Handling Practices and Microbial Quality of Raw Cow's Milk Produced and Marketed in Shashemene Town, Southern Ethiopia

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Abstract

The study was conducted in Shashemene town, Southern Ethiopia, aimed to assess general handling practices and microbial quality of raw cow's milk produced and marketed in the town. A total of 90 respondents from dairy cooperative milk collection centers, hotels, small shops and small scale milk producers were randomly selected. A total of 48 samples of raw cow's milk were collected in the morning to assess microbial quality of raw cow's milk. All of the samples were collected using proportional random sampling method. The overall mean total bacterial count, coliform count, spore-forming bacterial count and yeast and mould count of raw milk samples obtained in the study area were 7.125 ± 0.091, 4.999 ± 0.081, 4.703 ± 0.069 and 4.206 ± 0.082 log10 cfu/ml, respectively. Total bacterial count, coliform count, spore-forming bacterial count and yeast and mould count of milk samples obtained from dairy cooperative milk collection centers were significantly higher (P<0.05) than milk samples obtained from hotels, small shops and small scale milk producers. Therefore, it was concluded that the microbial quality of raw cow's milk produced and marketed in the study area was poor and this suggests the need for improved hygienic practices and handling of milk at all levels of dairy market chain.

Keywords: Handling practices, Microbial quality, Raw Cow milk, Shashemene Town.

INTRODUCTION

Milk is a good growth medium for many microorganisms because of its high water content, nearly neutral pH, and variety of available essential nutrients. Bacteria, yeasts and moulds are the common contaminants of milk. Their rapid growth, particularly at high ambient temperature can cause marked deterioration in quality of the milk and dairy products manufactured from it (FAO, 1989). Bacterial contamination of raw milk can occur from different sources such as air, milking equipment, feed, soil, faeces, and sick animals (Torkar and Teger, 2008).

The microbial load and types found in milk shortly after milking are influenced by factors such as animal cleanliness and health, equipment cleanliness, season, ambient temperature, storage and personnel health. Daily production and eventual marketing of milk requires special consideration to ensure its delivery to the market in hygienic and acceptable condition (Kivari et al., 2006). Milk produced at smallholders farm in Ethiopia is marketed without any form of pasteurization or quality control measures. There is scanty information on the microbial quality and chemical composition of raw milk in Ethiopia (Eyasu and Fekedu, 2000; Zelalem and Faye, 2006). Hygienic control of milk and milk products in Ethiopia is not usually conducted on regular bases. Apart from this, door-to-door raw milk delivery in the...
urban and peri-urban areas is commonly practiced with virtually no quality control at all levels (Godefay and Molla, 2000).

Moreover, most of the studies conducted yet concerning bacteriological quality of either raw or pasteurized milk at milk collecting centers and processing plants in Addis Ababa and its vicinity (Alehegn, 2004). However, there was no study conducted on quality of raw milk collected from dairy cooperative milk collection centers, hotels, small shops and small scale milk producers in Shashemene town. In addition, there is no formal quality control system in place to monitor and controls the quality of milk produced and sold in the town. The objective of this study was to assess the general handling practices and microbial quality of raw cow’s milk produced and marketed in Shashemene town.

MATERIALS AND METHODS

Study area

The study was carried out in Shashemene town, which is located between 7°11'09" to 7°13'19"N latitude and 38°35'02" to 38°37'05"E longitudes. Shashemene town is found in Oromia National Regional State, West Arsi Zone, and located 250 km south of the Addis Ababa, and placed at the road junction of Addis Ababa to Hawasa, Bale and Arba Minch. The town is located at an altitude ranging from 1900 to 1950 meters above sea level (masl). Its annual average temperature ranges between 18 and 25°C and has moderate annual rainfall ranging between 800 and 1300mm (BoFED, 2012).

Research Design

The study involved both cross-sectional survey method aimed to assess handling practices and a laboratory-based investigation aimed to determine microbial quality of raw cow’s milk produced and marketed in Shashemene town. A total of 90 respondents were selected using simple random sampling technique and interviewed using a semi structured questionnaires and 48 samples of raw cow’s milk were collected at morning from dairy cooperative milk collection centers, hotels, small shops and small scale milk producers from purposively selected three urban Kebeles.

