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# VALUE CHAIN AND EVALUATION OF MILK QUALITY IN SELECTED DISTRICTS AROUND ADDIS ABABA, ETHIOPIA

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**ABSTRACT**: Evaluation of milk value chain and the quality of milk were assessed in selected districts of surrounding Addis Ababa from September 2016 to April 2017. A total of 180 randomly selected market-oriented smallholder dairy farmers were involved in a cross-sectional study that was carried out by way of a questionnaire survey, rapid market appraisal, farm inspection and group discussion. The overall mean family size of respondents in this study was 5.63±1.926 persons with average livestock holding per household of 23.93±11.755 animals. Cattle were the predominant species representing 84.3% of the total TLU. The average number of lactating cows owned by the respondent farmers was 1.76±0.920 local and 2.79±3.445 crossbred animals. Average daily milk yield of crossbred and local milking cows were 9.11±2.902 and 1.889±0.6707 liters respectively. Overall mean lactation lengths of crossbred and local milking cows were 9.7±0.46 and 6.26±0.6624 months. Sixty milk samples were collected and microbiological and physicochemical analyses were carried out. The overall mean chemical compositions of milk for fat, protein and solids not fat (%) were 3.5693±0.10892, 2.9646 ± 0.04621 and 6.9632±0.12175 in bulk Tank milk samples. The overall mean microbiological count of log (TBC cfu/ml), log (CC cfu/ml) and log (SCC/ml) of raw milk was 8.2285±0.10041, 3.3363±0.10010 and 5.1622±0.07382, respectively. The proportion of raw milk used for household consumption was relatively small (5%). The major part (86%) of milk produced by smallholders is destined to market. The main outlets for raw milk identified were cooperatives (55.6%), processors (20.0%), vendor (20.0%), directly to consumer (2.8%) and hotels/ restaurants (1.7%). Price variations (cited by 87% of the respondents), lack of fair market (72.2%), lack of demand during fasting (49.4%), lack of preserving facilities, and absence of quality-based payment and no/less say in deciding milk price by producers were the major problems of raw milk marketing.

**Keywords:** Coliform, Milk, Physicochemical, Total bacteria, Value-chain.

## INTRODUCTION

Ethiopia has a huge potential to be one of the key countries in dairy production for various reasons (Pratt et al., 2008). These include a large population of milk cows in the country estimated at 9.9 million (CSA, 2008), a conducive and relatively disease free agro-ecology, particularly the mixed crop–livestock systems in the highlands that can support crossbred and pure dairy breeds of cows (Ahmed et al., 2003), a huge potential for production of high quality feeds under rain fed and irrigated conditions, existence of a relatively large human population with a long tradition of consumption of milk and milk products and hence a potentially large domestic market (Holloway et al., 2000).

A number of fundamental constraints underlie these outcomes, including traditional technologies, limited supply of inputs (feed, breeding stock, artificial insemination and water), poor or non-existent extension service, high disease prevalence, poor marketing infrastructure, lack of marketing support services and market information, limited credit services, absence of effective producers' organizations at the grass roots levels, and natural resources degradation (Berhanu et al., 2006). In addition, policy decision on milk and milk product marketing are taken in the absence of vital information on how they affect dairy producers, traders, exporters, and consumers. Similarly, current knowledge on dairy product market structure, performance and prices is poor for designing policies and institutions to overcome the perceived problems in the marketing system (Ayele et al., 2003).

Traditional farmers sell their raw milk informally due to the absence of organized marketing network that has made the produced milk unable to reach the consumer. Further losses incurred are quality losses by storing in unclean storage utensil, which is prone to high microbial contamination. Losses in spillage and contamination occur where handling during and after milking is traditional and care is not satisfactory. Additionally, the trade in the sub-sector is constrained by various structural, production, information exchange, and promotional problems, as well as financial constraints.



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Therefore, this study was conducted to evaluate value chain and the quality of milk in selected districts around Addis Ababa.

## MATERIALS AND METHODS

This study was conducted in purposively selected districts around the capital city of Addis Ababa namely Welmera and Sululta which are known for smallholder dairies are practiced for distribution of milk and milk products to the nearby city Addis Ababa. Welmera district is located 28 km west of Addis Ababa at $09^0 02$ North latitude and $38^0 34$ East longitudes with its altitude ranging from 2060-3380 m.a.s.l. whereas Sululta district lies between $39^0 30'$ N Latitude and $38^0$ 30' and $39^0$ 00 E longitude. It is located 40 km north west of Addis Ababa.

### Study population

Smallholder farmers in Sululta and Welmera districts owning crossbred and indigenous cattle for milk production constituted the study population.

### Study design

A cross-sectional study by way of questionnaire survey, rapid market appraisal, farm inspection, group discussion, interviewing key respondents and laboratory analysis of raw milk samples was carried out from September 2016 to April 2017. Marketing actors and smallholder dairy farmers in the selected study area were study participants.

### Sample size determinations

The sample size was determined by using mathematical model of Arsham (2007). The sample size, N, can then be expressed as largest integer less than or equal to $0.25/SE^2$.

$N=0.25/SE^2$

Where, confidence level of 95% and confidence interval of 5%, were considered. Based on the above formula the computed sample size was 180.

### Sampling procedure

To select a representative sample, the potential of the two districts were identified. Sululta district has 23 peasant associations (PAs), of which eight have potential in dairy production. From the list of these eight PAs, three were selected randomly. These included Moye-Gajo, Chancho-Buba, and Warrarsso-Malima PAs. Then ninety households owning dairy cattle were selected randomly from three PA's (thirty from each PA). Welmera District has also 24 PAs, of which six have potential in dairy production. From the list of these six, three of them namely Gelgelikuyu, Bekeka na kore-oddo and Gebarobi PAs were selected. Then ninety households owning dairy cattle were selected randomly from the three PA's.

