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Safety and Quality of Raw Cow Milk Collected from Producers and Consumers in Hawassa and Yirgalem areas, Southern Ethiopia

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Abstract
The objective of this study was to understand the hygienic milk handling practice and determine the safety and quality of raw milk collected from producers and consumers in Hawassa and Yirgalem areas. A total of 60 producers and 40 consumers were randomly selected and interviewed for the survey in the selected districts of Hawasa Zuria and Dale. A total of 120 raw milk samples were also aseptically collected and tested for microbial analysis and chemical composition (60 samples each from producers and consumers). General Linear Model (GLM) and other statistical tools were adopted to analyze the data and summarize the information. The result showed that clay pot is the major milk storing device for producers although it is inconvenient for hygienic cleaning, harbors bacteria which causes milk spoilage and consequently imposes risk of quality deterioration. The Cooling method of raw milk for 28% of producers was using of refrigerator while for 33% of the consumers; it was by boiling and then cooling system. Fumigation was a common traditional practice in the studied districts which is mainly used for flavoring and extending the shelf life, thereby reducing spoilage. It is one of the traditional hygienic measures used on milking utensils .In the raw milk samples, the mean total bacterial count for producers and consumers was 6.73 cfu mL^{-1} and 7.15 cfu mL^{-1}, respectively. The higher total bacterial count of consumers was due to poor sanitary conditions practiced during milking and hygiene of milking utensils. The coliform count for the raw milk collected from producers was 4.00 cfu mL^{-1} while it was 4.29 cfu mL^{-1} for consumers. The higher coliform count of the consumers was due to contamination of the milk collected from different value chain actors, unhygienic milk utensils and unsafe ways of management. There was no significant difference observed in the mean values of fat, solids-not-fat (SNF), protein, lactose, density and water percent in the two study locations. Significantly lower values for fat, SNF and water percent were observed for the milk samples collected from consumers than producers. The poor handling practice, higher bacterial count and substandard quality of composition could be due to limited knowledge of producers and consumers on the improved hygienic handling practices. Therefore, regular awareness creation about quality milk production and good handling practices should be provided for producers as well as consumers to improve the quality and the safety of the milk and also minimize consequent health risks especially on children, the sick and elderly.
Keywords: Milk handling, quality, safety, composition, producers, consumers

Introduction

Ethiopia holds a substantial potential for dairy development mainly due to its large livestock population development, coupled with the relatively suitable environment for livestock production. Cow milk is often produced and marketed to consumers without being pasteurized nor subjected to any quality standards (Zelalem and Faye, 2006). Dairy production mainly from Cattle is one of the most traditional activities of farmers in Sidama zone. Milk and milk products such as butter and fat extracted sour milk are the main parts of Enset[1] based diet in the Southern Region.

Hygienic handling practice of the milk with respect to quality has received a great concern around the world. This is especially true in developing countries where production of milk and various milk products usually takes place under unsanitary conditions and poor production practices. It was also reported that dairy production has a great contribution in improving human nutrition, particularly women and children (Ahmed *et al.*, 2004). Production of milk for consumers requires good hygienic practices such as clean milking utensils, washing milker's hands, washing the udder and use of individual towels during milking and handling, before delivery to consumers or processors (Getachew, 2003).

The unsafe handling practice results in the higher bacterial count, which in turn may cause spoilage of the milk and poor yields of its products (Oliver *et al.*, 2005). Moreover, the rise of bacterial count could cause food born diseases and imposes a great health risk on the consumers'. Hence, awareness raising and training of milk producers and consumers on improved hygienic milk production and handling techniques is required to reduce the bacterial load in milk and minimize its effect on health. This study, therefore, presents information on

[1] Enset is a banana like plant (commonly named as false banana) that is a dependable source of food especially in Southern parts of the country

the hygienic milk handling practices of the farmers and consequences of improper handling on the quality and safety of milk.