Sources of Data and Sampling Techniques

Milk samples were collected from the dairy cooperative milk collection centers; hotels, small shops and small scale milk producers, and questionnaires were employed to collect data from selected respondents. Among those selected respondents dairy producers and sellers were involved. All the samples were collected using proportional random sampling method.

Milk sample collection

A total of 48 samples of raw cow milk were collected at morning from four different sampling points namely, dairy cooperative milk collection centers, hotels, small shops and small scale milk producers from purposively selected three urban Kebeles. Five hotels, five small shops sellers, five small scale milk producers and one dairy cooperative milk collection centers from those who took part in the interview were selected at each Kebele. These households were selected based on the results of the survey work from each Kebele.

Samples of morning raw milk were aseptically taken twice at different times (December 2012 to February 2013) from each sampling point in five days interval. During collection, approximately 300 ml raw milk sample was aseptically collected from bulk milk container of producers and sellers and placed into sterile glass bottles. Subsequently, samples were labeled and put into icebox and then transported to the Dairy Technology Laboratory of Hawassa University to analyze microbial quality. The analysis was performed within two to three hours after sampling.

Microbial Analysis

The microbial analyses of milk samples include the determination of colony-forming units (CFUs) of total bacteria, coliform bacteria, spore-forming bacteria and yeast and mould using appropriate media. All media used for microbial analyses were sterilized before use according to the manufacturer’s guidelines.

Total bacterial count

For total plate count, appropriate decimal dilutions that would give the expected total number of colonies on a plate, i.e., between 30 and 300 colonies were selected (Richardson, 1985). The standard plate count (SPC) agar was cooled to 45°C before pouring. One ml of milk sample was added into sterile test tube containing nine ml peptone water up to serial dilution of 10⁻² and mixed thoroughly. Total bacterial count was made by incubating surface plated duplicate decimal dilutions of milk samples on standard plate count agar (Oxoid, UK) at 32 °C for 48 hours. Finally, colony count was made using colony counter (Schutt Count Plus D-37079, Germany).

Coliform count

One ml of milk sample was added into sterile test tube
containing nine ml peptone water up to serial dilution of 10^{-7} and mixed thoroughly. Duplicate appropriate decimal dilutions were surface plated and incubated at 32^\circ C for 24 hours on Violet Red Bile Agar (Pharma, US) and typical dark red colonies on uncrowned plates was considered as coliforms and counted. This was followed by a confirmatory test by transferring and incubating four to five typical colonies from each plate transferred into tubes containing 2% Brilliant Green Lactose Bile Broth (Oxid, UK). Gas production within 48 hours of incubation at 35^\circ C was considered as sufficient evidence for the presence of coliforms (Richardson, 1985).

**Spore-forming bacteria count**

The enumeration of spore-forming bacteria was done using plate count agar following the methods recommended by McLandsborough (2005). Milk samples were heated at 80^\circ C for 10 minutes in water bath and volumes of 0.1 ml of appropriate dilutions were surface plated as for the standard plate count using plate count agar. All plates were incubated in an inverted position for 3 days at 30^\circ C and colonies were counted.

**Yeast and mould count**

Samples of milk were serially diluted following similar methods as for total bacterial count but dilutions were surface plated on Potato Dextrose Agar (PDA) (Oxoid, Pvt. Ltd. MU 096: UK). The dried plates were then incubated at 25^\circ C for 3 to 5 days. Colonies with a blue green color was counted as yeasts and moulds (Yousef and Carlstrom, 2003).

**Statistical Analysis**

Data collected through the survey was analyzed using simple descriptive statistics (i.e. means and percentage). On the other hand, the number of microorganisms (colony forming unit) per milliliter of milk was calculated using the following mathematical formula FDA (2001).

\[ N = \frac{\sum CN}{(1+n_1) + (0.1+n_2)} \times d \]

Where \( N \) is the number of colonies per milliliter of milk, \( \Sigma c \) is the sum of colonies on plates counted, \( n_1 \) is the number of plates on the lower dilution counted, \( n_2 \) is the number of plates in next higher dilution counted and \( d \) is the reciprocal of lowest dilution factor used. Data from microbial counts were first transformed to logarithmic values (log_{10}) before statistical analysis. Then, data on the transformed microbial count values were analyzed using General Linear Model (GLM) procedure of SAS (SAS, 2009). Mean separation was carried out using the Least Significant Difference (LSD) technique when analysis of variance shows significant differences between means and differences were considered significant at p < 0.05.

