that the milk produced and marketed in the study area did not meet the quality standards set by the same Authority. The majority of the households in the study area reported the use of plastic containers for milking, transporting and storage. But these types of containers are not easy to clean with locally available cleaning methods and hence the milk residue may favor microbial multiplication that ultimately leads to having poor quality milk.

The overall mean total coliform count (TCC) observed from farm gate (4.49 ± 0.09) is lower than the result of Teshome *et al.* (2014) who reported an average TCC of 4.99 ± 0.081$\log_{10}$ cfu ml^{-1} for milk marketed in Shashemene town. However, the current study showed higher TCC values than the finding of Abebe *et al.* (2012) who report 4.18 ± 0.01 $\log_{10}$ cfu ml^{-1} for raw milk samples in the Ezha districts of the Gurage Zone. In the current study, the TCC of raw milk sampled from collection centers (7.05 ± 0.10) were significantly ($P < 0.001$) higher than that of milk samples taken from the farm gate. According to ES (2008), the TCC of good quality raw milk should not exceed 3 $\log_{10}$ cfu ml^{-1}. The presence of high TCC in milk indicates unsanitary conditions of milk production, processing and storage. Moreover, presence of large number of TCC in dairy products is an indicator of potential hazard to consumer's health due to possible presence of other enteric pathogens (Godefay and Molla, 2000).

The Spore Forming Bacteria Count (SFBC) found from the samples of peri urban producers and collectors was significantly ($P < 0.0001$) higher than that of milk samples from urban producers and collector (Table 11). This result is lower than the report of Teshome *et al.* (2014) who indicated 4.703 ± 0.069 $\log_{10}$ cfu ml^{-1} in Shashemene town.

4. Conclusion

The results of the current study have demonstrated that the major feed sources for cattle in the study area were a combination of grazing, grass hay, crop residues, concentrate and non-conventional feed resources like *atella* and *bean hull.* The overall average numbers of lactating local and crossbred cows per household in the study area were 1.86 ± 0.15 and 1.75 ± 0.16, respectively. About 99.2% of the farmers used separate house type barn for cows of which about 65.8% used corrugated iron sheet covered barns and the rest used grass thatched roof barns. Mean aerobic bacterial count (AMBC), coliform count (CC) and spore forming bacterial count (SFBC) for milk samples collected from milk collection center were significantly higher ($P < 0.05$) than milk samples obtained from farm gates. Generally, the overall microbial count increased during milking at on-farm to collection centers, reflecting poor hygiene at milking, milk handling and transportation. This is mainly due to poor hygienic condition of the feeding system, milking environment, poor udder and teats cleaning practices, failure to use separate towel for each cow and the poor personal hygiene of the milkers. Therefore, awareness should be created on the importance of adequate udder preparation, hygienic milking environment, and use of appropriate milk equipment to produce and supply wholesome milk to the market. Moreover, milk collection centers should be equipped with cold chains, the necessary dairy equipment and quality water supply to minimize milk contamination.

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