Methodology

The Study area

Sidama is one of the many administrative zones in Southern Nations and Nationalities Peoples Regional State (SNNPRS) of Ethiopia. Its capital town, Hawassa, is located at 275kms south of the city of Addis Ababa. Geographically, the town of Hawassa is located at an altitude of 1750 m.a.s.l and at 60 83' to $70^{-}17'$ N and $38^{0}24'$ to $38^{0}72'$ E. Sidama zone is currently divided in to 19 districts in which each district on average has a population of 100,000 (CSA, 2007). Hawassa zuria and Dale districts were selected for detail collection of data and information in this study. Hawassa town is located in Hawassa zuria districts while the town of yirgalem is located in Dalle district. Hawassa town, which is also the capital of SNNP region, is the economic and cultural hub of the region, having a total area of about 50 km^2 being divided into eight sub-cities (Kifle ketema) and 32 Kebeles (the smallest unit of administration). Yirgalem town, on the other hand, is located 260 kms south of Addis Ababa and 40 kms south of Hawassa. The town is situated at a latitude and longitude of 6°45′N and 38°25′E, respectively, and at elevation of 1776 m.a.s.l .

The study was, therefore, conducted in the urban and peri-urban areas of Hawassa and Yirgalem towns. Consumers were drawn from the towns while producers were selected from rural kebeles surrounding the towns.

Data Collection

Standard diagnostic survey techniques were adopted to collect the required data and information as per the objectives of the study. Blends of tools and techniques used included exhaustive desk reviews, preliminary collection of information and questionnaire based data collection. Desk reviews were employed at all stages in the course of the study even though it is largely used at initial stages. This stage helped to make general understanding of milk safety and quality issues both from published and unpublished sources including electronic and print media. It also helped to design data collection instruments that would be used in subsequent stages. Next, preliminary stage was used to collect descriptive information from selected target groups through key informant and focus group discussions. This stage was largely employed along with questionnaire based methods of data collection.

Thirdly, questionnaire based data collection technique was used to collect quantifiable data from sample respondents. The major target groups of the study from whom the data was collected through interviews included milk producers and consumers. A structured questionnaire was prepared and pre-tested in the pilot areas for consistency and relevance after which necessary adjustments were made before launching actual data collection. For the household survey, samples of respondents were drawn out of the population of milk producers and consumers through random sampling techniques. Accordingly, a total sample of 60 producers was randomly selected from rural kebeles located in the outskirts of the towns (30 producers from outskirts of Yirgalem and 30 from Hawassa towns) for household survey (Table 1). Moreover, a total sample of 40 consumers (25 from Hawassa and 15 from Yirgalem towns) was drawn from households located in each of the towns. Two different towns, Yirgalem and Hawassa, were purposely selected due to the different levels of urbanization which influences the practice of milking handling due to differences in the level of knowledge and awareness. In this case, Hawassa represents the town with better levels of urbanization, higher population and better facilities for milk handling while Yirgalem represents the town with lower level of urbanization, lower population and lower facilities for milk safety. Enumerators were recruited on merit basis and trained to collect data using a questionnaire through interviews of the selected respondents. Close supervision of enumerators and the collected data was set up throughout the course of the study to ensure quality of the data and information.

Table 1. Sample size for the survey and for the experiment

Category of the study	Producers			Consumers		
	Hawassa	Yirgalem	Overall	Hawassa	Yirgalem	Overall
Household survey	30	30	60	25	15	40
Milk hygiene and safety experiment	30	30	60	30	30	60

Milk sampling procedure

Two kebele's (least administrative units) were considered from each of the woredas for the sampling of milk from consumers and producers. The kebele's' were selected purposively on the basis of cattle population, milk production potential and number of producers as well as consumers who utilize milk through buying. The producers were taken from urban kebele of Hawassa and Yirgalem where as the consumers from the rural kebeles of the same study area.

The producer and consumer households were primarily identified in consultation with development agents located in the study districts. A random sampling procedure was again employed to select sample producers and consumers for collecting milk samples. A sample of 30 households from each of the towns who own at least one local milking cow was randomly selected. This means a total sample of 60 producers and 60 consumers was selected for collecting milk samples from Hawassa and Yirgalem towns, making a total sample of 120. From the collected milk samples, microbial quality parameters such as the total bacterial count and coliform counts were analyzed. Likewise, chemical composition parameters such as fat, SNF (Solid Non Fat), Protein, Lactose, Density, water %, freezing point and temperature were analyzed. These two analyses techniques have been briefly presented in subsequent sections:

Microbial analysis

The study has also employed microbial analysis, which is determination of Aerobic mesophilic bacterial Count and Coliform counts (CC) following the standard procedures. The milk was sampled within 1-2 hours after milking from the value chain actors' milking utensils. The samples were collected aseptically in sterilized universal bottles, kept in an icebox and transported to Hawassa University Dairy laboratory. All the analyses were done induplicate and performed within 8 hours of sampling. Aerobic Mesophilic Bacterial and Coliform counts were also done as presented in subsequent sections.