**RESULTS AND DISCUSSION**

**Hygienic Condition of Milk**

**Milking practice**

All the households milk their cows by using hand milking either washing cow teats or letting calf to suckle its dam for minutes to stimulate milk let-down. About 71.79% of milk producers milk their cows using hand milking by washing teats without calf suckling while 28.21% of milk producers milk their cows by hand after calf suckling. According to Merbis et al. (2001) restricted suckling before and after milking is used in most dual purpose cattle production systems of Latin America, partly as a consequence of difficulties in milking cows with Bos indicus genes without the presence of the calf.

As indicated in Table 1, all household milk producers’ milk their cows twice a day (morning and evening) while the cows are in a barn or under a tree shade. Most of the household milk producers cleaned the udder and teats of cows before milking. About 71.79% of the household milk producers wash the teats and udder of the cows before milking. However, it was observed that most of them did not use detergents for cleaning of udder and teats rather they cleaned only by tap water. Washing of udder and teats before milking was not practiced by some household milk producers who let the calf to suckle before milking and they believe that during calf suckling for milk letdown, the teats get washed by the saliva of calf and therefore it is not as such important to wash the teats before milking.

Moreover, 71.79% of the household milk producers did not use separate towels to dry the udder and teats of each cow. These practices may favor contamination of milk from the udder and teats of infected cows. Even though most of the household milk producers in Shashemene town wash cow’s udder before milking, because of poor hygiene of milking area and failure to use separate towel for individual cows, there could be high chance of contamination of the milk with pathogenic microorganisms.

Gran et al. (2002) reported that insufficient cleaning of the udder may result in contamination of milk. The use of detergent and good-quality water for cleaning could be expected to remove milk remains, including microorganisms that affect the microbial quality of milk. However, in this study, the result showed that 82.05% of the milk producers did not wash their hands using detergents prior to milking (Table 1). Apart from this, dust particles from unclean udder and from the body of the cows can contaminate the milk.

Data from the survey showed that 84.62% of the household milk producers’ did not have separate place...
Table 1. Milking procedure followed by household milk producers in the study area (n = 39).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Percent of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique of milking</td>
<td>71.79</td>
</tr>
<tr>
<td>Washing teat</td>
<td></td>
</tr>
<tr>
<td>Calf suckling</td>
<td>28.21</td>
</tr>
<tr>
<td>Frequency of milking</td>
<td></td>
</tr>
<tr>
<td>Once a day</td>
<td></td>
</tr>
<tr>
<td>Twice a day</td>
<td>100</td>
</tr>
<tr>
<td>Practice of washing the udder and teats before milking</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>71.79</td>
</tr>
<tr>
<td>No</td>
<td>28.21</td>
</tr>
<tr>
<td>Presence of separate towel</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>71.79</td>
</tr>
<tr>
<td>No</td>
<td>28.21</td>
</tr>
<tr>
<td>Practice of washing hands with soap before milking</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>17.95</td>
</tr>
<tr>
<td>No</td>
<td>82.05</td>
</tr>
<tr>
<td>Presence of separate place for milking the cow</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>15.38</td>
</tr>
<tr>
<td>No</td>
<td>84.62</td>
</tr>
<tr>
<td>Presence of separate worker for milk</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>76.92</td>
</tr>
<tr>
<td>No</td>
<td>23.08</td>
</tr>
<tr>
<td>Practice of cleaning containers before and after milking</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>64.10</td>
</tr>
<tr>
<td>No</td>
<td>35.90</td>
</tr>
<tr>
<td>Barn hygiene/cleaning</td>
<td></td>
</tr>
<tr>
<td>Daily basis</td>
<td>71.79</td>
</tr>
<tr>
<td>Once a week</td>
<td>10.26</td>
</tr>
<tr>
<td>Twice a week</td>
<td>17.95</td>
</tr>
</tbody>
</table>

n= number of respondents

for milking (Table 1). As a result, milking was usually done under poor hygienic conditions (usually in the barn) which were often contaminated with cow dung, urine and infested with flies. The influence of dirty cows on total bacteria counts depends on the extent of soiling of teat surface and cleaning procedures used immediately before milking. Milking heavily soiled cows could potentially result in bulk milk counts exceeding $10^4$ per ml (Bramley and McKinnon, 1990).