### Data collection

**Questionnaire survey.** The questionnaire that was structured and closed type for its major part was pre-tested before its full administration. The questionnaire was focusing on demographic characteristics of the study participants, husbandry practices, milk production, processing, and marketing and utilization situations. Furthermore, marketing constraints of raw milk was investigated.

**Rapid Market Appraisal (RMA).** Rapid Market Appraisal (RMA) using checklists and observation was implemented to understand how a product or commodity flows to reach the end users.

**Farm inspection.** Farms were inspected once at the same time with the questionnaire survey. Activities observed during the farm visit encompassed kinds of utensils used, milking practices, milk handling and storage conditions.

**Group discussions.** Group discussions at three different PA'S of Sululta and three PA'S of Welmera were undertaken, in order to understand the overall community situations and get insight about milk marketing, milk handling, limitations and strength milk marketing. Groups were composed of 10 to 12 members constituted by different age and social groups. Discussion participants were identified in consultation with the district development agents. A sample checklist, which served as a guide and consisting of the main points for the group discussion was prepared.

**Interviewing key respondents.** Chairmen of PA'S, representatives of the sub PA'S and extension workers were interviewed. The agricultural office workers at PA'S levels were also participants in the process.

**Collection of raw milk samples.** Raw milk samples were collected at farm and milk collections centers by following strict aseptic procedures. Physicochemical test of raw milk was performed and the presence of bacteriological agents was assessed; standard plate count, coliform and somatic cell count tests were done. Before



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sampling, milk was thoroughly mixed after which 25 ml of milk was transferred into sterile sampling bottles. The milk sample bottles were capped, labeled with a permanent marker and stored in an ice packed cool box and transported to the Ethiopian Meat and Dairy Technology Institute, Debre-zeit where the different analysis were conducted.

### Bacteriological quality tests

Tests employed to determine the quality of milk were Standard plate count, Coliform count, and Somatic cell count. A detailed description of the steps followed in each of the methodologies is presented in the following sections.

### Standard plate count (SPC)

The standard plate count of raw milk samples was performed by putting one ml of milk sample into a sterile test tube having 9 ml peptone water. After mixing, the sample was serially diluted up to 1: $10^{-7}$ and duplicate samples of 1 ml of diluted milk samples were streaked on 15-20 ml standard plate count agar media and then incubated for 48 hours at 37$^{o}$C to encourage bacterial growth. Finally, colonies counts were made using colony counter. Single bacteria species or clusters grow to become visible colonies that were then counted. All plate counts were expressed as the number of colony forming units (CFU) per milliliter. Results from plates, which contained 10 to 300 colonies per plate were recorded. If plates from two consultative decimal dilutions yield colony counts of 10 to 300, the counts for each dilution were computed by the following formula (APHA, 1993).

$$N = \frac{\sum \text{colonies}}{[(1*n1) + (0.1*n2)]*d}$$

Where: N = number of colonies per milliliter of milk,
$\sum C$ = sum of colonies on plates counted,
$n_1$= number of plates on lower dilution counted,
$n_2$ = number of plates in next higher dilution counted and
d = dilution from which the first counts are obtained.

### Coliform count (CC)

One ml of milk sample was added into a sterile test tube having 9 ml peptone water. After mixing, the sample was serially diluted up to 1: $10^{-4}$ 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 laying over by Violet Red bile Agar solution (VRBA) then incubated at 37°C for 24 hours. Finally, colony counts were made using colony counter. Typical dark red colonies were considered as coliform colonies.

### Somatic cell count (SCC)

For counting somatic cells, the microscopic method was used. Milk film preparation, staining and counting were done according to the standards set by the International Dairy Federation (IDF, 1995). To obtain a uniform distribution of cells, milk samples were mixed by moving upside down gently 25 times and letting it to stand for 2 minutes to permit air bubbles and foam disappear. Microscopic slides were degreased with alcohol before milk film preparation. A 0.01ml of milk was taken with a 50µl micropipette calibrated at 10 and spread evenly over one $cm^2$ area on a microscopic slide and allowed to dry at room temperature on a leveled table. One $cm^2$ area was delineated by a template prepared from a cap board. Dried films were fixed with ethanol for 15 minutes. Stained with toluidine blue for 5 minutes and washed with tap water gently and allowed to dry in a dust free area. Stained slides were stored in slide box until counted. Using oil immersion objective those cell nuclei clearly recognizable and those at the periphery with more than 50% of the cell body in view were counted. Twenty fields were counted from given sampled milk. The number of cells per ml of milk was calculated by multiplying the average number of cells per field with Magnifications filed (laboratory manual).

$$\text{Somatic cell per ml of milk} = \frac{\sum SCOperfield*10{,}000}{0.0346*20}$$

Where $\sum SCOperfield$= the summations somatic cell counted per each field
0.0346= oil immersion calibrated
20= Total number of field counted

### Physicochemical test

The chemical compositions of milk (fat, protein, and solid not fat) and physical characteristics (density and freezing point), of the milk samples, were determined by Eko-milk analyzer (Bulgaria), according to manufacturer's instructions. Milk samples were mixed gently 4-5 times to avoid any air enclosure in the milk. Then 25 ml samples were taken in the sample-tube and put in the sample- holder one at a time with the analyzer in the recess position.


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Then when the starting button activated, the analyzer sucks the milk, makes the measurements, and returns the milk in the sample-tube and the digital indicator (IED display) shows the specified results.

