

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

**ASSESSMENT OF MILK SUPPLY CHAIN AND EVALUATION OF
PHYSICOCHEMICAL PROPERTIES AND MICROBIAL LOAD OF RAW MILK IN
SELECTED DISTRICTS OF ARSI ZONE, ETHIOPIA**

By

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DEBRE-ZEIT, ETHIOPIA

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FAO	Food and Agriculture Organization
ESAF	European Society of Animal Production
EU	European Union
FAO	Food and Agriculture Organization
GLM	Global Good Model
HR	Horn of Africa
ICF	International Dairy Federation
IPPI	International Policy Research Institute
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Systems
IPS	International Project Service
IS	Inter-Group Study
ICC	ICC Collection Centers
MA	Ministry of Agriculture
MSD	Maple Seed
NEPAD	New Partnership for African Development

ABBREVIATIONS

AFC	Age at First Calving
AI	Artificial Insemination
AMAE	Assela Model Agricultural Enterprise
ANOVA	Analysis of Variance
APHA	American Public Health Association
AZLPHMA	Arsi Zone Livestock Production, Health and Marketing Agency
BOAM	Business Organizations and Access to Markets
CC	Coliform Count
CFU	Colony Forming Unit
CI	Calving Interval
DDE	Dairy Development Enterprise
DMSCC	Direct Microscopic Somatic Cell Count
EARO	Ethiopian Agricultural Research Organization
ESAP	Ethiopian Society of Animal Production
EU	European Union
FAO	Food and Agricultural Organization
GLM	General Linear Model
HH	Household
IDF	International Dairy Federation
IFPRI	International Food Policy Research Institute
ILCA	International Livestock Centre for Africa
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Success
IPS	International Project Service
LS	Large Scale
MCC	Milk Collection Centers
MOA	Ministry of Agriculture
N	Sample Size
NEPAD	New Partnership for African Development

OoARD	Offices of Agriculture and Rural Development
PA	Peasant Association
PDC	Primary Dairy Cooperatives
SCC	Somatic Cell Count
SD	Standard Deviation
SDDP	Smallholder Dairy Development Project
SDP	Smallholder Dairy Project
SE	Standard Error
SNF	Sold Not Fat
SNV	Netherlands Development Organization
SPC	Standard Plate Counts
SPSS	Statistical Packages for Social Sciences
SS	Small Scale
TBC	Total Bacterial Count
UNICEF	United Nations Children's Fund
UNRRA	United Nations Relief and Rehabilitation Administration

ABSTRACT

A cross-sectional study was conducted from September 2010 to May 2011 in five selected districts of Arsi zone to assess the husbandry practices, characterize milk marketing system, identify constraints and opportunities for the dairy sector and to provide baseline information on physicochemical properties and microbial load of raw milk. A total of 220 smallholders were interviewed using semi-structured questionnaires and 100 milk samples were collected, followed by laboratory analysis for physicochemical characteristics and microbial quality of milk. The five study districts showed similarities in herd composition, husbandry practices and milk yield from local breeds, but milk yield from crossbreed animals, age at first calving and calving intervals differed significantly ($P<0.05$). The constraints more frequently cited in the study districts were feed related, animal diseases, AI, veterinary and extension services accessibility. Although the majority of the constraints cited were similar in the study districts, there were significant ($P<0.05$) differences in the number of citations between the districts. Informal milk marketing represented the major channel of (79.09% of the respondents) the milk market. In the study areas, milk price and demand were affected, primarily, by season, access to market and fasting and non-fasting days. The mean results of fat and total solids percentage among the different collection centers were statistically significant ($P<0.05$) with highest fat and total solids percentage recorded from Lemu Ariya PDC (4.83%) and Lemu Michael PDC (13.19%) respectively. Similarly, the total bacterial count, coliform count and somatic cell count showed significant differences ($p<0.05$) between the collection centers with the highest bacterial (5.82 cfu/ml), coliform (3.19 cfu/ml) and somatic cell (5.81 cells/ml) counts were recorded from Lemu Michael PDC, Lemu Ariya PDC and AMAE dairy farm respectively. The informal milk market largely dominating the milk supply chain and the variations in milk compositional and microbial quality observed across and within different collection centers and dairy farms calls for the need to give equal focus to market and hygienic aspects of milk as improving production and productivity of dairy cattle, while planning interventions.

Key words: *Arsi, dairy marketing, microbial quality, milk and physicochemical characteristics*

1. INTRODUCTION

Ethiopia holds huge potential for dairy development due to its large livestock population, the favorable climate for improved high yielding animal breeds, and the relatively disease-free environment for livestock. Given the considerable potential for smallholder income and employment generation from high value dairy products, development of the dairy sector in Ethiopia can contribute significantly to poverty reduction and nutrition in the country. Despite this fact, dairying has not been fully exploited and the direct contribution it makes to the national economy is limited (Ahmed, 2004).