About 23.08% of the household milk producers’ respondents indicated that laborers were not specifically involved in either milking or sanitation. According to these respondents, the employees were engaged in several additional workloads other than milking and cleaning (Table 1). Thus, it was possible that those employees who were engaged in milking and other additional assignments like cleaning may contaminate the milk as most of them were not using detergents for washing their hands. This might be increasing the microbial counts of the milk marketed in the study area.

Table 1 also shows that 35.90% of the household milk producers’ respondents did not clean milking utensils regularly before and after milking. According to these respondents, the households clean milk utensils once after using it and place on a shelf; subsequently they were using it for milking without cleaning it again. Parekh and Subhash (2008) stated that use of unclean milking and transport equipment can contribute to poor hygienic quality of the milk. Thus, as Murphy (1996) pointed out, cleaning and disinfection of equipment after each milking is important to reduce contamination of milk by microorganisms from the equipment and with rinsing, about 10% of the number of bacteria found in milk can be reduced. Bramley and McKinnon (1990) also found out that milk residue left on equipment contact surfaces supports the growth of a variety of microorganisms. However, efficient cleaning and sanitization of dairy farm utensils could help to improve the quality of raw milk and its products.

Furthermore, Bonfoh et al. (2006) reported that in milk production area, besides udder infection and water quality, hygienic behavior with respect to hand washing, container’s cleaning and disinfection are the key areas that remain of relevance to milk hygiene intervention. In contrast to this, the result of this study indicated that some of the respondents of the milk producers did not practice cleaning and disinfection of the milk containers suggesting lack of required awareness about the
importance of keeping the hygienic condition of the milk (Table 1).

The practice of cleaning milking areas (barn and under a tree shade) varied among households. Accordingly, about 71.79% of the respondents clean milking area on daily basis, 10.26% clean once a week and 17.95% of respondents clean twice a week. Food Hygiene Regulations (2006) reported that the milking area must minimize the risk of contamination from any source, including dust, flies, birds or other animals. However, in the present study, milking was usually done under poor hygienic conditions and most of the households did not have separate place for milking. This may increase the microbial contamination of the milk from the milking environment. According to the European Union and US regulations, the acceptable limit for total aerobic bacterial count is less than $10^3$ cfu/ml. However, all of the milk samples analyzed exceeded the standard.

**Milk handling practices**

The type of utensils used for transportation, collection and storage of milk by milk sellers were found to be different (Table 2). Most of them used plastic containers, plastic jars (jerry-can) and the rest used stainless steel. As indicated in Table 2, all dairy cooperative milk collection centers, 70.83% hotels, 75.00% small shops/kiosks and 84.62% small scale milk producers of the respondents used plastic buckets for milk collection and about 20.83% hotels, 16.67% small shops/kiosks and 10.26% small scale milk producers of the respondents use plastic jars (jerry-cans) for milk collection. The equipments used to milk the cows were plastic buckets. However, some of the households (8.33% hotels, 8.33% small shops/kiosks and 5.13% small scale milk producers) adopted stainless steel. This is in line with the findings of Yitaye et al. (2009) and Teklemichael (2012) who reported that 83% of the surveyed urban dairy farms in Bahir Dar and Gondar and 75% of the surveyed in Dire Dawa town used plastic utensils, respectively. Since proper metal milk containers are expensive, milk producers use plastic containers which are difficult to clean and disinfect and thus it might contribute to poor quality of the milk (Omore et al., 2005).

The left-over of milk and other dirt particles within the container may result in the contamination of milk. Omore et al. (2005) had also reported that lack of formal training and use of plastic containers are the main factors that contribute to the low quality of raw milk sold by producers and informal milk traders. Non-food grade plastic cans, buckets and Jerry-cans must not be used (Kurwijila, 2006). On the other hand, in the selected study area, the majority of milk producers and sellers were using plastic buckets for milking and milk collection. These types of equipment are not suitable for sanitizing and may contribute to the source of contamination of the milk samples.