### Data analysis

The data collected were entered into Micro-soft-Excel spreadsheet for managing the data and analyzed using SPSS version 17. Descriptive statistics like means, standard deviation and frequency distribution were used to describe the farming system characteristics in the study area. One-way ANOVA statistical analysis was used for comparison of the performance variation. The correlation statistical analysis was used to study the interaction between the farming system characteristics and the interaction between physicochemical and microbiology of raw milk sample.

## RESULTS

The overall mean family size for all respondents was 5.63±1.926 persons. The family size ranged from 2 to 12 people. Fifty-two percent of the family members were male and the rest (48%) were female. The overall average livestock holding per household was 23.93±11.755. The average family and herd size of the two districts namely Sululta and Wolmera pointed out by the respondents (Table 1).

### Cattle composition

Table 2 shows the size and composition of cattle owned by the smallholders in the study areas. All the surveyed smallholders owned on average 13.03±8.802 (12.29 TLU) cattle. The average number of Lactating cows owned by the respondent farmers was 1.76±0.920 local or 1.76 TLU and 2.79±3.445 crossbred animals or 4.185 TLU. Cattle were the predominant species representing 84.3% of the total TLU. The smallholders prefer to have crossbred cows because of their greater milk production, even though they require high management and susceptible to disease than local breeds.

### Milking and milk handling practices

Ninety-four percent of the respondents of the study area were using the plastic pail for milking and milk handling. Nearly 6% were using Stainless steel pail. Difficulties of using these utensils were difficult for cleaning (1.1%), accessibility in local markets (5%) and no problem of using these utensils (93.9%) were indicated by the respondents of the study area. Through group discussions with the participant of the study areas it was pointed out that all the respondents practice washing the utensils used for milking and milk handling. Commonly they were washing the milking utensils with warm water by using soap and finally allow drying till milking. In the study area cows are hand milked and calves are allowed to suckle their dams prior to as well as after milking. About 100%t of the respondents in Sululta and Wolemera area pointed out that they milk their cows two times a day at morning and evening. They milked their cows at the barn, where the animals are sheltered. As illustrates on Table 3, all respondents were washing their hands and vessels before milking. Seventy-two percent of respondents were also washing udder before milking. Nearly 19% of the smallholders were using individual towels for cleaning udder of milking cows, in 52.2% of the cases collective towels were used while in the rest (28.9%) no towel use was practiced.

### Milk production and use aspects

Mean of Lactation length of crossbred and local milking cows were 9.72±0.45 and 6.353±0.7681 in Sululta, 9.68±0.47 and 6.167±0.5567 in Wolmera district respectively and overall mean of lactation length of crossbred and local milking cows were 9.7±0.46 and 6.26±0.6624 months respectively. Average daily milk yield of cross bred and local cows in Sululta were 9.56±3.010 and 1.809±0.4574 liter/day respectively. Moreover, crossbred and local cows in Wolmera areas were 8.60±2.703 and 1.96±0.8193 liters/day respectively. Overall mean summery of daily milk yield at the study areas of crossbred milking cows (9.11±2.902) and local milking cows (1.889±0.6707) liters as shown on table 4.

Overall mean of milk producing, Processing, consuming and selling per day per household was 26.88±4.76, 1.23±1.603, 1.29±1.176 and 23.32±5.22 liters respectively (Table 5). The proportion of raw milk used for household consumption was relatively small. As figure 1 illustrates, the major part of milk produced by smallholders is destined to market. Smallholders also process milk to butter and cheese. Milk was soured for 2-3 days before processing it in to butter and cheese. The one way of ANOVA analysis showed significance difference at ($P<0.01$) and ($P<0.05$) among the District from which the milk sample for milk produced and milk sold per day/liter.



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**Table 1** - Average family size and herd in smallholder dairy farms in the study district.

| Variables | Sululta (N=90) Mean±SD | Wolmera (N=90) Mean±SD | Overall (N=180) Mean±SD |
|---|---|---|---|
| Family size | 5.49±1.819 | 5.77±2.028 | 5.63±1.926 |
| Male | 2.88±1.211 | 3.04±1.469 | 2.96±1.346 |
| Female | 2.68±1.198 | 2.76±1.248 | 2.72±1.220 |
| Livestock | 25.22±12.382 | 22.63±11.009 | 23.93±11.755 |
| Cattle | 14.69±11.619 | 11.37±3.905 | 13.03±8.802 |
| Lactating cows | 4.57±4.316 | 3.38±1.427 | 3.97±3.260 |
| Local cows | 2.18±0.384 | 2.08±.278 | 2.13±0.336 |
| Cross bred cow | 4.28±0.450 | 4.32±.470 | 4.30±0.459 |
| Sheep | 5.92±4.238 | 6.66±4.490 | 6.26±4.356 |
| Equines | 1.80±0.924 | 2.16±1.256 | 1.97±1.105 |

SD=standard deviations N=number of respondents

**Table 2** - Cattle herd size and composition in TLU in smallholder farms.

| Variables | Sululta (N=90) Mean±SD | TLU | Wolmera (N=90) Mean±SD | TLU | Overall (N=180) Mean±SD | TLU |
|---|---|---|---|---|---|---|
| Cattle | 14.69±11.619 | 13.006 | 11.37±3.903 | 11.391 | 13.03±8.802 | 12.29 |
| L.M. cows | 1.68±0837 | 1.68 | 1.83±0.993 | 1.83 | 1.76±0.920 | 1.76 |
| C.M. cows | 3.30±4.511 | 4.95 | 2.21±1.252 | 3.315 | 2.79±3.445 | 4.185 |
| Calves | 3.23±3.083 | 0.646 | 2.76±1.126 | 0.552 | 3.01±2.357 | 0.602 |
| Heifers | 2.78±3.131 | 1.668 | 2.16±1.094 | 1.296 | 2.47±2.359 | 1.482 |
| Bulls | 1.56±0.940 | 1.872 | 1.39±0.549 | 1.668 | 1.48±0.777 | 1.776 |
| Oxen | 2.19±0.518 | 2.19 | 2.73±1.166 | 2.73 | 2.48±0.956 | 2.48 |