Aerobic Mesophilic Bacterial Count (AMBC): The milk samples were diluted in 0.1% peptone water (by transforming 1ml of the previous dilution in 9ml of 0.1% peptone water). AMBC was made on plate count agar (PCA) by incubating aerobically surface plated duplicate plates with appropriate decimal dilution of milk samples at 32^{o}C for 48hrs. According to Richardson (1985), the total normal number of colonies expected is between 30 and 300. All counts were made in duplicates.

Coliform Count (CC): One ml of milk sample was added into sterile test tube having 9 ml peptone water. After mixing, the sample was serially diluted up to 1:10^{-5} and duplicate samples (1 ml) were pour plated using 15-20 ml Violet Red Bile Agar solution (VRBA). After thoroughly mixing, the plated sample was allowed to solidify and then incubated at 32ºC for 24 hrs. Dilutions were selected for plate counts of between 15 and 150 colonies. Typical dark red colonies (>0.05 mm in diameter) were considered as coliforms and counted accordingly Finally, colony counts were made using colony counter and dark red colonies were considered as Coliform colonies.

Chemical Analysis

The chemical analysis considers tests of fat, protein, Solid Non Fat (SNF), density, lactose and salt. Such tests were also undertaken in the present study including the water content percentages. The analysis was made in Hawassa Agricultural Research Center by using the milk analyzer "Lacto scan SP". It offers series of user-friendly, rapid analyses which can be applied for measurement of fat (FAT), solids non-fat (SNF), density, proteins, lactose, salts, water content percentages, temperature (°C), freezing point, pH, conductivity, as well as total solids of one and the same sample directly after milking, at collecting and during processing.

Their minimum lower consumption and lack of consumables make milk analyzers Lacto scan attractive for the dairy industry. Easy to work with, low cost maintenance and low price make milk analyzer Lacto scan suitable for dairy farms, dairy enterprises, milk selection centers and laboratories. The milk analyzer is to make quick analyses of milk on fat (FAT), non-fat, solids (SNF), proteins, lactose and water content percentages, temperature (°C), freezing point, salts, as well as density of one and the same sample directly after milking, at collecting and during processing.

As illustrated in Table 2, the measuring range for fat is from 0.01 to 25% while it is 3% - 15% for non-fat solids. The standard measurement range for water content can rise as high as 70%. The density ranged from as low as 1015 kg/m to as high as 1040 kg/m.

Table 2: Standard measurement range and its precision of Lacto-scan for milk composition indicators

Indicators	**Measuring range**	**±Std.dev**
Fat	from 0.01 to 25%	± 0.10%
Non – fat solid	from 3% to 15%	±0.15%
Proteins	from 2% to 7%	±0.15%
Lactose	from 0.01 % to 6 %	±0,20%
Density	from 1015 to 1040 kg/m^3	±0.3 kg/m^3
Water content	from 0 % to 70 %	±3.0%
Temperature of milk	from 1^{0}C to 40^{0}C	±1.0%
Freezing point	from – 0.4^0 to – 0.7^{0}C	±0.001%
Salts	from 0.4 to 1.,5%	±0.05%

(Source: www.lactoscan.com)

Statistical analysis

Descriptive statistical tools were largely employed to analyze survey based data collected from sample households and also for the raw milk samples collected from producers and consumers. Qualitative data were also summarized by using descriptive statistics. The results of total bacterial count and coliform counts were first transformed to logarithmic values (log 10) and these values were analyzed using the General Linear Model (GLM) for least squares means in SPSS (version 20) using a fixed effect model. The Least Significant Difference (LSD) test used to separate the means and differences was considered significant at $P<0.05$.

The following GLM model was used to analyze the microbiological quality and chemical composition of milk:

$Y_{iJ} = \mu + A_i + e_{ij}$, Where,

Y_{ij} = Log_{10} transformed Aerobic Mesophilic Bacterial count/coliform count or Gross chemical composition of j^{th} milk sample taken from i^{th} milk sources/Locations

μ = Over all mean value of the respective parameter

A_i = Effect of the i^{th} Location and Milk sources (i=2, Producer and Consumer) or (i=2, Hawassa and Yirgalem)

eij=error

Statistical significance test of the findings with qualitative parameters was also made using chi-square tests ($\chi 2$). The $\chi 2$ statistic was calculated using the formula:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{\left(A_{ij} - E_{ij}\right)^2}{E_{ij}}$$

Where:

Aij = actual frequency in the i-th row, j-th column

Eij = expected frequency in the i-th row, j-th column

r = number or rows

c = number of columns

The distribution of the statistic X^2 is ***chi-square*** with (r-1)(c-1) degrees of freedom, where r represents the number of rows in the two-way table and c represents the number of columns. The distribution is denoted χ^2 (df), where df is the number of degrees of freedom. The chi-square distribution is defined for all positive values.

