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Original Article

Milk Handling, Processing Practices and Quality Evaluation

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ABSTRACT

The study was conducted in Abuna Gindeberet district, west Shewa zone of Oromia region to evaluate milk handling, processing practices and physiochemical and microbial quality. Six PAs were purposively selected in proportion to the size of PAs, dairy cattle potential and accessibility from highland, midland and lowland agro-ecologies. Households who owned at least one lactating dairy cow and producing milk and milk products during the study period were the targeted population. A total of 155 smallholder dairy producers were randomly selected based on proportional from each PAs and interviewed individually using semi-structured questionnaire. For milk quality evaluation, 30 samples of raw cow milk were collected from producers during milking and transported to laboratory. The collected data were analyzed using SPSS software version 24.0. The result showed that hand milking was entirely the milking system practiced in the study area. In the area, 88%, 10% and 2% of the respondent have experience of using "Okole" in Afan Oromo made from woven grass, plastic buckets and metal bucket for milking, respectively. Whereas Clay Pot "Buchuma" in Afan Oromo (51.6%), Calabash/Gourd "Qabee Aannanii" in Afan Oromo (34.2%) and Plastic (14.2%), were the major utensils used for milk storage. The overall mean (±SD) of raw cow's milk for moisture, fat, SNF, Lactose, protein, ash and total solid were 86.04±1.10, 4.19±0.70, 9.77±0.58, 5.39±0.31, 3.53±0.26, 0.78±0.09 and 13.96±1.10, respectively. The results differ significantly ($p>0.05$) among the three agro-ecologies. Alcohol test result indicated that of the total samples, 60%, 23.3% and 16.7% were normal milk, curd forming milk and slightly precipitated milk and the results did not differ($p>0.05$) among the three agro-ecologies. The overall mean (±SD) of total bacteria count (TBC),

Coliform Count (CC), and Yeast & Mold of sampled raw milk were 5.99±0.35log_{10}cfu/ml, 8.13±0.31log_{10}cfu/ml, 7.24±0.21log_{10}cfu/ml, respectively. The results did not differ ($p>0.05$) among the three agro-ecologies. Based on the result of the present study, it is evident that poor milk handling and processing practices undertaken in the study area that need urgent intervention by concerned stakeholders. Furthermore, it is recommended to conduct research in multidisciplinary and controlled experiments.

Keywords: Milk Quality, Milk Microbiology, Milk Physicochemical, Gindeberet, Ethiopia.

INTRODUCTION

Livestock production in Ethiopia is mainly on smallholder farming system, with livestock having a multipurpose use. Moreover, livestock accounts for approximately 47.69% of the total agricultural gross domestic product (GDP) and 23.8% of national foreign currency earnings (IGAD, 2013).

Dairy production is used as an enterprise and economically viable and greatly contributes to poverty reduction, food security, increased family nutrition and income and job opportunity creation (Niraji, 2014). It plays a vital role in economic development, especially in developing countries as both driving economic growth and profiting from it. It is a valuable device to increase income, employment, food and foreign exchange earnings as well as better nutrition as an engine of growth. The share of animal products in total food budget increases faster than that of cereals due to relatively high-income elasticity of demand for animal products (Dayanandan, 2011).

Ethiopia is endowed with large number of livestock species and ranked 5th on the world. According to Central Statistical Agency (2018), the total cattle population of the country is 60.39 million, of which 12.39 million were dairy cows; and the annual milk production is 3.1 billion litres. Heeding breed groups, out of this total cattle population, 98.24, 1.54 and 0.22 percent are indigenous, hybrid and exotic breeds, respectively (CSA, 2018). Per capita consumption of milk is approximately 19 kg per year (FAO, 2018), which is below recommended 200 liters. This is also much lower than Africa and world per Capital's average of 40kg/year and 105kg/year, respectively (AGP, 2013).

Milk has a complex biochemical composition and high water activity. Due to its high nutritive value, raw milk serves a good medium for microbial growth that degrades the milk quality and shelf-life. The demand of consumers for safe and high quality milk has placed a significant responsibility on dairy producers, retailers and manufacturers producing and marketing safe milk and milk products (Mennane *et al*., 2007). Adverse environmental condition is highly affecting the quality of milk and milk products. In areas where the climate is hot and humid, the raw milk gets easily fermented and spoiled during storage unless it is refrigerated or preserved. However, such storage facilities are not readily available in rural areas and cooling systems are not feasible due to lack of the required dairy infrastructure (Gemechu *et al.*, 2015). Chemical composition of milk is variable and influenced by genetic factors like breed and environmental stress such as stage of lactation, changes in feeding, etc. Milk composition and production are the interaction of many elements within the cow and external environments (O'Connor, 1994). However, it is generally

accepted that the dairymen can alter many of these factors to achieve milk production and increase profit.

According to FAO (2018) and CSA (2018a) report, Oromia with 24.43 million cattle ranked first out of nine regional states in Ethiopia. Western Shewa Zone contributes 2.07million cattle. Among this cattle population, Abuna Gindeberet district contributes 137,279 of cattle. The district has a high potential for dairy production due to high demand for milk and milk products. However, there is presently no detailed study conducted in the district on milk handling, processing practices and milk quality evaluation that could be affordable to the resource poor. Thus, this study was critical to evaluate milk handling practices, processing and milk quality detection.

MATERIALS AND METHODS

a. Description of the Study Area

The study was conducted in Abuna Gindeberet district, which is located at 170km from Addis Ababa on the way to North West from January 2018 to June 2019. Agriculture is the main activity in the study area, where livestock productions in general and dairy production in particular are mainly produced. Abuna Gindeberet district has an elevation ranging from 1000 to 2604 meter above sea level (m.a.s.l). The temperature of this district varies from 10-30℃ (Mulubiran, 2013). The study area has three agro-ecologies (lowland-17%, Midland-56% and Highland-27%) (www.elevationmap.net). The estimated livestock populations in the district are 137,279cattle, 39,590sheep, 52,977goats, 19,455asses and 405mules, 39,367chickens and 14,569 bee colonies (AGOoFED, 2018).