As indicated in Table 2, all respondents of dairy cooperative milk collection centers, hotels and small shops/kiosks washed milk containers with tap water. However, 23.08% of small scale milk producers were using washing and smoking techniques for cleaning milk containers. Smoking of the milking and storage containers was done by using wood splinters of ‘Weyira’ (Olea africana). They mentioned that smoking is used to develop desirable flavor in the milk. In addition to imparting pleasant flavour, smoking has anti-microbial activity and thus inhibits growth of microorganisms in milk (Mogessie and Fekadu, 1993). All of the respondents from dairy cooperative milk collection centers, hotels, small shops/kiosks and small scale milk producers used tap water both for their animals and household use. Table 2 also depicts that all of the respondents from hotels, small shops/kiosks and small scale milk producers did not testing the quality of milk. Only dairy cooperative was testing adulteration of milk by using lactometer at collection centers.

As indicated in Table 3, all of the dairy cooperative milk collection centers and small scale milk producers did not use cooling systems for storing milk before selling. After mixing the milk obtained from different cows, they were either keeping it at room temperature until it was sold or transporting it at ambient temperature to selling points. Improper cooling system and poor handling practices during transportation could result in increased number of contaminant microbes in milk. Rizwan et al. (2011) had reported that contamination of raw milk originates during milking, transportation and storage. As a result, FAO/WHO (2007) recommended that milk should be cooled below 4°C or processed and conserved well immediately after milking or processing. However, due to the absence of appropriate cooling systems at small scale milk producers, milk in the present study area was usually transported at ambient temperatures to selling points. This may leads to increased microorganism in the milk and cause health problem among consumers. Therefore, it would be beneficial to have an access to cooling facilities for retarding bacterial growth in raw milk during collection and transportation to the selling points.

The survey data showed that, 41.67% hotels and 33.33% of the small shops/kiosks kept milk in a refrigerator while the rest stored at room temperature until all the milk samples were sold out (Table 3). According to FAO/WHO (2007), the temperature of the milk shall not exceed 8°C during transportation and storage unless the milk has been collected within 2 hours of milking, and it should be cooled to a temperature equal to or below 6°C when collected on a daily basis or should be cooled to a temperature equal to or below 4°C when not collected every day.
Table 2. Types of milk containers, methods of cleaning milk containers, water source and handling of milk in the study area (n=90)

<table>
<thead>
<tr>
<th>Variables</th>
<th>DCMCCs (n=3)</th>
<th>Hotels (n=24)</th>
<th>Kiosks (n=24)</th>
<th>SSMPs (n=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>Types of containers used for milk collection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic buckets</td>
<td>100</td>
<td>70.83</td>
<td>75.00</td>
<td>84.62</td>
</tr>
<tr>
<td>Plastic jars (jerry-cans)</td>
<td>-</td>
<td>20.83</td>
<td>16.67</td>
<td>10.26</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>-</td>
<td>8.33</td>
<td>8.33</td>
<td>5.13</td>
</tr>
<tr>
<td>Methods of cleaning milk containers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing by tap water</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>76.92</td>
</tr>
<tr>
<td>Washing by tap water and smoking</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>23.08</td>
</tr>
<tr>
<td>Water source</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap water</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Practice of testing quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>No</td>
<td>-</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

n= number of respondents, DCMCCs = Dairy cooperative milk collection centers, SSMPs = Small scale milk producers, Kiosks = Small shops

Table 3. Storage system of milk before sale in the study area (n=90)

<table>
<thead>
<tr>
<th>Variables</th>
<th>DCMCCs (n=3)</th>
<th>Hotels (n=24)</th>
<th>Kiosks (n=24)</th>
<th>SSMPs (n=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage method before selling milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At room temperature</td>
<td>100</td>
<td>58.33</td>
<td>66.67</td>
<td>100</td>
</tr>
<tr>
<td>Use of refrigerator</td>
<td>-</td>
<td>41.67</td>
<td>33.33</td>
<td>-</td>
</tr>
</tbody>
</table>

n= number of respondents, DCMCCs = Dairy cooperative milk collection centers, SSMPs = Small scale milk producers, Kiosks = Small shops