The *P-value* for the chi-square test is $P(\chi^2 \geq X^2)$, the probability of observing a value at least as extreme as the test statistic for a chi-square distribution with (r-1) (c-1) degrees of freedom. Moreover, the number of microorganisms (colony forming units) per ml of milk was calculated using the following formula.

Count = Sk/n1 + 0.1n2x d Where,

Sk = sum of all colonies counted

n1 = number of plate from the lowest dilution used for computing the count,

n2 = number of plates in the next dilution factor used for computing the count,

d = reciprocal of the dilution factor of the lowest dilution used for computing the count corresponding to n1.

Results and Discussion

Milk handling practices

Milking equipment and hygiene practices

Hygienic milk handling practice should take into account the sanitation of milking environment, the milker and utensils used to collect and store milk. This is because, equipment used for milking, processing and storage determine the quality of milk and milk products and this has even be supported by earlier studies (Abebe *et al*., 2012). According to this study, 70% of the producers in Yirgalem and 47% in Hawassa zuria have used primarily clay pot as milking equipment (Table 3). Similar study has also reported that clay pot was majorly used to store milk in the Mid Rift Valley of Ethiopia (Negash *et al*., 2012). The statistical test has indicated significant difference between the two towns in the producers types of milking equipments used, the practice of fumigation and cleaning ($X^2=30.0$, $df=6$, $P=0.01$).

According to the local understanding, clay pot was largely used as milking utensil because it is locally made, easily available and affordable even for lower income households. Even though clay pot could be perceived to minimize the likely temperature of the environment, it is not designed for easy and proper cleaning. Moreover, its porous nature easily harbors bacteria and also makes hygienic cleaning inconvenient and ineffective. As a result, it is more likely to inflict milk spoilage, and consequent quality deterioration and health risks. Plastic bucket and calabash are the second and third commonly used milking equipments in the studied districts, respectively. Plastic bucket was reported to be the primary milking device in Hawassa. This was because Hawassa is more urbanized town than Yirgalem and the demand for plastic bucket is higher in Hawasa than yirgalem. On the other hand, stainless steel is believed to be appropriate milking equipment in spite of less adoption by the households. Not only that it is easy for hygienic cleaning, it is also not as porous as clay pot. However, stainless steel may not be easily available and costly as compared to local milking equipment. But yet, its durability and safety pays to own one and households need to be encouraged further to depend on stainless steel milking equipment. Even the study by Yilma (2012) has also described in his study that the milking equipment should be easy to clean so as to ensure the quality of the milk. The findings have also figured out that 85% of the overall producers in both districts fumigate their milking equipment while 88% of them wash and flavor the milk containers prior to storing. Farmers usually smoke their milk container to improve the flavor and also increase its shelf life. A similar reason was also reported by Biruk *et al*. (2012). It is believed that the practice of fumigation has the function of improving the flavor of milk and milk products through the smoke produced from different types of plants. Moreover, fumigation is perceived to have the purpose of disinfecting (sterilizing) the milking equipments, thus reducing the numbers of micro-organisms and there by extending the shelf life of milk and milk products.

In general, milking and storage equipment commonly used by households are believed to be inconvenient for hygienic cleaning and reportedly cause quality deterioration of milk and impose health risks on the consumers. Even though there are equipment recommended for milking and storage of milk, they have not been widely used on account of unawareness and limited availability.