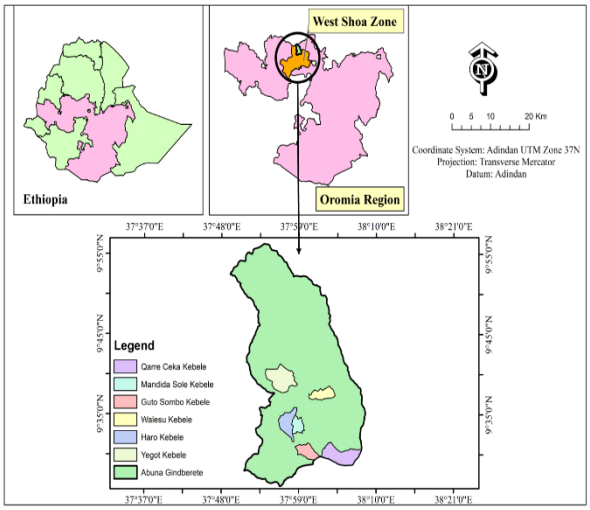


Figure 1: Maps of the study area
Source: GIS Sketch (2018)

b. Research Design

The study was conducted in two parts; briefly, household survey and milk quality analysis. For the first part, a single-visit formal survey method was followed to gather the data focusing on assessing the milk handling and processing practices. The second part dealt with evaluating physicochemical composition and microbial quality of raw milk.

Part I: Household Survey

The study district was purposively selected based on its dairy production potential and accessibility. By using stratified sampling technique agro ecologies were stratified into highland, midland and lowland. Accordingly, six PAs were selected in proportional to the sizes of the population and number of dairy cattle population from each agro-ecology.

The proportion was calculated by the formula (Kaps and Lamberson, 2004) as:

$$\mathbf{P_i = \frac{N_i}{N} \times 100}$$

Where,

P_i - represents the proportion of PAs included in each agro-ecology;

i - 3 Agro-ecology,
N - 41 whole Rural PAs in the district, and
N_i - otal number of Rural PAs in each Agro-ecology 'i' (N_1=highland 11PAs, N_2=mid-highland 23PAs, and N_3= lowland 7PAs). Then the sample size of each agro-ecology was calculated as $n_i = \mathbf{n} \times \mathbf{P_i}$and n represent the total sample size $n = \sum n_i$

Therefore,

$$P_1 = \frac{N_1}{N} = \frac{11}{41} = 0.2683$$

$$P_2 = \frac{N_2}{N} = \frac{23}{41} = 0.5610$$

$$P_3 = \frac{N_3}{N} = \frac{7}{41} = 0.1707 \text{ and}$$

$$n_1 = n \times P_1 = 6 \times 0.2683 \cong 2,$$

$$n_2 = n \times P_2 = 6 \times 0.5610 \cong 3 \text{and}$$

$$n_3 = n \times P_3 = 6 \times 0.1707 \cong 1$$

Accordingly, a total of six peasant associations (Haro and Yegot from highland; Welensu, Guto-Sombo, and Mandida-Sole from Midland and Qarre-Ceka from lowland) were selected based on dairy production potential and accessibility to transport raw milk samples for laboratory analysis at the standardized time (24hrs). Households who owned at least one lactating dairy cow and producing milk and milk products during the study period were the targeted population. And then the sample size was determined by the formula given by Yamane (1967) with 92 % confidence level.

$$\mathbf{n = \frac{N}{1+N(e)^2}}$$

Where, n = sample size

N = Total number of households (HH) (22626 HHs)

e = Sampling error =8% (0.08)

1= probability of the event occurring

Therefore,

$$\mathbf{n = \frac{N}{1+N(e)^2} = \frac{22626}{1+22626(0.08)^2} \cong 155}$$

Accordingly, 155 households were selected using the formula of proportion ($n = n_i \times p_i$) for this study.

c. Methods and Sources of Data

Both qualitative and quantitative data were collected from secondary and primary sources from the selected district and communities. Home to home interview were done by researchers with help of DAs of each peasant association since DA knows every farmers. Semi-structured questionnaire were prepared for respondents accordingly. The questionnaires were initially prepared in English and later translated into Afan Oromo (local language) and then a pre-test of the interviews was carried out before the actual interviews were started. The questionnaire was edited for its validity, consistency, and clarity based on the pre-test result.

Both primary and secondary data were collected. The primary data were collected from the target respondents. The secondary data were collected from zonal and district's agricultural office, CSA reports, and other relevant sources. In order to verify the information collected from respondents, key informant interviews (KII) and focus group discussions (FGD) were also under taken.

Part II: Milk Sampling Procedures and Methods of Analysis

The second part of the study was taking raw milk samples for analysis of its quality in terms of physiochemical and microbial quality. A total of 30 milk producers, (11 from both highland and midland, and 8 from lowland) agro-ecologies were selected for taking milk samples. Accordingly, 280ml of raw milk sample was aseptically taken from milking utensil of the producers by mixing thoroughly. And samples were placed into sterile plastic bottles within 15minute of milking at ambient temperature. Then each sample

container was sealed air tightly immediately after filling and labeling with the details of its sources (producer, cows breed, feed type, lactation stage, time of collection, place of milking and milk handling utensils) as important information. And the samples were kept in the icebox and transported to Holeta Agricultural Research Center's Dairy Microbiology and Chemistry within 24 hours of production and analyzed immediately after arrival at the laboratory. Both physical and chemical qualities of raw milk (i.e., pH, temperature, specific gravity, SNF, fat %, protein %, lactose %, added water, ash %) of sample milk were determined using Automatic Milk Analyzers (AMA) that is known as Lactoscan. Besides, some physical qualities (titrable acidity, organoleptic test, clot-on boiling test, alcohol test) analyzed using method of the Association of Official Analytical Chemists (AOAC, 1990). Raw milk microbial loads were determined.

a. Milk Physical Quality Assessment
Specific Gravity

Milk sample was filled gently into a measuring cylinder at room temperature. Then a Lactoscan was placed to sink slowly into the milk and the reading was taken. According to (O'Connor, 1994), normal cows' milk should have a specific gravity between 1.028 and 1.032g/cm^3. After recording the Lactoscan reading specific gravity was calculated by the formula; $SG = \frac{Lc}{1000} + 1$ Where, Lc = corrected lactometer reading at a given temperature.