Microbial Quality of Raw Cow Milk

Total bacterial count

Mean total bacterial count was significantly different (P < 0.05) among milk samples collected from small scale milk producers, small shops, hotels and dairy cooperative milk collection centers (Table 4). On the other hand, there was no marked difference among milk samples collected from dairy cooperative milk collection centers and hotels. The total bacterial count obtained in this study is generally high compared to the acceptable level of $1 \times 10^5$ bacteria per ml of raw milk (O’Connor 1994).

The total bacterial count obtained from dairy cooperative milk collection centers was significantly higher (P < 0.05) than milk samples collected from hotels, small shops/kiosks and small scale milk producers (Table 4). This might be due to further contamination of the milk during transportation, use of poorly cleaned milk containers and absence of cooling systems at milk selling points. Higher total bacterial count of milk samples obtained from small scale milk producers could be attributed to improper cleaning of the udder and milking containers before and after milking, failure to use separate towel for each cow, improper cooling system and milk contamination from the hands of producers. In general, using plastic buckets for milk collection and keeping raw milk at room temperature until sold out in vends shops/kiosks, hotels, dairy cooperative milk collection centers and household of milk producers may lead to high number of total bacterial count in study area.

In the present study, total bacterial count of raw milk collected from dairy cooperative milk collection centers was lower than that reported by Ahmed et al. (2008) who found high total bacterial count of $9.089 \pm 0.281 \log_{10}$ cfu/ml in milk samples collected from dairy farms of Khartoum State. Likewise, Francesconi (2006) reported total bacterial count of $10^{8}$ cfu/ml from milk sample collected in most dairy cooperatives operating in Ethiopia. Correspondingly the total bacterial count obtained from small scale milk producers was lower than that reported by Debebe (2010) who found a total bacterial count of $6.98 \pm 0.15 \log_{10}$ cfu ml$^{-1}$ milk samples collected from milk producers (Table 4).
The mean total bacterial count of raw cow's milk (7.125 log_{10} cfu/ml) obtained in this study was lower than the earlier findings of Zelalem (2010), Haile et al. (2012) and Teklemichael (2012) who reported a total bacterial count of 9.10 log_{10} cfu/ml for milk samples collected from different parts of Ethiopia, 10.28 log_{10} cfu/ml from distribution containers (at selling point) and 9.137 log_{10} cfu/ml from vendors, respectively. However, Aberra (2010) reported lower mean values of total bacterial counts 7.78 x 10^{5} cfu ml^{-1} from raw milk samples in and around Addis Ababa. Likewise, Bekele and Bayileyegn (2000) reported lower mean values of total bacterial counts 1.1 x 10^{5} cfu ml^{-1} from the producer's bucket and 4 x 10^{5} cfu ml^{-1} from storage containers before cooling. Fekadu (1994) also reported that the minimum and maximum total bacterial count of raw cows' milk produced in southern region to be 6 to 8.8 log_{10} cfu/ml. Furthermore, higher total bacterial count (7.58 log_{10} cfu/ml) were reported by Asaminew and Eyassu (2011) for milk samples obtained from individual farmers and dairy cooperatives in Bahir Dar Zuria district. Similarly, Alganesh (2007) reported higher total bacterial count of cows’ milk produced in Bila Sayo and Guto Wayu districts of eastern Wollega to be 7.4 x 10^{7} and 2.0 x 10^{7} cfu/ml, respectively.

**Coliform count**

The mean coliform count was significantly different (P < 0.05) among milk samples collected from small scale milk producers, small shops, hotels and dairy cooperative milk collection centers (Table 4). On the other hand, there was no marked difference among milk samples collected from hotels and small shops/kiosks. The coliform count obtained from dairy cooperatives was significantly higher (P < 0.05) than milk samples obtained from hotels, small shops and small scale milk producers (Table 4). This might be due to further contamination of the milk during transportation, inadequately cleaned milking utensils, the practice of washing the milk containers together with other materials and absence or improper cooling systems at milk selling points. The presence of coliforms in milk at small scale milk producers might be attributed to the initial contamination of the milk samples either from the lactating cows or the milkers, milk containers and the poor practice of cleaning milking area.