SD =standard deviation; TLU= tropical livestock units; N= number of respondents; TLU=250kg of live weight of livestock; L.M. cows=local milking cows; C.M. cows= crossbred milking cows

**Table 3** - Observed milking practices in the study areas (N=180)

| Variable | Frequency | Percent | Frequency | Percent |
|---|---|---|---|---|
| | Yes | | NO | |
| Wash milkier hands and vessels | 180 | 100.0 | -- | -- |
| Wash udder before milking | 129 | 71.7 | 51 | 28.3 |
| Wash udder before and after milking | -- | -- | 180 | 100.0 |
| Use of individual towels | 34 | 18.9 | 145 | 80.6 |
| Use of collective towels | 94 | 52.2 | 86 | 47.8 |
| No towel | 52 | 28.9 | 128 | 71.1 |

**Table 4** - Average lactation length and daily milk yield of local and cross bred milking cow of small holder farmers.

| Variables | Sululta(N=90) Mean ± S.D | Wolmera(N=90) Mean ± S.D | Overall(N=180) Mean ± S. D |
|---|---|---|---|
| Lactation length of local cattle in month | 6.353± 0.7681 | 6.167 ± 0.5567 | 6.26 ± 0.6624 |
| Lactation length of cross bred cows in month | 9.72 ± 0.45 | 9.68 ± 0.47 | 9.7 ± 0.46 |
| Average daily milk yield of local cows(/liter/day) | 1.809± 0.4574 | 1.96± 0.8193 | 1.889 ± 0.6707 |
| Average daily milk yield of cross bred cows( /lit/day) | 9.56 ± 3.010 | 8.60 ± 2.703 | 9.11 ± 2.902 |

SD= standard deviations; N=number of respondents

**Table 5** - Milk production and partition in to different use categories at smallholder farm level.

| Category/area of study | | Mean ± S. D | 95% CI | Df | F ratios | P-value |
|---|---|---|---|---|---|---|
| Milk produced at farm/lit/day | Sululta | 28.01±3.135 | 27.35-28.67 | 1 | 10.762 | 0.001** |
| | Wolmera | 25.74±5.756 | 24.54-26.95 | 178 | | |
| | Overall | 26.88±4.76 | 26.18-27.58 | 179 | | |
| Milk processed/lit/day | Sululta | 1.29±1.493 | 0.98-1.6 | 1 | 0.215 | 0.643 |
| | Wolmera | 1.18±1.713 | 0.82-1.54 | 178 | | |
| | Overall | 1.23±1.603 | 1.00-1.47 | 179 | | |
| Milk consumed at home/lit/day | Sululta | 1.43±1.272 | 1.17-1.7 | 1 | 2.534 | 0.113 |
| | Wolmera | 1.16±1.059 | 0.93-1.38 | 178 | | |
| | Overall | 1.29±1.176 | 1.12-1.47 | 179 | | |
| Milk sold/lit/day | Sululta | 24.11±4.67 | 23.13-25.09 | 1 | 4.245 | 0.041* |
| | Wolmera | 22.52±5.631 | 21.34-23.7 | 178 | | |
| | Overall | 23.32±5.22 | 22.55-24.08 | 179 | | |

**P-value is significant at 0.01 levels; SD= standard deviation; CI = confidence interval; df= degree of freedom



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### Milk marketing

Table 6 shows distance between production and market place. Nearly 54.9% of the households were nearby to the market center for their raw milk marketing while about 4% of the households travel more than 10 km.

### Milk sales outlet

The main outlets for raw milk identified as shows in (Table 7) were cooperatives, processors, vendor, directly to consumer and hotels/restaurants 55.6%, 20.0%, 20.0%, 2.8% and 1.7% respectively.

### Raw Milk marketing constraints

Table 8 illustrates raw milk marketing constraints at specific study area. The respondent farmers indicated that, price variations (87.2%), lack of fair market (72.2%) and lack of demand (49.4%) during fastening were the major problem of raw milk marketing in descending order of importance. As shows on table 9 milk price decided by producer, processor and collector were 6.1%, 25%, and 68.9%respecively as ascending order. Additionally through group discussion almost the entire group member pointed out they have less /no power to decided milk price at the study area.

Quality based payment was also another raw milk marketing constraints of the study area. They indicated quality based payment was enhanced quality of milk supplied to processors at the same time as encouraging them to produce more and quality milk. Through group discussions of respondents in the sturdy areas pointed out they possessed less preserving facilities for surplus milk produced and demand especially during fasting were great influence on raw milk marketing. Additionally, they showed that less adopted technologies for enhancing shelf life of raw milk in the study areas.