Titrable Acidity

Titratable acidity of the milk samples was determined according to the method of the Association of Official Analytical Chemists (AOAC, 1990). Titratable acidity is a measure of freshness and bacterial activity in milk. The production of acid in milk is normally termed souring and the sour taste of such milk is due to the production of lactic acid. The percentage of acid present in dairy products at any time is a rough indicator of the age of the milk and how it has been handled (FAO, 2009). Acidity was measured by titration with 0.1N sodium hydroxide solutions and using 1% ethanol solution of phenolphthalein as the indicator (O'Connor, 1994). A dye, which changes color at a specific pH, was added to the milk and titrated with a base (added little by little) until the color changes. By recording the volume of the bases required and the volume of the milk sample, the amount of lactic acid was calculated by the following formula (FAO, 2009).

$$\text{Titrable Acidity (\%)} = \frac{V_1 x N x\ 9}{V_2}$$

Where, V_1 = volume in ml of the standard 0.1 NaOH used

N = Normality of 0.1N NaOH

V_2 = volume in ml of milk solution used

Normal milk acidity ranges from 0.10 to 0.20% lactic acid. Any value above 0.20% can safely reckon as the developed lactic acid.

Temperature and pH Value

The temperature and pH Value of the milk samples was determined in the laboratory using AMA (Lactoscan). Milk sample was filled gently into a measuring cylinder at room temperature. Then a Lactoscan was placed to sink slowly into the milk and both temperature and pH values on the reading were recorded. The temperature was recorded to the nearest 0.5°C (O'Connor, 1994).

Organoleptic Test

Three trained persons carried out this test at each household during sample

collection. Milk utensil was opened immediately; smelling, tasting and seeing were done. To establish nature and intensity of smell; whether the milk has foreign odors (e.g. smoky, burnt, weedy, cowry, chemical/drug smell) the observation was made to examine the appearance of the milk (color of the milk, any marked separation of fat, color, and physical state of the fat, foreign particles or physical dirt). Besides, the trained persons identify the flavor of the milk, whether the milk has a taste of sourness, bitterness, and sweetness milk (O'Connor, 1994 & FAO, 2009). Accordingly, for odor, appearance and flavor experienced and purposively trained persons were decided on the level of Normal, Fair and slightly rancid.

Alcohol test

A protein in milk that has become sour (i.e. because of lactic acid formation) was coagulated when mixed with alcohol. Five milliliters of milk and 5 ml of 68 % alcohol (ethanol) were placed in a beaker. Then the beaker was shaken several times gently to mix, and any clot formation was noted. Then the beaker was examined for the formation of curd. The curd formation indicates the absence of freshness of the milk (FAO, 2009). Then finally, the milk was recorded as categorized in the level of normal, curd formed and precipitated levels and analyzed in percentages.

b. Milk Chemical Quality Assessment

According to FAO (2009) principles, compositional properties (fat, protein, lactose, water, and ash %) were the features of raw milk related to the natural composition. It has special importance to the value for further processing. Based on these principles the chemical compositions of milk analysis were tested by using the AMA (Lactoscan). The milk samples were put in a test tube, and the Lactoscan was inserted into the milk for one minute, and it displayed the result on the reading palate. Finally, the reading of all chemical parameters was recorded based on this machine reading and analyzed. However, the totals solids (TS) content in milk is the mass % of substances in the milk, comprising fat, protein, lactose, minerals, and vitamins. A total solid based on density was calculated as the estimation for total solids, was estimated SNF of Lactoscan reading as; SNF = TS - fat %.

Milk Microbial Load Assessment

The microbial test considered for determination of the bacterial load in the raw milk samples were Standard Plate Count (SPC), Coliform Count (CC), spore-forming bacteria and yeast and mould by using appropriate media. By using, pour plate method serial dilutions of the samples, $1:10^{-1}$ to $1:10^{-6}$ was made. Then about 0.1gm (surface plating) and 1gm (pour plating) dilutions were mixed with culture medium in pre-labeled sterile plates. For each sample, the analysis was made in duplicate plates. For all tests, the media were prepared according to the guidelines given by manufacturers. Peptone water and other media prepared for each test (except VRBA was sterilized by boiling) were autoclaved for 20 min at 121°C (Richardson, 1985). The following methods were engaged in analysis of the microbial load of the raw milk samples. The corresponding SPC and CC were computed from duplicate plates containing between 25-250 colonies. Plates containing less than 25 colonies were taken as too less to count (TLTC) and plates containing greater than 250 colonies for too numerous to count (TNTC). The colonies were counted by colony counter. The number of colony forming units (N) per milliliter of the sample was calculated using the following formula;

$$\mathbf{N} = \frac{\sum \mathbf{C}}{(\mathbf{1} \times \mathbf{n_1}) + (\mathbf{0.1} \times \mathbf{n_2})} \times \mathbf{d}$$

Where, N = Number of colonies per ml of milk sample
ΣC = Sum of all colonies on plates counted
n_1 = number of plates used in lowest dilution counted
n_2 = number of plates used in highest dilution counted
d = dilution factor of the lowest dilution used.

Coliform Count

The CC was made by mixing 10ml of milk sample into the sterile stomacher tube having 225 ml peptone water (1%). After mixing, the sample serially diluted up to $1:10^{-4}$ in sterile test tubes having 9ml of peptone water and duplicate samples (1ml) were plated using 15-20 ml Violet Red Bile Agar (VRBA) in a sterile petri dish. After thoroughly mixing, the plated sample was allowed to solidify and then incubated at 33.3ºC for 24 hours and a count was made. Typical dark red colonies (> 0.5 mm in diameter) are considered as coliform. Gas production after 24 h of incubation at 33.3°C was considered sufficient evidence for the presence of Coliforms.

Total Bacterial Count

The TBC was also referring to as the Standard Plate Count, Total Viable Count or Colony Count. This method involves growing bacteria in colonies on an agar gel, which contains nutrients to support microbial growth. Milk was diluted and added to the agar (PCA) in a sterile petri-dish, and then the Petri dish was incubated at 35°C for two days. The colonies are counted after the 48hours.