Table 3: Producers milking equipment, practice of fumigation and cleaning (% of households)

Parameters	Yirgalem (N=30)	Hawassa (N=30)	Overall (N=60)
Milking equipment			
• Clay pot	70	47	58.4
• Stainless steel	6.7	0	3.4
• Plastic bucket	33.3	56.7	45
• Wooden container	10	0	5
• Calabash (Qil)	13.3	0	6.65
HHs practice of fumigation and Cleaning			
• Fumigating milking equipments	86.7	83.3	85
• Rubbing for washing and flavoring milk containers	86.7	90	88.4

HH=Households $X^2=30.0$, *df=6*, *P=0.01*

Cooling Facility for Raw Milk

Both producer and consumer households in both towns adopted different milk cooling practices as illustrated in Table 4. One aspect of proper milk handling practice is the area of cooling. According to 12 % of producers and 18 % of consumers, they put the raw milk in cooler places for preserving, which is a traditional way of cooling system. In the producer category, there was a statistically significant difference in the cooling practices between the households of Hawassa and Yirgalem towns ($X^2=16.65$, *df=2, P=0.01*). Similar test was also observed in the consumer category ($X^2 = 20.93$, *df=2, P=0.01).*

The traditional practice of cooling raw milk, however, often shortens shelf life and exposes the milk to spoilage. Only 28% of producers and 25% of consumers used refrigerator in both study areas. Moreover, the results illustrate higher usage of refrigerator in Hawassa town than Yirgalem for both producers (53%) and consumers (33%). This might be due to the fact that Hawassa is a more urbanized town than yirgalem with considerable numbers of residents (producers and consumers) aware of techniques of maintaining quality of perishable products, such as milk. Similar result was also reported by Ayenew (2008) in urban areas in the North western parts of Ethiopian highlands. Since raw milk is unstable product as compared to processed products, keeping it in refrigerated condition below 4^oc is has been reported to be suitable (FAO, 2004,). This is because, cooling the raw milk under this temperature makes the bacteria inactive and prevents them to grow (Pandey and Voskuil, 2011).The results, however, revel that smaller proportion of producers and consumers used refrigerator for cooling and storing of the raw milk. One of the reasons could be economic where large proportions of households in urban areas do not afford to purchase refrigerator. Similar results were also reported in small scale producers of the Ethiopian highlands by Yilma and Faya (2006).

Table 4: Raw milk Cooling practices of producers and consumers (% of households)

Cooling pracices	Producer*		Overall	Consumer**		Overall
	Ha	Yi		Ha	Yi	
Putting in Refrigerator	53.3	3.3	28.3	33.3	16	24.7
Putting in cooler place	3.3	23.3	11.7	16	20	18
By boiling and cooling	0	0	0	52	13.3	32.7

Ha=Hawassa; Yi=Yirgalem **X^2-test for producers: $X^2 = 16.65$, df=2, P=0.01*
***X^2-test for consumers: $X^2 = 20.93$, df=2, P=0.01*

Milk spoilage problem and reason of spoilage

Table 5 demonstrates the rate of raw milk spoilage and reasons for the loss of quality. It was figured out that 66% of consumers and 52% of the overall producers encountered the problem of milk spoilage. The proportion of consumer households who faced milk spoilage problem was 85% in the town of Yirgalem while it is 47% for the households in the town of Hawassa (47%). In both consumer households, poor milk handling practice has been blamed to be the responsible factor for milk spoilage. According to 74% and 33% of the overall consumer households in both districts, poor handling practice and lack of cooling facility, respectively, were reported to be the causes of problems resulting to milk spoilage. The proportion of households who suffered from poor handling practices was 67% for Yirgalem residents while it is 37% for residents of Hawassa town.

Producers have also identified poor handling practice (52%) to be the major factor behind milk spoilage followed by lack of technical knowledge (18%) These results are in agreement with the finding of Table 3 above in that most of the households depend on traditional way of cooling and preserving than usage of refrigerator. The traditional way of cooling might expose the milk to contaminants and increase the bacterial count which eventually leads to spoilage problem.

Moreover, the spoilage problem of raw milk was higher in Yirgalem than in Hawassa. This might be due to better cooling facility, knowledge of handling and access to different facilities of households in Hawassa than Yirgalem.

Table 5. Producers and consumers milk spoilage problem and reason for the spoilage (%)

Parameters	Consumers*		Overall (N=40)	Producers**		Overall (N=60)
	Yi	Ha		Yi	Ha	
Encountered problem of spoilage	84.9	46.7	65.8	70	40	51.7
Reasons for milk spoilage						
• Poor milk handling practices	75	72	73.5	66.7	36.7	51.7
• Use of inappropriate containers	8.3	4	6.15	13.3	0	6.65
• Lack of cooling facilities	45.5	20	32.75	16.7	13.3	15
• Adulteration	0	16.7	8.35	0	0	0
• Lack of technical knowledge	0	0	0	10.0	26.7	18.35

**X^2- test for consumers: $X^2 = 5.24$, df=5, P>0.05*
***X^2- test for producers: $X^2 = 811$, df=5, P>0.05*

Milk quality and safety

Chemical composition of milk over different location

The composition of milk constituents can vary considerably depending on the individual animal, breed type, stage of lactation, age, and health status. Herd management practices such as the way of feeding management and environmental conditions over location also influence milk composition (O'Connor, 1995). Under this study, the composition was evaluated over the sources of milk which was collected from producers and also consumers in Hawassa Zuria and Yirgalem district.