**Table 6** - Distance of market center for milk in smallholder dairy farmer of study areas (N=175 households).

| Distance of marketing place | Frequency | Percent |
|---|---|---|
| Less than 1 km (nearby) | 96 | 54.9 |
| Between 1 – 5 km (proximity) | 70 | 40.0 |
| Between 5 – 10 km (intermediate) | 2 | 1.1 |
| More than 10 km(far) | 7 | 4.0 |

**Table 7** - Marketing channel of smallholder farmer of the study area.

| Milk out let | Frequency | Percent |
|---|---|---|
| Cooperatives | 100 | 55.6 |
| Hotels/restaurants | 3 | 1.7 |
| Vendor | 36 | 20.0 |
| Processors | 36 | 20.0 |
| Directly to Consumer, | 5 | 2.8 |

**Table 8** - Descriptions of marketing problems of small holder at the study area

| Constraints | Frequency | Percent | Frequency | Percent |
|---|---|---|---|---|
| | Yes | | NO | |
| Price variations | 157 | 87.2 | 23 | 12.8 |
| Lack of fair market | 130 | 72.2 | 50 | 27.8 |
| Lack of demand during fastening | 89 | 49.4 | 91 | 50.6 |

**Table 9** - Marketing channel of smallholder farmer of the study area.

| Decisions of milk price | Frequency | Percent |
|---|---|---|
| Producer | 11 | 6.1 |
| Processor | 45 | 25 |
| Collector | 124 | 68.9 |

### Factors influencing milk production, consumption and marketing

Milk production was positively and significantly correlated with experience of raising cattle for milk productions, raw milk sold ($P<0.01$) and significantly correlated with distance of milk marketing ($P<0.05$). Milk sold was positively and significantly correlated with experience of raising cattle, milk productions and distance of milk sold ($P<0.01$). Milk consumption was negatively and significantly correlated with cattle herd size ($P<0.01$) (Table 10).

### Physicochemical and microbiological quality of milk

The average chemical compositions of milk for fat (%), protein (%) and solids not fat (%) content were 3.6043±0.12200, 2.9749±0.05147 and 6.9992±0.13452 in raw milk samples mixture from producer respectively. Additionally, the mean of milk chemical compositions for fat (%), protein (%) and solids not fat (%) content were



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3.3243±0.15814, 2.8929±0.08510 and 6.7114±0.24844 in raw milk samples mixture from collector respectively. The average physical properties of milk sample indicate on (Table 11) with density, freezing point 1.02721± 0.000477 and -0.47143±0.00774 in raw milk sample from producer; 1.02623±0.000874 and -0.45788 ± 0.016510 in raw milk sample from collector respectively. The overall Average of microbiological count of log (TBC cfu/ml), log (CC cfu/ml) and log (SCC/ml) of raw milk was 8.2577±0.10499, 3.3210±0.11295 and 5.0806±0.08484 for milk sample from the producer; 8.2577±0.10499, 3.3400±0.10352 and 5.1205±0.07533 for milk sample from collector respectively (Table 12). The overall mean of chemical compositions of milk for fat (%), protein (%) and solids not fat (%) contents were 3.5693±0.10892, 2.9646±0.04621 and 6.9632±0.12175 in raw milk sample mixture from the two districts respectively. Additionally the overall mean of physical properties of milk sample indicated on (Table 13) with density, freezing point 1.02665±0.00061 and -0.47088±0.0070 in raw milk sample from the two districts. The ANOVA showed significance difference (P<0.05) due to the source area of raw milk samples for fat, protein and freezing point. Moreover, ANOVA showed highly significant difference at (P<0.01) due to the source area of raw milk samples for solid not fat. The overall mean of the microbiological count of log (TBC cfu/ml), log (CC cfu/ml) and log (SCC/ml) of raw milk was 8.2285±0.10041, 3.3363±0.10010 and 5.1622±0.07382 for milk sample from the two districts respectively (Table 14). The ANOVA showed significant difference at (P<0.01) due to the source area for log (TBC cfu/ml)

**Relationship among and between the physicochemical and microbiological test of Milk**

Milk protein was positively and significantly correlated with fat, solid not fat and density of milk (P<0.01) and significantly correlated with each other (P<0.01). Milk protein was negatively and significantly correlated with added water and freezing point. Fat, solid not fat (SNF) and density of milk were also negatively and significantly correlated with added water and freezing point (P<0.01) (Table 15).

**Table 10 - Correlations among different characteristics of small holder dairy farmers**

| Variable | Family size | ERCMP | Cattle | MPF/day | MS/day | MC/day | DMP |
|---|---|---|---|---|---|---|---|
| Family size | 1 | | | | | | |
| ERCMP | 0.149* | 1 | | | | | |
| Cattle | 0.124 | 0.012 | 1 | | | | |
| MPF/day | 0.121 | 0.375** | -0.119 | 1 | | | |
| MS/day | 0.085 | 0.342** | -0.146 | 0.908** | 1 | | |
| MC/day | -0.006 | -0.160 | -0.613** | 0.103 | 0.091 | 1 | |
| DMP | -0.155* | 0.232** | 0.235 | 0.175* | 0.284** | -0.080 | 1 |

*correlation is significant at the 0.05 level; **highly significant at the 0.01 level; ERCMP=experience of raising cattle for milk productions; MPF= milk produced at farm; MS= milk sold; MC= milk consumed and DMP= distance of marketing place.