Yeast and Mold Count

The milk samples were analyzed for the presence and concentration of yeasts and molds. One ml of milk sample serially diluted in $1:10^{-4}$ and $1:10^{-5}$ using peptone water was transferred into sterile plates. Total yeast and mold count was carried out using Potato Dextrose Agar (PDA) the plates were incubated at 25°C for 48hours (FAO, 1997). The number of colony forming units (N) of yeast and mold, bacteria per milliliter of the sample was calculated using the previous formula.

D. Method of Data Analysis

Both quantitative and qualitative data collected were coded and entered into the computer using Excel data sheet management and analyzed by SPSS version 24.0. To test the difference among agro-ecologies for certain variables, z-test and chi-square test were employed. For the analysis of milk quality like microbial analyses, the number of microorganisms (colony forming units) per gram of milk samples was calculated as average count per plate 1 and 2 the dilution factor (IDF, 1987). Some of the colonies of SPC counted were under 30 (TLTC) and other were over 300 (TNTC); for the colony counts, TLTC and TNTC took an approximate number of the ranges of the 30-300 colonies. Log_{10} transformed values were analyzed using the General Linear Model (GLM) procedure of SAS (2014). Fisher's LSD was used for mean separation techniques. The specific ANOVA model used for the test was as follows:

$\mathbf{y_{ij} = \mu + a_i + \varepsilon_{iji} = 1,...,a; j = 1,...,n \Rightarrow a=3}$ **and n=9**

Where,
y_{ij}= individual observation j^{th}, in the i^{th} location, (AHH),
μ = the overall mean value,
a_i = the fixed effect of the location where i =3, and
ε_{ij}= random error

RESULTS AND DISCUSSION

A. Milking Management

The results of milking procedures, place of milking, milking utensil used for milking and storage were presented in table 1.

Hand milking was entirely milking practiced in the study area and usually performed by women. Calves were allowed for partial suckling their dams for sometimes before and after milking. Since zebu breed did not lactate without calves suckling, farmers in the study area accomplish it. Of the total respondents, 96.8% of the farmers milked their cows twice per day and 3.2% of them once a day during the dry season when feed is scarce. The result of the present study was similar with the findings of Amistu *et al*. (2015), Kassa and Fiseha (2016) and Amanuel *et al*., 2018).

The total respondents, 88%, 10% and 2% of the respondents were using "Okole" in Afan Oromo made from Woven grass, plastic buckets and metal bucket utensils for milking, respectively. Whereas, clay pot "Buchuma" in Afan Oromo (51.6%), Calabash/gourd "Qabee annanii" in Afan Oromo (34.2%) and plastic buckets (14.2%) were milk storage utensils in the study area. Narrow neck Calabash/gourd known as "Wessoo" or "Abuubbii" in Afan Oromo was the only milk churning material in the study area. This findings was in agreement with the results of Amanuel et al. (2018) who reported that "Qabee" and bottle gourd "Abuubbii or Ro'oo'' in Afan Oromo) is exclusively milk vessel used for the churning purpose in Gimbi district of Western Ethiopia.

Across the agro-ecologies of the study area, there was no significant difference ($P>0.05$) in time of milking, kind of utensil used for milking, storing and processing. But there was a significant difference in the milking area between the lowland and highland areas (table 1). The difference in the milking area among the lowland and highland was due to the different housing system.

B. Milking Hygienic Practices

Hygienic practices are major pathways to produce safe and quality products for the consumers, thereby reduce microbial contamination and loss of product (FAO, 2009). The hygienic practices during milking and other activities that were done by the farmers in the study area were presented in table 1.

The total respondents, 57% of the households were smoking the utensil before milking or processing as hygienic practices, the rest (43%) were exercise washing of the udder before milking. This result was in agreement with the report of Debela (2016) that 40% of farmers were washing the udder before milking. In contrast to the current result, Gebeyew *et al*. (2016) reported that half of the respondents do not wash the udder at all, for they believed that it is cleaned when the calf suckles before milking.

The farmers that reported washing teats of local cows confirmed that they did it during contamination with cow dung or other mud available on the teat since calf refused to suckle dam. Those farmers that could not practice washing udder of milking cows were witnessed that the calf suckles the udder of the cow before milking it is no need of washing and this result was in line with the results of Amanuel *et al.*, (2018).

68.4% of the respondents used warm water for cleaning the hands, milk utensils and teat/udder. Using hot water to clean the vessels helps to remove fat from the milk (O'connor, 1994). The current study was in contrast to the results of Gebeyew *et al*. (2016) and Rahel (2008) that reported only 27.7% and 26.7% of the producers washed udder with the warm

water. This might indicated that the information gap on hygienic milk and milk products production practices among dairy cattle keepers in various areas.

Table 1: Milking Practices, milking area and utensils used in the Study Area (%)

Activities	Agro Ecology			Total
	HL (N=42)	ML (N=87)	LL (N=26)	
Frequency of Milking Per Day				
Morning Only	0%	5.7%$_a$	0%	3.2%
Morning, And Evening	100%$_a$	94.3%$_a$	100%$_a$	96.8%
Milking Area				
In House	42.9%$_a$	13.8%$_b$	0%	19.4%
Barn/"Dallaa"	33.3%$_a$	77.0%$_b$	61.5%$_{a, b}$	62.6%
Open Land	23.8%$_{a, b}$	9.2%$_b$	38.5%$_a$	18.1%
Kind of utensil used for milking				
Woven Grass (Okolee)	81.0%$_a$	88.5%$_a$	100.0%$_a$	88%
Plastic Bucket	14.3%$_a$	10.3%$_a$	0%	10%
Metal Bucket	4.8%$_a$	1.1%$_a$	0%	2%
Utensil used for milk Storages				
Plastic	14.3%$_a$	16.1%$_a$	7.7%$_a$	14.2%
Clay Pot	45.2%$_a$	57.5%$_a$	42.3%$_a$	51.6%
Calabash	40.5%$_a$	26.4%$_a$	50.0%$_a$	34.2%

NB: HL: Highland, ML: Midland, LL: Lowland N: number of respondents, each subscript letter (a-c) denotes a subset of Agro ecology categories whose column proportions do not differ significantly from each other at the 0.05 level.