Accordingly, it was observed that the samples collected from Hawassa and Yirgalem had essentially the same milk composition in terms of fat, SNF, protein, lactose, water and temperature (Table 6). For the samples of Hawassa, the overall means for each of the constituents were fat (4.44) SNF (8.23), protein (3.14), lactose (4.87), density (27.69) and added water (2.83). The sample taken from Yirgalem has also depicted closely similar average values for the same constituents in spite of minor differences. In this study, the results of fat, SNF and protein were observed to be lower than the findings of Fikirneh (2012) and Alganesh et al., (2007). On the other hand, the result of this study was comparable with findings of Zelalem et al., (2004) in terms of protein and SNF percents, reporting 3.17% and 8.43%, respectively. Similar study made by Alganesh (2007) has also reported that there is no significant difference in the chemical composition of parameters in Horro Cattle in East Wollega area of Ethiopia that is due to the similarity of breed, animal size, interval between milking, age, stage of lactation, feed regime and feeding system.

Table 6. Gross Chemical composition of cow milk over location

Variables	Hawassa (N= 60)	Yirgalem (N= 60)	Significance Level (SL)
	Mean ±SE	Mean ± SE	
Fat	$4.44^a \pm 0.22$	$4.64^a \pm 0.22$	NS
SNF	$8.23^b \pm 0.19$	$8.36^b \pm 0.19$	NS
Protein	$3.14^c \pm 0.07$	$3.14^c \pm 0.07$	NS
Lactose	$4.87^d \pm 0.10$	$4.86^d \pm 0.10$	NS
Density	$27.69^e \pm 0.68$	$27.97^e \pm 0.68$	NS
Water percent	$2.83^f + 0.99$	$2.55^f \pm 0.99$	NS
Temperature	$6.25^g \pm 0.76$	$6.57^g \pm 0.76$	NS

Means with different superscripts within the same column are significantly different(P<0.05). N = Number of sample; NS=Not Significant

Chemical composition of milk over different milk sources (producers and consumers)

Figure 1 illustrates the overall chemical composition of cow milk collected from producers and consumers. A total of 60 samples were collected from producers and another 60 from consumers. According to the findings, a significant difference (p≤0.05) was observed in the parameters of fat, SNF, added water and freezing point. It is stated that the fat content in raw milk was significantly affected by the factors like feed, parity, breed and stage of lactation. Although the above mentioned factors affected the content of fat in raw milk, in a composite sample was collected from producers and consumers in this study. The findings pointed out lower fat content of producers (5.09%) and consumers (3.98%0 than the results reported by Gurmessa *et al.* (2015) which was highest in an open market (6.20%) and lowest in households milk producers (5.82%) in the case of Borana zone. On the other hand, a lower fat content (4.71 %) was reported by Asaminew (2007) for local cows' milk in Bahir Dar milk shed than the reports of this study. The Food and Drug Administration (FDA) requires not less than 3.25% of milk fat for fluid whole milk. The finding of this study is also in line with FDA's requirement.

The result of SNF content of producers in this finding was similar with the maximum of SNF value of producers reported by Debebe (2010). The collection of samples in the current study was from the consumers directly without recognizing the chain where the milk was brought from. Some of the consumers directly brought the milk from the producers and kiosks (milk selling houses) while others do not even know the source of the milk. Usually milk sellers in different parts of Ethiopia add water to the milk either knowingly or unknowingly. One of the reasons could be unawareness of the side effects of adding water while the other was to increase the volume of the milk to be sold in the interest of making more money. The study made by Ryoba *et al* (2005) described in their study that adulteration of milk by addition of water may induce chemical and microbial health hazards as well as reduce nutritional and processing quality, palatability and market value of the milk. Since lower fat and SNF values and higher percent of water were traced in this study from the samples of consumers, the nutritional quality of the raw milk was also poor. The significant difference in the contents of Fat and SNF is also related with the addition of water. Usually, households in the urban and peri-urban centers buy milk for feeding children, sick individuals and older people. This consequently has detrimental impacts especially on the nutritional quality, health and growth of children.