**Table 11** - Physicochemical properties of milk at farm and collection points in study area.

| Variables and category | | N | Mean ± Std. Error | 95% CI |
|---|---|---|---|---|
| Fat (%) | Producer | 49 | 3.6043±0.12200 | 3.3590 - 3.8496 |
| | Collector | 7 | 3.3243±0.15814 | 2.9373 - 3.7112 |
| | Overall | 56 | 3.5693±0.10892 | 3.3510 - 3.7876 |
| Protein (%) | Producer | 49 | 2.9749±0.05147 | 2.8714 - 3.0784 |
| | Collector | 7 | 2.8929±0.08510 | 2.6846 - 3.1011 |
| | Overall | 56 | 2.9646±0.04621 | 2.8720 - 3.0572 |
| SNF (%) | Producer | 49 | 6.9992±0.13452 | 6.7287 - 7.2696 |
| | Collector | 7 | 6.7114±0.24844 | 6.1035 - 7.3193 |
| | Overall | 56 | 6.9632±0.12175 | 6.7192 - 7.2072 |
| Density | Producer | 49 | 1.02721±0.000477 | 1.02625 - 1.02817 |
| | Collector | 7 | 1.02623±0.000874 | 1.02410 - 1.02837 |
| | Overall | 56 | 1.02709±0.000432 | 1.02622 - 1.02795 |
| Added water (%) | Producer | 40 | 14.4087±1.45661 | 11.4625 - 17.3550 |
| | Collector | 7 | 14.2700±3.05519 | 6.7942 - 21.7458 |
| | Overall | 47 | 14.3881±1.30856 | 11.7541 - 17.0221 |
| Freezing point | Producer | 49 | -0.47143±0.00774 | -0.4870 - (-0.4559 ) |
| | Collector | 7 | -0.45788±0.016510 | -0.4983 - (-0.4175) |
| | Overall | 56 | -0.46974±0.007066 | -0.4839 - (-0.4556) |

SE = Standard error; CI = confidence interval N= number of sample



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**Table 12** - Microbiological quality of milk at farm and collection points in study area.

| Variables and category | | N | Mean ± Std. Error | 95% CI |
|---|---|---|---|---|
| Log (CC/cfu/ml) | Producer | 49 | 3.3210±0.11295 | 3.0939 - 3.5480 |
| | Collector | 8 | 3.4569±0.26971 | 2.8191 - 4.0946 |
| | Overall | 57 | 3.3400±0.10352 | 3.1327 - 3.5474 |
| Log (TBC/cfu/ml) | Producer | 44 | 8.2572±0.11195 | 8.0314 - 8.4830 |
| | Collector | 8 | 8.2601±0.31391 | 7.5179 - 9.0024 |
| | Overall | 52 | 8.2577±0.10499 | 8.0469 - 8.4684 |
| Log (SCC) | Producer | 47 | 5.0806±0.08484 | 4.9098 - 5.2513 |
| | Collector | 8 | 5.3548±0.11766 | 5.0766 - 5.6331 |
| | Overall | 55 | 5.1205±0.07533 | 4.9694 - 5.2715 |

Log = logarithm in base ten (normal logarithm); CC = coli form count; SCC =somatic cell count; TBC = total bacterial count; cfu = colony forming unit per ml of milk sample; SE = standard error; CI = confidence interval

**Table 13** - Physicochemical properties of milk for the two districts.

| Variable | | N | Mean ±Std. Error | 95% CI | Df | F ratios | P-value |
|---|---|---|---|---|---|---|---|
| Fat (%) | Sululta | 27 | 3.3185±0.13027 | 3.0507 - 3.5863 | 1 | 5.32 | 0.025* |
| | Wolmera | 29 | 3.8028±0.16215 | 3.4706 - 4.1349 | 54 | | |
| | Overall | 56 | 3.5693±0.10892 | 3.3510 - 3.7876 | 55 | | |
| Protein (%) | Sululta | 27 | 2.8485±0.05218 | 2.7413 - 2.9558 | 1 | 6.46 | 0.014* |
| | Wolmera | 29 | 3.0728±0.06985 | 2.9297 - 3.2158 | 54 | | |
| | Overall | 56 | 2.9646±0.04621 | 2.8720 - 3.0572 | 55 | | |
| SNF (%) | Sululta | 27 | 6.6307±0.14321 | 6.3364 - 6.9251 | 1 | 7.80 | 0.007** |
| | Wolmera | 29 | 7.2728±0.17720 | 6.9098 - 7.6357 | 54 | | |
| | Overall | 56 | 6.9632±0.12175 | 6.7192 - 7.2072 | 55 | | |
| Density | Sululta | 27 | 1.02593±0.00051 | 1.02488 - 1.02698 | 1 | 1.27 | 0.266 |
| | Wolmera | 30 | 1.02730±0.00105 | 1.02514 - 1.02945 | 55 | | |
| | Overall | 57 | 1.02665±0.00061 | 1.02544 - 1.02787 | 56 | | |
| Added water | Sululta | 26 | 15.4562±1.80236 | 11.7441 - 19.1682 | 1 | 0.82 | 0.37 |
| | Wolmera | 21 | 13.0657±1.90496 | 9.0920 - 17.0394 | 45 | | |
| | Overall | 47 | 14.3881±1.30856 | 11.7541 -17.0221 | 46 | | |
| Freezing point | Sululta | 27 | -0.45456±0.00987 | -0.47485-(-0.43428) | 1 | 5.21 | 0.026* |
| | Wolmera | 30 | -0.48557±0.00934 | -0.50468 -(-0.46647) | 55 | | |
| | Overall | 57 | -0.47088 ±0.0070 | -0.48498- (-0.45679) | 56 | | |

** is highly significant at the (P< 0.01); * is significant at the (P< 0.05) level; SE = standard error; CI = confidence interval; Df = degree of freedom