The majority (75.5%) washed the milking and milk storage utensils and left it dry by smoking. Besides, they polish with herbs or stover/fiber known as "foxsoo" in Afan Oromo to clean unwanted wastes and used different herbs to get a pleasant aroma and to improve the shelf life of the products. While the remaining farmers have used sunlight and keeping utensil downward in the air to dry after washing 18.7%, and 5.8%, respectively. This might rush the utensil for contamination with the foreign pathogen.

All farmers in the study area were using the herbs and other plants for cleaning/washing and smoking to get a pleasant aroma and shelf life of the products. The plants/herbs mainly used in milk utensil cleaning were *Lantana Trifolia* (Kusaye), *Rutachalepensis* (Chiladem), *Ocimum Hardiense* (Shokonota), *Hyparrhenia spp.* (Margacita) and *Ocimum Sanctum* (Basoobilaa), whereas "Ejersa" (*Olea Africana*) and "Urgessa" (*Premnas Chimperi*) are the major herbs used for somking of milk and milk products utensils (Table 2). In line with this finding, different studies (Amanuel et al., 2018 and Debela, 2016) showed as these herbs and plants used for cleaning and smoking commonly by dairy farmers in different regions of the country for improving good flavor and aroma; to increase shelf life of milk and milk product and to facilitate fermentation of milk for processing, based on the selection and availability.

C. Milk Quality Characterization of the Study Area

Added water to raw milk

As the result of milk quality analysis indicated, there was no adulteration of milk samples with water in the study area (Table 3). This finding was in contrast with the finding of the Desaleng (2018) who reported

in Bishoftu and Akaki about 2.80±3.60 of milk samples were adulterated with water.

The pH Values of Raw Milk

According to O'Connor (1995) and FAO (2009) fresh cow milk has a pH value that ranges from 6.6 to 6.8 when milk temperature is 20℃. In the current study, the overall mean (±SD) pH of milk was (6.47±0.42), which is not within the normal pH range. This might be due to increased acidity of milk due to bacterial multiplication. The current result was also less than the results of 6.66±0.04 and 6.5 ±0.17 reported by Dessaleng (2018) and Dajene (2017) in Bishoftu and Akaki areas and Jibat district of West Shewa zone of central Ethiopia, respectively. The difference from the previously done scholars' findings and the current result is due to the variation of production system, milk handling system and the difference in agro ecologies. The mean pH values of raw milk samples were not significantly different at (P>0.05) between the three agro-ecologies. This might be due to the similarity in the milk holding equipment, age of milk and handling techniques and increasing titratable acidity and bacterial contamination of milk along with the milk sampling to the place of testing.

Table 3: The Mean and SD physical quality analysis of raw cow milk in each agro-ecology

Parameters	HL (N=11) Mean±SD	ML(N=11) Mean±SD	LL(N=8) Mean±SD	Total(N=30) Mean±SD	P Value
Water added (%)	0.00	0.00	0.00	0.00	
pH value	6.46±0.42^{a}	6.54±0.55^{a}	6.37±0.16^{a}	6.47±0.42	0.681
Temperature (℃)	24.58±1.38^{a}	24.62±0.89^{a}	23.96±0.51^{a}	24.43±1.04	0.340
Titratable acidity (%)	0.30±.08^{a}	0.52±0.23^{b}	0.29±0.10^{ac}	0.38±0.18	0.003
Specific gravity (g/cm^{3})	1.0334±0.0014^{a}	1.0306±0.0007^{b}	1.0337±0.0006^{ac}	1.0325±0.0017	0.000
Freezing point	-0.61±0.04^{a}	-0.58±.03^{bc}	-0.55±.03^{c}	-0.58±0.04	0.003

HL: Highland, ML: Midland, LL: Lowland N: number of respondents; SD: standard deviation; the mean with difference superscript across the row is significant at the .05 level.

The Temperature of Raw Milk

The overall mean (±SD) of the raw milk Lactoscan reading was 24.43±1.04℃. There was no significant difference (P>0.05) in the mean of milk samples temperature among the agro-ecologies of the study area (Table 3). This might be due to lack of a cooling system. As the temperature increases, there is an increase of microbes in the milk. Most bacteria prefer to grow in the temperature region of 20 ºC to 45 ºC (FAO, 2009). The current study was less than the results of 25.93 ± 0.21℃ reported by Debela et al. (2015) in the case of Yabello Districts of Borana zone Southern Ethiopia. This might due to the agro-ecologies difference in the current and previous studies.

The Titratable Acidity of Raw Milk

The overall mean of Titratable Acidity/lactic acid (%) of sampled raw milk was 0.38±0.18. The mean titratable acidity/lactic acid % of raw milk samples were significantly different (P<0.05) between the three agro-ecologies (Table 3). The % of total titratable acidity did not follow a reverse trend with the pH. Normal milk acidity ranges from 0.10 to 0.20% lactic acid. Any value over 0.20 % can safely be reckoned as the developed lactic acid (FAO, 2009). In the current study, the milk samples collected from three agro-ecologies had a titratable acidity value of greater than 0.20%. this might be there was a lack of cooling system, poor handling practices during milking until milk were collected and took a long time to arrive at the laboratory. Therefore, there was the development of the bacteria, which resulted in lactic acid production.

The Specific Gravity of Raw Milk

The overall mean and (±SD) of the specific gravity of raw milk samples collected from householders was 1.0325±0.0017 g/cm^3 (Table 3). Significant differences (P<0.05) were observed for specific gravity across the agro-ecologies. The proportion of milk constituents influences the specific gravity of milk. Each of which has different specific gravity approximately as follows; water (1.000), Fat (0.930), Protein (1.346), Lactose (1.666), Salts (4.12) and SNF (1.616). As well as, the specific gravity of milk was decreasing by the addition of water, addition of cream (fat), while removal of fat and reduction of temperature increases the specific gravity of milk (O'Connor, 1995). Besides, the specific gravity of normal milk ranges from 1.027–1.035g per ml with a mean value of 1.032 g per ml (Tamime, 2009). FAO (1988) also reported that the specific gravity of normal milk ranges from 1.028-1.033 gram per milliliter. In the current study, the results obtained were within the ranges of normal cow milk.