For years or decades, Ethiopia ranked first in cattle population in Africa, but the dairy industry is not developed even as compared to east African countries like Kenya, Uganda and Tanzania. Regarding dairy production, the national milk production remains among the lowest in the world, even by African standards (Zegeye, 2003).

Dairy marketing in Ethiopia appears less developed than neighboring countries with similar agro-climate conditions, like Kenya and Uganda. Smallholders dominate dairy production in all the three countries, Kenya, Uganda, and Ethiopia. Similarly, all the three countries have parallel formal and informal marketing system where the proportion of milk production marketed in the formal market constitutes a very small portion of the total milk produced. However, in Kenya the proportion of milk sold in the formal market is 15% compared to 5% percent in Uganda (Muriuki and Thorpe, 2001) and 2% share in Ethiopia (Van der Valk and Abebe, 2010).

Market demand and milk quality issues are as important as improving production and productivity. Dairy producers demand higher producers' price, supplier agents and whole sellers while consumers require a guarantee from the producers for quality milk supply. In general, the milk supply chain, which is defined as a string of business units working together to satisfy market demands and achieve better profit margin includes production of quality milk, processing, transporting and storage (Betre, 2007).

Spoilage and contamination may occur in the milk chain as a result of poor hygiene, long periods of transportation and lack of appropriate storage facilities. Deficient hygiene has often been

considered to be one of the major causes of spoilage of products, resulting in a loss of income, both for farmer and smallholder dairies (Betre, 2007).

The safety of dairy products with respect to food borne diseases is a great concern around the world. This is especially true in developing countries where production of milk and various dairy products take place under rather unsanitary conditions and poor production practices (Mogessie, 1990; Zelalem and Faye, 2006). Moreover, the composition of milk makes it an optimum medium for the growth of microorganisms that may come from the interior of the udder, exterior surfaces of the animal, milk handling equipment and other miscellaneous sources such as the air of the milking environment (Richardson, 1985).

The conventional procedure for measuring the sanitary quality of milk is to estimate its bacterial content. The number of bacteria in aseptically drawn milk varies from animal to animal, even from different quarters of the same animal. Aseptically drawn milk from healthy udder contains an average of 500-1000 bacteria/ml. The initial counts of 10^5 bacteria/ml in milk are evidence of poor production hygiene (O' Conner, 1994).

In Ethiopia, in most cases, milk produced is marketed without any form of pasteurization or quality control measures (Zelalem and Faye, 2006). A considerable part of this milk is subjected to post harvest losses due to the high perishable nature of milk and mishandling. On the other hand, there was little attention from the government side to the development of processing systems and appropriate milk marketing. Information on the physicochemical composition and microbial qualities of raw milk produced and marketed by smallholder producers are scanty not to say inexistent.

Therefore, the objectives of this research work were,

- To assess dairy husbandry practices, characterize milk marketing system and identify constraints and opportunities of the dairy sector;
- To provide baseline information on physicochemical properties and microbial load of raw milk in selected districts of Arsi zone.
- Develop recommendations that will lead to safe and quality milk production in milk supply chain of the study districts.

2. LITERATURE REVIEW

2.1. Historical profile of the dairy sector in Ethiopia

In the first half of the 20th century, dairying in Ethiopia was mostly traditional. Modern dairying started in the early 1950s when Ethiopia received the first batch of dairy cattle from United Nations Relief and Rehabilitation Administration (UNRRA). With the introduction of these cattle in the country, commercial liquid milk production started on large farms in Addis Ababa and Asmera (Ketema, 2000). Government intervened through the introduction of high yielding dairy cattle on the highlands in and around major urban areas. The Government also established modern milk processing and marketing facilities to complement these input oriented production effort. Most of the interventions are focused on urban-based production and marketing including the introduction of exotic dairy cattle, feeding with high ratio of dairy concentrated feed, modern dairy infrastructure and high management level (Ahmed *et al.*, 2004).

To facilitate growth of the sector, UNICEF established a public sector pilot processing plant at Shola on the outskirt of Addis Ababa in 1960. The plant started by processing milk produced by the large farms. The plant significantly expanded in a short period and started collecting milk from smallholder producers in addition to large farms. This led to further expansion of large dairy farms. During the second half of the 1960s, dairy production in the Addis Ababa area began to develop rapidly as a result of the expansion in large private dairy farms and the participation of smallholder producers with indigenous cattle facilitated by establishment of the milk collection centers (Ahmed *et al.*, 2004). Subsequently, different dairy development projects were launched in different parts of the country. The distribution of exotic dairy cattle, particularly the Holstein Friesian, in different parts of the country, especially around the major urban areas, also contributed to the further development of dairying in Ethiopia.

2.2. Dairy production systems in Ethiopia

Milk production in Ethiopia is largely from the smallholder farmers in the highlands and the pastoralists in low land areas of the countries. However, the production is not market oriented and a minor portion of the locally produced milk enters the commercial sector owing to the marketing constraints and lack of processing techniques suitable for smallholder dairying. Four

major systems of dairy production can be distinguished in Ethiopia. These are; the lowland pastoral dairy production systems, rural highland small-holder dairy production system, urban and peri-urban small scale dairy production system and large scale dairy production system (Kelay, 2002).