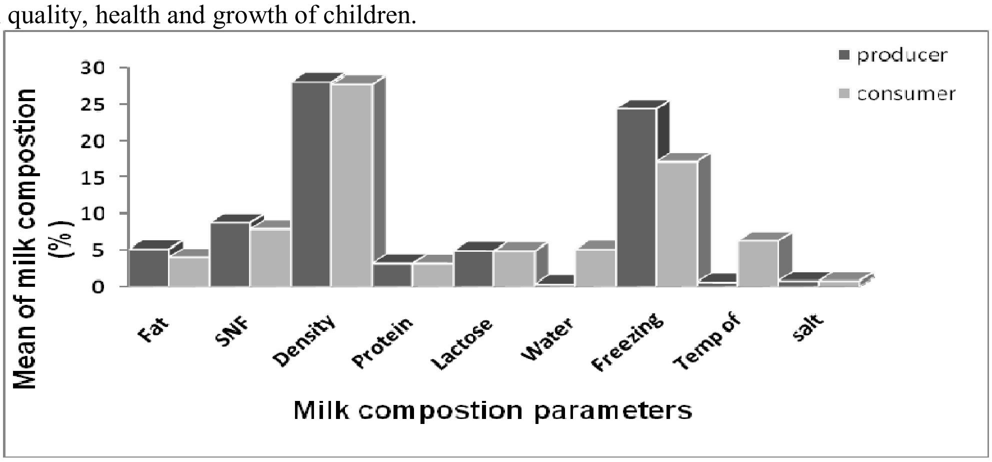

Figure 1: The chemical composition of cow milk collected from samples of producers and consumers

Producers and consumers microbial load of cow milk

TBC (Total Bacterial Count): Total bacterial count of milk samples collected from Yirgalem were significantly

($p<0.05$) higher than those from Hawassa. A similar study also reported that the level of TBC was significantly different by location (Fikirneh *et al*., 2012)

Lower Total bacterial count of Hawassa could be due to better management and the use of relatively better milking equipments such as plastic containers as compared to the practice in small towns as Yirgalem (table 3).The rise in the coliform count of the milk samples from households in the town of Hawassa higher than Yirgalem was related with the semi-intensive management system such as the milking, feeding and other management practices within confined barn. Thus, there was more exposure of the cow to contamination particularly of the udder by urine and dung. The CC result of the milk samples collected from the households in Hawassa (4.81) is comparable with the results of Asaminew and Eyassu (2011) which reported 4.49 ml^{-1} from raw milk samples collected from Bahir Dar and Mecha districts and 4.46 ml^{-1} reported by Alganesh *et al*. (2007) in the raw milk samples collected from small holder producers in East Wollega, respectively.

Table 7. Least Square Mean (±SE) of Total Bacterial Count and Coliform Count over location

	Hawassa (N = 60)	Yirgalem (N=60)	Significance Level (SL)
TBC(log cfu mL^{-1})	$6.84^a \pm .07$	$7.03^b \pm .07$	*
CC log cfu mL^{-1}	$4.81^a \pm .18$	$3.48^b \pm .18$	*

N= number of samples taken; TBC (Total Bacterial count), CC (Coliform count) cfu= colony-forming units; Means with different superscripts within the same column are significantly ($p<0.05$) different.

As illustrated in Figure 2, total bacterial counts were significantly different ($p<0.05$) between producers and consumers. The higher TBC was recorded in the milk collected from consumers (7.15) while it was lower in the milk collected from producers (6.73). Tesfay *et al* (2013) has also reported comparable findings due to higher TBC of milk obtained from dairy farm (5.84) which may represent the producers and one of the customers of milk sellers (9.14) might be consumers. There is also slightly higher Coliform count of consumers (4.29) than producers (4.00). This finding is also congruent with the results of Tesfay *et al* (2013) where 4.13 ± 0.76 cfu/ml of count for the samples collected from dairy farm. It is also in line with what Ali and Abdelgadir (2011) reported, which is 4.18 ± 0.01 log10 cfu/ml from raw milk samples.

Generally, the results showed that the quality of milk obtained from the different sources across the study locations was poor. The higher total bacterial counts are the indication of a diseased udder, unsanitary handling of milk, or unfavorable storage temperatures (Benson, 2001; Chambers, 2002; Biruk et al., `2009). The higher coliform count observed in this study may be due to the initial contamination of the milk samples either from the cows, the milkers, milk containers and the milking environment. A similar reason was also described in different studies (Abebe et al. 2012; Jayarao et al., 2004).