The Freezing point of Raw Milk

The overall mean and (±SD) of the freezing points of milk samples were -0.58±.04 and significantly varied (P < 0.05) among the three agro-ecologies of the study area (Table 3). According to FAO (2009), water has a freezing point of 0°C, whereas normal milk has a freezing point of around -0.540 °C, due to dissolved components (mainly lactose and salts). Besides, the Ethiopian Quality Standards Authority (2009), the requirements of the freezing point should be -0.550℃ to - 0.525℃ for raw whole milk. The current study was slightly similar to the normal milk freezing point; therefore, the milk samples had a normal freezing point. However, the freezing point of milk in the current result was greater than the average milk freezing points reported by Dessaleng (2018) of -0.55±0.03 and the freezing point of milk could be affected during the cooling or the addition of wash water to the tank in most cases. Also, the current result was less than the results of -0.941 ± 1.40 reported by Shimelis (2016) with milk collected from the study conducted in Addis Ababa.

Organoleptic Test of Raw Milk

An organoleptic test was carried out at each household's house during sample collection. Of the total milk samples tested organoleptically, 60%, 20%, and 20% were normal, fair and rancid, respectively (Table 4). The current study result was supported by the finding Hailemikael et al. (2016) who reported 69% of milk had a normal taste in Around Burie town in case of Dairy Cooperatives.

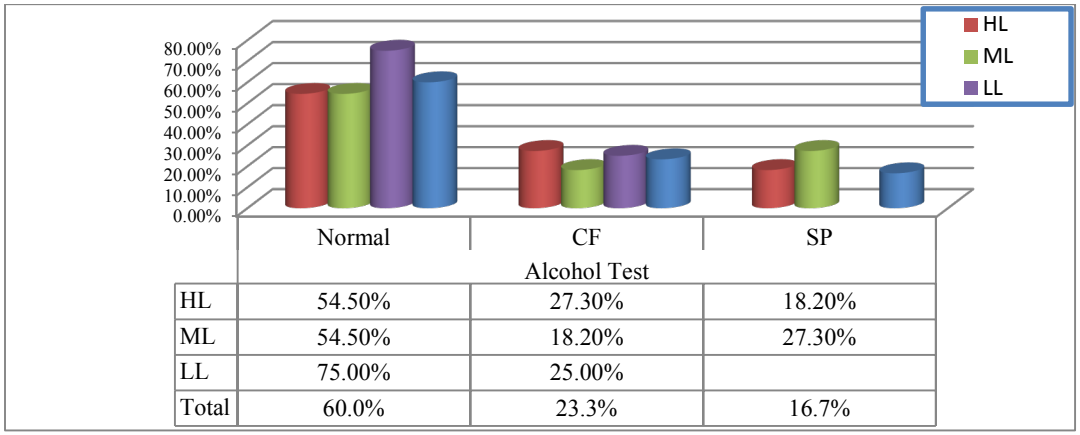
Table 4: Organoleptic test of raw local cow milk samples (%)

Parameters		Agro Ecology			Overall
		HL (N=11)	ML (N=11)	LL (N=8)	
Organoleptic	Normal	54.5	54.5	75.0	60.0
	Fair	36.4	18.2	-	20.0
	Rancid	9.1	27.3	25.0	20.0

HL: Highland, ML: Midland, LL: Lowland N: number of respondents; Each subscript letter denotes a subset of Agro Ecology categories whose column proportions do not differ significantly from each other at the .05 levels

Alcohol and Clot on Boiling Test of Raw Milk

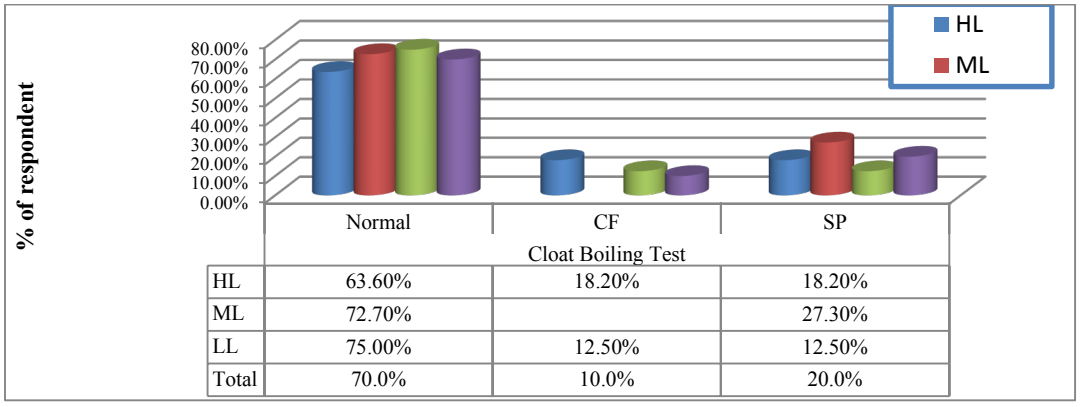
The alcohol and clot on boiling test results were presented in Figure 2. The alcohol test result revealed that 60% of the milk samples were normal, whereas the remaining (23.3%) and (17.7%) were forming coagulation and slightly precipitated. Milk that contains more than 0.21% acid or calcium and magnesium compounds greater than normal amounts coagulates when alcohol is added (O'Connor, 1994). Clot on boiling test result showed that 70%, 10% and 20% of sampled milk were observed as normal, a clot formed and slightly precipitated, respectively. The current study result was comparable with the findings of Alganesh and Fekadu (2012) who reported that 20% of the sampled milk was forming curd on clot on boiling test and 58 % of the milk samples were more likely to clot in Bila Sayo and Guto Wayu of East Wollega. This was probably due to initial contamination of the milk samples either from containers or from the general milking environment.