**Table 14** - Microbiological quality of milk for the two districts of study area

| Variable | | N | Mean±Std. Error | 95% CI | Df | F | P |
|---|---|---|---|---|---|---|---|
| Log (CC/cfu/ml) | Sululta | 30 | 3.3925±0.14411 | 3.0978 - 3.6873 | 1 | 0.302 | 0.585 |
| | Wolmera | 31 | 3.2819±0.14074 | 2.9944 - 3.5693 | 59 | | |
| | Overall | 61 | 3.3363±0.10010 | 3.1361 - 3.5365 | 60 | | |
| Log (TBC/cfu/ml) | Sululta | 27 | 7.9548±0.12902 | 7.6896 - 8.2200 | 1 | 7.774 | 0.007** |
| | Wolmera | 29 | 8.4834±0.13799 | 8.2008 - 8.7661 | 54 | | |
| | Overall | 56 | 8.2285±0.10041 | 8.0273- 8.4298 | 55 | | |
| Log (SCC) | Sululta | 28 | 5.2643±0.10299 | 5.0530 - 5.4757 | 1 | 1.753 | 0.191 |
| | Wolmera | 31 | 5.0699±0.10406 | 4.8573 - 5.2824 | 57 | | |
| | Overall | 59 | 5.1622±0.07382 | 5.0144 - 5.3099 | 58 | | |

** is highly significant at the (P< 0.01); Log = logarithm in base ten (normal logarithm); CC = coli form count; SCC =somatic cell count; TBC = total bacterial count; cfu = colony forming unit per ml of milk sample; SE = standard error; CI = confidence interval



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**Table15** - Correlations among different characteristics of physicochemical and microbiological test of milk from selected area of small holder dairy farmers

| Milk | Fat (%) | Prot. (%) | SNF | Density | AW | Fp | Log (CC) | Log (TBc) | Log (SC) |
|---|---|---|---|---|---|---|---|---|---|
| **Fat (%)** | 1 | | | | | | | | |
| **Prot. (%)** | 0.671** | 1 | | | | | | | |
| **SNF** | 0.624** | 0.977** | 1 | | | | | | |
| **Density** | 0.565** | 0.969** | 0.997** | 1 | | | | | |
| **AW** | -0.562** | -0.951** | -0.984** | -0.976** | 1 | | | | |
| **Fp** | -0.634** | -0.918** | -0.942** | -0.529** | 1.000** | 1 | | | |
| **Log (CC)** | -0.148 | -0.062 | -0.068 | -0.141 | 0.089 | 0.053 | 1 | | |
| **Log (TBC)** | 0.138 | 0.075 | 0.070 | 0.030 | -0.066 | -0.081 | -0.075 | 1 | |
| **Log (SCC)** | 0.068 | 0.075 | 0.074 | 0.001 | -0.228 | -0.127 | -0.097 | 0.005 | 1 |

**= Correlation is significant at the (P< 0.01) level; SNF = solid not fat, AW = added water; Fp = freezing point; log (CC) = logarithms of Coli form count; log (TBC) = logarithms of total bacterial count; log (SCC) = logarithms of somatic cell count.

## DISCUSSION

The overall mean family size obtained in the present study for all respondents was 5.69±1.87 person's less than those reported by Tolera (2007) for Girar Jarso (5.77 persons) and by Abera (2008), 6.12 persons per house hold at kuyu district. The family size ranged from 2 to 12 persons at the study area which is comparable with the report of Kelay (2002) that family size ranged from 1 to 13 persons in Addis Ababa. About 78.9% of the households were basic educations and above in this study. This value is by far higher than the report of Sisay (2006) for Gondar area (38.5%). This finding indicates that, the education coverage between the study areas were different.

The cattle herd size of the study area was 12.27 TLU. The work of Abdinasir (2000) indicated that the cattle herd size at Bilalo and Lemmu areas are 8.57 TLU and 10.38 TLU respectively. In the present study area, the cattle herd was dominated by crossbreds that results in larger TLU cattle herd size as compared with Bilalo and Lemmu of Arsi area.

The present study also showed that milk production was positively and significantly correlated with experience of raising cattle for milk productions, raw milk sold (P<0.01) and significantly correlated with distance of milk marketing (P<0.05). Whereas the family sizes were not correlated with cattle herd size. On contrast finding reported by Abbinasir (2000) and Kelay (2002) indicated that family size and cattle herd size were positively and significantly correlated. These variations may be due to hired labor was means of overcoming family labor resource.

The average milk yield of cross bred cows in the study area was 9.11±2.902 litres per day, which was comparable with average milk yield of 10 litres reported by Yoseph (1999), Azage et al. (2000), and Mekonnen et al. (2006). Moreover, the average milk yield of local cows was 1.889±0.6707 which was comparable with reported by Zewdu (2004) indicated that the overall average daily milk yield of local cows in the first and second lactations in North Gonder Zone was 1.69 and 1.86 liters, respectively.

The overall average lactation length of local and crossbred cows was 6.26±0.6624 and 9.7±0.46 months, respectively in the study area. The lactation length of the indigenous cows observed in this study is comparable with the national average of 7 months (CSA, 2005). The lactation length in crossbred cows observed in this study is shorter than the lactation length of 11.7 months reported for crossbred cows in the central highlands of Ethiopia (Zelalem and Ledin, 2001a). The variation in lactation length in the present study may be credited to feed shortage and poor genetic potential of the sample population.

Overall mean of milk producing, processing, consuming and selling per day per household was 26.88±4.76, 1.23±1.603, 1.29±1.176 and 23.32±5.22 liters respectively. Eighty-six point seven percent (86.77%) of the milk produced in the area was sold by the producer through different channels. Amount of milk processed, consumed and used for calves was 4.6%, 4.8% and 3.84% respectively. This study is inconsistent with study conducted around Addis Ababa indicated that from total milk production 73% is sold, 10% is left for household consumption, 9.4% goes to calves and 7.6% is processed into butter (Azage and Alemu, 1998).