The overall coliform count of raw cow’s milk obtained in the current study (4.999 log_{10} cfu/ml) was slightly higher than the earlier findings of Asaminew (2007), Derese (2008), Ali and Abdelgadir (2011) and Abebe et al. (2012) who reported a coliform count of 4.49 log_{10} cfu/ml in milk samples in the West Shewa zone of Oromia region, 4.84 log_{10} cfu/ml in milk samples collected from Bahir Dar milk shed, 4.18 ± 0.01 log_{10} cfu/ml for raw milk samples and 4.03 log_{10} cfu/ml in raw whole cow’s milk in the Ezha districts of the Gurge zone, respectively.

In the current study, the coliform count of raw cow milk collected from dairy cooperative milk collection centers was higher than that reported by Asaminew and Eyassu (2011) who found coliform count of (4.94 ± 0.23 log_{10} cfu/ml) in milk samples collected from dairy cooperatives in Bahir Dar Zuria district. Correspondingly, Teklemichael (2012) reported lower mean values of coliform counts of (4.130 ± 0.757 log_{10} cfu/ml) from milk samples collected from Dire Dawa town dairy farms. On the other hand, the coliform count of raw cow milk collected from small scale milk producers was lower than that reported by Debebe (2010) who found high coliform counts (4.88 ± 0.16 log_{10} cfu/ml) in milk samples collected from milk producers in and around Addis Ababa city.

According to the European Union standards for coliform counts of raw milk should be less than 10^{2} cfu/ml (Fernandes, 2009). The present study showed that the coliform count of all milk samples exceeds the standards given for raw milk by European Union and US regulations. Generally, the presence of high numbers of coliforms in milk indicates that the milk has been contaminated with fecal materials, unclean udder and teats of cow’s, inefficient cleaning of the milking containers, poor hygiene of the milking environment, contaminated water and cows with subclinical or clinical coliform mastitis can all lead to elevated coliform count in raw milk (Jayarao et al., 2004).

**Table 4.** Mean (±SD) microbial counts (log_{10} cfu/ml) of raw cow’s milk samples collected from dairy cooperative milk collection centers, hotels, small shops/kiosks and small scale milk producers in Shashemene town.

<table>
<thead>
<tr>
<th>Variables</th>
<th>DCMCCs (n = 3)</th>
<th>Hotels (n = 15)</th>
<th>Kiosks (n = 15)</th>
<th>SSMPs (n = 15)</th>
<th>Overall Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBC</td>
<td>7.365 ± 0.012a</td>
<td>7.321 ± 0.010a</td>
<td>7.192 ± 0.039b</td>
<td>6.621 ± 0.051c</td>
<td>7.125 ± 0.091</td>
</tr>
<tr>
<td>CC</td>
<td>5.321 ± 0.049a</td>
<td>5.094 ± 0.043b</td>
<td>4.964 ± 0.076b</td>
<td>4.619 ± 0.072c</td>
<td>4.999 ± 0.081</td>
</tr>
<tr>
<td>SFBC</td>
<td>5.084 ± 0.050b</td>
<td>4.610 ± 0.016b</td>
<td>4.617 ± 0.018b</td>
<td>4.499 ± 0.021c</td>
<td>4.703 ± 0.069</td>
</tr>
<tr>
<td>YMC</td>
<td>4.465 ± 0.107ab</td>
<td>4.401 ± 0.117a</td>
<td>4.112 ± 0.016b</td>
<td>3.846 ± 0.030c</td>
<td>4.206 ± 0.082</td>
</tr>
</tbody>
</table>

Means followed by different superscript letters within a row are significantly different (P < 0.05). DCMCCs = Dairy cooperative milk collection centers, SSMPs = Small scale milk producers, Kiosks = Small shops, TBC = Total bacterial count, CC = Coliform count, SFBC = Spore forming bacterial count, YMC = Yeast and mould count, n= number of samples.
Spore forming bacterial count

Mean spore forming bacterial count was significantly different (P < 0.05) among milk samples collected from small scale milk producers, small shops, hotels and dairy cooperative milk collection centers (Table 4). On the other hand, there was no marked difference among milk samples collected from hotels and small shops. The average (±SD) values of spore-forming bacteria counts (SFBC)/ml of milk samples collected from dairy cooperative milk collection centers were significantly higher (P < 0.05) than raw milk samples obtained from hotels, small shops and small scale milk producers (Table 4).