	Normal	CF	SP
HL	54.50%	27.30%	18.20%
ML	54.50%	18.20%	27.30%
LL	75.00%	25.00%	
Total	60.0%	23.3%	16.7%

HL: Highland, ML: Midland, LL: Lowland CF: curd forming; SP: slightly precipitated

Figure 2a: The alcohol test of raw local cow collected from producer in agro ecologies (%)



	Normal	CF	SP
HL	63.60%	18.20%	18.20%
ML	72.70%		27.30%
LL	75.00%	12.50%	12.50%
Total	70.0%	10.0%	20.0%

HL: Highland, ML: Midland, LL: Lowland CF: curd forming; SP: slightly precipitated

Figure 2b: The clot-on boiling test of raw local cow collected from producer in agro ecologies (%)

D. Raw Milk Chemical Compositions

Water Composition of Raw Milk

The overall average % of moisture in the milk constituent was 86.04±1.10 % (Table 5). There was a significant difference in water constituents of raw milk ($P<0.05$) across the three agro-ecologies of the study area. This might be due to the difference in

the feeding system and feed source variation in each agro-ecology. The current result of moisture content was in the ranges of normal raw milk moisture content of 85.5 to 89.5% reported by FAO (2009).

Total Solid (TS) Content of Raw Milk

The overall average result of TS content in raw cow milk sampled in the present study was 13.96±1.10% (Table 5). Statistical analysis showed that there were significant differences (P<0.05) within the TS content of milk collected from different agro-ecologies. The current study result was within the recommended standards of TS ranges between 10.5- 14.5% by FAO (2009) and Quality and Standards Authority of Ethiopia/QSAE (2009) requirements of unprocessed whole milk should be compiled in minimum 12.80% in Total solid content. This result was slightly similar with the results of Gemachu et al. (2015) who found total solid in milk 12.87% in Shashemene town southern Ethiopia. The total solid in milk might be due to breed, feeding and management system variation that have an important effect on milk composition quality.

Fat Composition of Raw Milk

The overall average and standard deviation of fat composition of raw cow milk sampled was 4.19±0.70 in % (Table 5). The statistical analysis revealed that there was a significant difference between the highland and midland areas at the P<0.05 level of significance. This variation might be due to the feeding and management system difference across each agro-ecology. According to the European Union, the quality standard for unprocessed whole milk fat content should not be less than 3.5% (Tamime, 2009).

Table 5: Overall Mean Compositional Quality Analysis of Raw Local Cow Milk

Parameters	Agro Ecology (Mean±SD)			Total (n=30)	P Value
	HL (n=11)	ML (n=11)	LL (n=8)	Mean ± SD	
Moisture %	85.47 ± 1.09^{a}	86.97±0.84^{b}	85.55±0.46^{c}	86.04 ± 1.10	0.001
TS %	14.53 ± 1.09^{a}	13.03±0.84^{b}	14.45±0.46^{c}	13.96 ± 1.10	0.001
Fat %	4.40±0.79^{a}	3.78±0.60^{b}	4.46±0.50^{ac}	4.19 ± 0.70	0.049
SNF %	10.14±0.45^{a}	9.25±0.35^{b}	9.99±0.47^{c}	9.77 ± 0.58	0.000
Lactose %	5.51±0.27^{a}	5.09±0.20^{b}	5.64±0.05^{c}	5.39 ± 0.31	0.000
Protein %	3.62±0.16^{a}	3.30±0.26^{b}	3.73±0.04^{c}	3.53 ± 0.26	0.000
Ash %	0.83±0.04^{a}	0.72±0.12^{b}	0.81±0.05^{ac}	0.78 ± 0.09	0.007

HL: highland; ML: midland; LL: lowland; SD: standard Deviation; n: number of samples; TS: total Solid; SNF: Solid nonfat; The mean with difference superscript across the row is significant at the 0.05 level.

Similarly, Quality and Standards Authority of Ethiopia/QSAE (2009) requirements of unprocessed whole milk should be compiled in a minimum of 3.5% in fat content. Therefore, the fat content of the current study was within the recommended standard.

Solid- Non- Fat (SNF) Content of Raw Milk

The average SNF content of milk sampled for the present study was 9.77±0.58 in %. Statistically, significantly there was difference of SNF content of milk at (P< 0.05) This was due to the difference in fat content, which depend on the amount of roughage feeds fed to the animal. The minimum SNF % set by European Quality Standards for unprocessed whole milk is 8.5 % (Tamime, 2009). Also, FAO (2009) recommended SNF content should be in the ranges of 8.2-10 %. Therefore, the current result was within the recommended standard and the sampled raw cow milk considered as normal milk.

Protein Composition of Raw Milk

The overall mean and standard deviation of the protein content of raw cow milk samples collected from each agro-ecology was 3.53±0.26. There was a significant difference (P<0.05) in protein content of raw cow milk collected from the producer in three agro-ecologies. The difference in protein content across the agro-ecologies might be due to the variation in the feed source, feeding practices and management practice within the agro-ecologies. According to QSAE (2009), the minimum protein content of unprocessed whole milk is 3.20%. The value of protein content obtained in the current study fulfills the criteria developed by the Quality and Standards Authority of Ethiopia.

Lactose Composition of Raw Milk

The overall mean and (±SD) of the lactose composition of raw cow milk obtained from the three different agro-ecologies was 5.39±0.31. There was a significant difference (P<0.05) between the agro-ecologies of the study area in the lactose composition. This might be due to feed source, feeding system variation, lactation stage, parity and action of lactose hydrolyzing enzymes produced by microorganisms during handling and transportation to the laboratory. According to European Union Quality Standards for unprocessed whole milk, lactose content should not be less than 4.2% (Tamime, 2009). Besides, the lactose content of milk thought can range from 3.6 to 5.5% (O'Mahony, 1988). Therefore, average lactose content (5.39±0.31 %) observed in this study for the milk samples was within the recommended standards.

Ash Composition of Raw Milk

Ash content of raw milk obtained from milk producers of three agro-ecologies averaged 0.78±0.09. The ash contents of milk samples collected from householders significantly different (P < 0.05) across agro-ecologies. According to O'Connor (1995), the ash content of cow milk remains relatively constant, 0.7 to 0.8 % and breed, stage of lactation and the feed of the animal influences it. Therefore, the ash content of the raw milk obtained from household milk producers of the present study was within the standardized ash content of whole milk.