Marketing channels are routes through which products pass as they are moved from the farm to the consumer. From this study the main outlets for raw milk identified were cooperatives, processors, vendor, directly to consumer and hotels/restaurants. These are consistent with the result in any marketing system various actors participate in marketing of commodities and process of transactions made. These include itinerate /mobile traders, semi-whole sellers, retailers, cooperatives and consumers as reported by Holloway et al. (2000). Collectors collect the milk from the small holder and commercial dairy producers, they sale it to retailers, hotels, restaurants and processors. There



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exist two types of collectors in the milk value chain. Cooperative collection centers are formal collectors organized by the bureau of agriculture in their respective districts. They have members of small holder dairy producers which supply daily production of milk in order to supply to the larger processors in Addis Ababa markets. In addition to collecting from cooperative and individual collectors, larger processors are also collect milk from smallholder farmers giving them additional cents over a liter of milk than other collectors. This condition had a negative effect on cooperative collection centers and mutual agreement and win-win approach should be followed among all the actors involving milk supply chain.

Among constraints of milk marketing, price variations, Lack of fair market and Lack of demand during fastening were the most indicated ones. The current study agreed with the report by Baltenweck and Staal (2000) for Kenyan highlands inaccessibility of fresh milk marketing. Through group discussion almost the entire group member pointed out they have less /no power to decided milk price at the study area. Quality based payment was also another raw milk marketing constraints of the study area. They indicated quality based payment was enhanced quality of milk supplied to processors at the same time as encouraging them to produce more and quality milk. Finally, milk marketing constraints were possessing less preserving facilities for surplus milk produced and demand especially during fasting were great influence on raw milk marketing.

Nearly 19% of the smallholders were using individual towels for cleaning udder of milking cows in 52.2% collective towels were used while in the rest (28.9%) no towel use practiced. It was reported by Galton et al. (1986) that pre-milking udder preparations play an important part in the contamination of milk during milking. Most of the dairy owners did not use towel and a few dairy owners used a single towel for all cows commonly to dry the udders. The reuse of towel for cleaning and sanitizing may result in recontamination of the udder. Since drying was not or insufficiently practiced, contamination level of milk was becoming higher.

The overall mean fat percentage (3.5693±0.10892) of whole milk collected from the smallholder farmers in the current study is less than the fat content of whole milk collected from smallholder farmers reported by Alganesh (2002) for eastern Wollega (6.05%) and also slightly less than reported by Asaminew (2007) for Bahir Dar Zuria (4.14%). The variation in fat percentage observed in the present study may probably due to variation in stage of lactation, feeding regime and parity. The overall mean protein (2.9646±0.04621) content from bulk milk obtained in the current study is lower than those reported by O'Connor (1994) for local cows' milk and also lower than Zelalm and Ledin (2001b) for whole milk in the central highlands of Ethiopia (3.1%). The average SNF (6.9632±0.12175) content of milk obtained in the current study is slightly lower than reported by Alganesh (2002) for eastern Wollega (8.22%).

The overall mean total bacterial count of cows' milk produced in the study area was 8.2285$\log_{10}$cfu/ml. The total bacterial count obtained in this study is generally high as compared to the acceptable level of 1 x $10^5$ bacteria per ml of raw milk (O'Connor, 1994). The current study is consistent with Fekadu (1994) 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. Commonly, lack of knowledge about clean milk production and use of unclean milking equipment would be some of the factors which contributed to the poor hygienic quality of milk produced in the study area.

The overall mean coliform count of milk produced in the area was 3.3363$\log_{10}$cfu/ml. The coliform count of cows' milk obtained in the current study is smaller than reported given by Fekadu (1994) for districts of southern region (3.8 $\log_{10}$ cfu/ml). The current result is also inconsistent with the reported by Zelalem and Bernard (2006) for cows' milk collected from different producers in the central highland of Ethiopia (6.57$\log_{10}$cfu/ml). The higher coliform count obtained 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. The overall mean of somatic cell count in log (SCC/ml) of raw milk was 5.1622 ±0.07382 for milk sample from the two districts.

## CONCLUSIONS AND RECOMMENDATIONS

Dairy production became a crucial element of the farming activities and income generating for household in "Sululta" and "Wolmera" distract of Oromia special zone surrounding Addis Ababa.

The proportion of raw milk used for household consumption was relatively small and the major part of milk produced by smallholders is destined to market. Smallholders also process milk to butter and cheese. Milk was soured for 2-3 days before processing it in to butter and cheese. The main outlets for raw milk identified were cooperatives, processors, vendor, directly to consumer and Hotels/restaurants. Price variations, lack of fair market, lack of demand during fastening, lack of quality based payment and lack of preserving facilities were the major problem of raw milk marketing in the study areas.

Hygienic conditions of milking and storage processes, transferring of milk into different containers and sieves, unclean milk equipment were basic determinants of milk quality. Majority of raw milk samples from producer and collector bulk milk sample had higher TAPC and coliform counts, which was higher than the international acceptable limits.



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Based on the aforementioned conclusions, the following recommendations are forwarded:

- Smallholders should be provided/supported with extension and training opportunities for hygienic conditions of milking, storing and processing;
- Quality based pricing in the milk value chain could contribute as incentive to producers for production of quality mil;
- Smallholders should be provided/supported with credit facility and market information;
- Regulatory mechanisms should be established and enforced to deter milk and milk products adulteration.

## DECLARATIONS


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### Author's contribution

Both authors have contributed equivalent effort for this manuscript.


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### Competing interests

The authors have not declared any conflict of interests.

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