The mean SFBC of raw cow’s milk obtained in this study (4.703 ± 0.069 log_{10}cfu/ml) was lower than the earlier finding of Teklemichael (2012) who reported a spore forming bacterial count of 6.392 ± 0.154 log_{10} cfu/ml from milk vendors in Dire Dawa town. The relatively higher SFBC in milk samples obtained from dairy cooperative milk collection centers may indicate that there was poor environmental sanitation and poor handling practice at the selling sites. It could also be associated to the spores which transferred from feed, feces, bedding material and soil in to milk. Feces and bedding materials contaminate the cow’s teats. Teat cleaning prior to milking only partly reduces attached dirt and spores (Vissers and Driehuis, 2007).

In the study area, the survey result indicated the existence of poor hygienic condition of the milking environment, inefficient cleaning of milk utensils, use of plastic bucket for milking and collection might have contributed to the contamination of the milk by spore forming bacteria. In general, the raw milk sold by milk dairy cooperatives, hotels, small shops and small scale milk producers in Shashemene town do not meet the international standards set by regulatory agents and thus could pose health hazards to the consumers.

Yeast and mould count (YMC)

The overall mean of YMC were 4.465, 4.401, 4.112 and 3.846 log_{10} cfu/ml for milk samples collected from the dairy cooperatives, hotels, small shops and small scale milk producers, respectively. Mean value of yeast and mould counts were significantly different (P<0.05) among milk samples collected from small scale milk producers, small shops, hotels and dairy cooperative milk collection centers (Table 4). However, there was no significant difference (P>0.05) observed among milk samples collected from dairy cooperatives and hotels.

YMC of dairy cooperative milk collection centers was significantly (P < 0.05) higher than the milk samples obtained from hotels, small shops and small scale milk producers. However, Haile et al. (2012) reported higher Yeast and mould counts of 4.65 log_{10} cfu/ml for milk samples collected from storage containers and 7.13 log_{10} cfu/ml for milk samples collected from distribution containers in Hawassa, Southern Ethiopia.

An increasing trend of YMC was observed beginning from the time of milking until the milk reached at selling points. Accordingly, mean of YMC increased by 0.619, 0.555 and 0.226 log_{10} cfu/ml for samples taken from dairy cooperatives, hotels and small shops as compared to the count in small scale milk producers, respectively. The increase from point of production to arrival at selling point was by 1.4 log_{10} cfu/ml (Table 4).

The high YMC observed in milk obtained from dairy cooperative milk collection centers might be attributed to contamination from air, containers or poor personal hygiene milk sellers. Yeast and mould are considered to be spoilage organisms. Some yeast and moulds, however, are public health concerns due to their production of mycotoxins, which are not destroyed during food processing or cooking (McLandsbrough and Ann, 2005).

CONCLUSIONS

The observed poor quality of milk produced at small scale milk producers was probably due to the poor hygienic condition of the milking environment, absence of cooling system, poor sanitary condition of the milk containers, poor udder and teats cleaning practice, failure to use separate towel for each cow and the poor personal hygiene of the milkers. Similarly, the poor quality of milk sample at hotels and small shops/kiosks were most likely due to poor cleaning system of milk collection containers, use of plastic buckets and keeping the milk at room temperature. Additionally, very high microbial count observed in milk samples collected from dairy cooperative milk collection centers could be attributed to the absence of cooling systems, use of plastic containers for milk collection, mixing of milk obtained from different cows and the presence of further contamination at the milk selling sites. Generally, this study showed that the quality of the milk obtained from dairy cooperative milk collection centers, hotels, small shops/kiosks and small scale milk producer was poor. Therefore, it was concluded that the microbial quality of raw cow’s milk produced and marketed in the study area was poor and this suggests the need for improved hygienic practices and handling of milk at all levels of dairy chain.

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