E. Raw Milk Microbial Characteristic

Coliform Count (CC)

The mean (±SD) of coliform count (CC)/ml of raw milk samples collected from milk producers in three-agro ecology was 5.99±0.35 $\log_{10}$cfu/ml (Table 6). There was no significant difference (P>0.05) among the agro-ecologies in CC counts. A similar study conducted by Amistu et al. (2015) indicated that a higher mean range of coliform bacterial counts of 5.42±1.735 to 5.78±0.985 $\log_{10}$cfu/ml for samples collected from the farmer and retail shop on Sebeta site. The current result of coliform counts/ml was higher than the findings of Tesfaye et al. (2015) (4.13 ±0.76 $\log_{10}$cfu/ml), Asaminew and Eyassu (2011) (4.49±0.11 $\log_{10}$cfu/ml) and Negash et al. (2012) (4.35±0.06 $\log_{10}$cfu/ml) for raw cow's milk. However, lower than from the result of Yilma and Faye (2006) who reported the higher coliform count of 6.57log10cfu/ml. in line with FAO (2009), the presence of high numbers of Coliforms in milk indicated that the milk has been contaminated with fecal materials. Also, this could be attributed to insufficient pre-milking and udder preparation, poor hand washing practices of milkier and use of poor quality and non-boiled water for cleaning of milking utensil, which introduces the pathogen to milk.

Table 6: Overall mean (±SD) CC, TBC, and YMC counts (log_{10}cfu/ml) of raw milk samples.

Parameters	HL (n=11) Mean±SD	ML(n=11) Mean±SD	LL(n=8) Mean±SD	Overall(n=30) Mean±SD	P Value
CC (log_{10}cfu/ml)	5.90±0.43[a]	5.96±0.38[a]	6.14±0.12[a]	5.99±0.35	0.323
TBC (log_{10}cfu/ml)	8.27±0.38[a]	7.98±0.19[a]	8.13±0.25[a]	8.13±0.31	0.069
YMC (log_{10}cfu/ml)	7.15±0.25[a]	7.36±0.16[a]	7.21±0.15[a]	7.24±0.21	0.050

HL: highland; ML: midland; LL: lowland; SD: standard Deviation; n: number of samples; CC: Coliform Counts; TBC: Total Bacterial Count; YMC: Yeast and Mold Count; the mean with difference superscript across the row is significant at the 0.05 levels

Total Bacterial Count

The total bacterial count is also a good indicator for monitoring the sanitary conditions practiced during production, collection, and handling of raw milk. The mean total bacterial count (TBC)/ml of milk was not significantly different (P >0.05) among milk samples collected from three agro-ecologies. The average values of TBC/ml of raw milk samples collected from milk producers of the study area was 8.13±0.31log_{10}cfu/ml. This value is highly greater than the minimum quality standard value of the country (2 x10^6), ES (2009). In line with study by Alganesh et al. (2018) the higher TBC observed in the current study might be explained in terms of initial contamination of milk samples either from milking cows or from the exterior of an udder, body, mastitis milk, milkier, un-hygienic milking areas, and milk container. This showed that the sanitary conditions under which the sampled milk has been produced and handled were generally substandard. The total bacteria count obtained from the current research result was slightly higher than research conducted in the country by Tamirat (2018) (6.15log_{10}cfu/ml); Azeze & Haji (2015) (7.03±0.07log_{10}cfu/ml) and Negash et al. (2012) (7.08log_{10}cfu/ml). And the current value was lower than the total bacteria count reported by Yilma (2010) (9.10log_{10}cfu/ml) and Bereda *et al*., (2012) (9.82log_{10}cfu/ml). The total bacterial count in the present study was slightly similar to a study conducted in selected areas of Amhara, Oromia National Regional States, Ethiopia by Dehinenet et al. (2013) reported 8.0±0.89log_{10}cfu/ml, and Amistu *et al.,* (2015) reported 8.07±0.834log_{10}cfu/ml from the informal merchant at Sululta. The variation of TBC in the current study with another scholar might be due to handling of the sample during collection, hygienic practices performed during milking and foreign contamination during milking.

Yeast and Mold Count

Yeast and mold are considered as spoilage forming organisms. As shown in Table 6 the overall mean and standard deviation of YMC of raw milk samples collected from milk producers was 8.13±0.31 log_{10}cfu/ml. YMC was statistically not significantly different (P>0.05) between the agro-ecologies. The total YMC of the current result was higher than research conducted in the country by Korma et al. (2018) (7.21 ± 0.21 log_{10}cfu/ml) and Debela et al. (2015) (4.266 ± 0.032 log_{10}cfu/ml) obtained from milk samples from urban and rural households in Hawasa District, Southern Ethiopia and from the producers Yabello District, Borana zone, Ethiopia respectively. The higher YMC resulted in the current finding might be due to contamination of milk during milking, poor milkier hygienic and longer locating in room temperature during sample transportation due to lack of cool during transportation to the laboratory.

CONCLUSION

From the results of the study, it was concluded that there was poor milk handling and processing practices in the Abuna Gindeberet district. The overall milk and

milk products handling practices and pressing processes was undertaken traditionally by using traditionally made utensils. This may hinders milk products making stable throughout the year, decreases quality and safety of milk and milk products and then reduces regular income and nutritional values.

As results of physiochemical properties analysis indicated, most of the quality parameters of sampled milk were fulfilling the required standards except, the pH Value, titratable acidity (%), organoleptic test, clot-on boiling, and alcohol test. The microbial qualities of the milk in the current study were indicated poor, as judged from the high values of total bacterial count (TBC), coliform count (CC), and yeast and mold count (YMC). This might be due to un-hygienic condition of milking; unclean milk handling equipment and the use of contaminated water for washing of milk and milk products' utensils. This high bacterial load, the presence of pathogenic bacteria in several samples not only affects the raw milk quality, but poses a safety issue to the consumer.

RECOMMENDATIONS

Based on the above conclusion the following recommendations are forwarded:

- Extension service should be given to dairy cattle producers heeding management and improvement of milk quality and milk handling practices.
- Handling of dairy products could be improved by replacing traditional equipment's with improved one by giving training for those peoples participating in milk handling practice and production.
- The government should provide infrastructural facilities for the producers to deliver their products to consumers in an easy manner. That includes processor plants and cooling equipment to deliver dairy products to market without perished.
- In general, the result of microbial analysis of this study indicated that urgent measures are needed to ensure lean and safe milk production at the farmer level through the promotion of good hygienic practices and adequate sanitary measures at all stages of milk production.
- Further investigation is needed on milk and milk product quality in detail with controlled analysis.

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