Thus, strengthening extension services and training of farmers (producers) and consumers on improved milk handling practices are required. Awareness raising and capacity building of various actors in the milk value chain is still fundamental to regularly monitor and ensure the overall hygienic conditions of milk production.

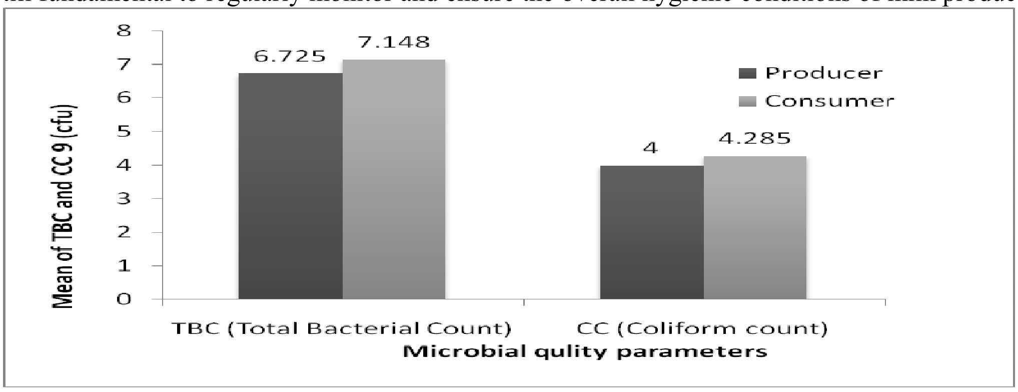

Figure 2: Total Bacterial Count (TBC) and Coliform Count (CC) of cow milk over different milk sources

CONCLUSION

➢ The study has apparently unveiled that the quality of milk samples collected from urban and peri-urban areas of Hawassa and Yirgalem towns was generally below standards. This is mainly due to unawareness and lack of strict hygienic practices during milking and subsequent poor handling. Moreover, traditional apparatus used for milking and storing of milk are observed to be harboring spots of bacteria and causes of milk contamination not only because of the porous nature of internal surfaces but also the design making hygienic cleaning ineffective. The higher total bacterial and coliform counts for consumers in the studied districts was attributed to poor handling of the milk, poor sanitation of the equipments and unsafe practices of cooling and storing.

➢ Adulteration of milk with water, powder and other substances was reported to be a common practice being practiced in the studied districts and consequently a major factor reducing the quality of milk. It happens at any stage of the milk value chain in the interest of increasing the volume of milk and thereby raises incomes. Little is, however, known on the quality implications and thereby health consequences of adulterated milk. Moreover, similar price offered to quality and adulterated milk has exacerbated further quality deterioration. There are also no institutional frameworks to control milk quality across the value chain.

- Even though this study was piloted in the two districts, it is firmly believed that the findings of this study and also of similar results in earlier studies could represent the menace that is taking place on the milk value chain across the country.

RECOMMENDATION

- Maintain the quality of milk and safeguard consumers (especially children, the sick and elderly) from enormous health risks through adequate sanitary measures across the milk value chain from the stages of production to consumption. These measures could include proper handling of the cow, personnel hygiene, use of hygienic milking and processing equipments, improving milk and milk handling environment, among others.
- Adequate awareness on improved milk handing and hygienic practices should also be created for all the actors in the milk value chain (including producers, milk vendors, traders, processors and consumers) to make them contribute to the best of ensuring the quality of milk. The current result has figured out the need of training on the potential causes of contamination, public health risks of consuming contaminated raw milk and techniques of producing good quality milk.
- Designing integrated programs to address the serious problem of milk adulteration, including training of producers, consumers, development agents, health extension agents, processors, milk vendors and other actors across the milk value chain.
- Mechanisms should also be established to set price differences based on milk quality. Dairy farmers and traders supplying clean and hygienic milk shall receive premium prices as compared to those supplying adulterated milk. Moreover, there should be mandated institutional frameworks, such as regulatory bodies, to control milk quality across the value chain.
- Easily understandable manuals, fliers and posters could also be prepared and distributed at large in local languages to reach the large mass of the community and create overall awareness on improved milk handling practices and the associated health benefits. Preparing informative articles with tangible evidences for the consumption of electronic and print mass media could also be another option to reach the large mass of the population in the country.

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