2.2.1. Lowland pastoralist dairy production system

About 30% of the livestock population in Ethiopia is found in the pastoral areas. These areas comprise 50% of the total land area of the country and have altitudes below 1500 meter above sea level. Pastoralism is the major dairy production system in the lowland. Livestock doesn't provide inputs for crop production but they are the very backbone of their owners providing all of the consumable and saleable outputs and regarded as insurance against adversity. Milk production is dependent on season due to the rainfall pattern that influences feed availability (Ketema and Tsehay, 1995).

2.2.2. Rural highland smallholder dairy production system

In the highland areas, agricultural production system is predominantly subsistence smallholder mixed farming, with crop and livestock husbandry. In this system, feed for livestock consists of forages, crop residues and stub grazing and hay native pastures. The majority of milking cows in the smallholders milk production are indigenous breeds which have low production performance and with the average age at first calving of 53 months and average calving intervals of 25 months. The average cow lactation yield of 524 liters for 239 days, of which 238 liters is off-take for human use while 286 liters is suckled by the calf. But also a very small number of crossbred animals are milked to provide the family with fresh milk butter and cheese. Surpluses are sold, usually by women, who use the regular cash income to buy household necessities or to save for festival occasions (Mukasa-Mugerewa *et al.*, 2009).

2.2.3. Urban and peri-urban small scale dairy production system

This system is developed in and around major cities and towns located mainly in the highlands of Ethiopia. The main feed resources are agro-industrial byproducts and purchased roughage. The system comprises small and medium sized dairy farms that own crossbred dairy cows. Farmers use all or part of their land for forage production. The primary objective of milk production is

generating additional cash income to the household (Ketema and Tsehay, 1995; Azage *et al.*, 2000).

2.2.4. Large scale dairy production system

This system is a specialized market oriented dairy operation practiced by the state sector and very few private commercial farms. Most of these farms are located in and around Addis Ababa and basically keep exotic dairy stock (Ketema and Tsehay, 1995; Azage *et al.*, 2000).

2.3. Milk processing practices in Ethiopia

Cows are the main source of milk, and it is cows' milk that is the focus of processing in Ethiopia. However, dairy processing in the country is basically limited to smallholder level and hygienic qualities of products are generally poor (Layne *et al.*, 1990; Zelalem and Faye, 2006). Dairy processing in Ethiopia is generally based on '*ergo*' (fermented milk), without any defined starter culture or with a natural starter culture. Raw milk is either kept at ambient temperature or kept in a warm place to ferment prior to processing (Mogessie, 2002).

Butter is another most important product of smallholder dairy processing. In the study conducted at Borena region of Ethiopia, butter was found to be an important source of energy as food for humans and is used for cooking and as a cosmetic. The storage stability of butter, while not comparable to ghee, is still in the order of four to six weeks. This gives butter a distinct advantage over fresh milk in terms of more temporal flexibility for household use and marketing (Layne *et al.*, 1990).

Efficiency of traditional butter production was measured for 28 instances in which soured milk was churned by women in 20 households of Borena region. Prior to churning, the milk had a temperature of $20.0 \pm 0.42^{\circ}\text{C}$ and an acidity of $1.06 \pm 0.03\%$. The milk was churned for 40.0 ± 2.5 minutes and afterwards the temperature of the buttermilk was $23.7 \pm 0.32^{\circ}\text{C}$. The sour milk contained about 46.8g of fat, compared with 7g of fat in the buttermilk after churning. Thus some 85% of the butterfat was extracted by churning. Butter yield was $66.9 \pm 5.6\text{g}$ but moisture content of the butter was not determined (Layne *et al.*, 1990).

2.4. Milk marketing systems in Ethiopia

In Ethiopia, milk and milk products are channeled to consumers through both formal and informal marketing systems. Until 1991, the formal market of cold chain, pasteurized milk was exclusively dominated by the dairy development enterprise (DDE) which supplied 12 percent of the total fresh milk in the Addis Ababa area (Holloway *et al.*, 2000). Recently, however, private businesses have begun collecting, processing, packing and distributing milk and other dairy products. Still, the proportion of total production being marketed through the formal markets remains small (Muriuki and Thorpe, 2001).

According to Tsehay (1998), a milk-marketing group can be defined as a group of smallholder farmers who individually produce at least one liter of saleable milk and are willing to form a group with the objective of collectively processing and marketing milk. To facilitate milk marketing by smallholders with crossbred cows, SDDP catalyzed the formation of producer 'milk groups' (also called 'milk units' or 'mini-dairies') to process milk into butter, local cottage-type cheese (*ayib*), and yoghurt-like sour milk (*ergo*), primarily in the northern Shewa zone, north of Addis Ababa. Two similar producer groups were formed south of Assela (Arsi zone) with assistance from the Ministry of Agriculture, and another group was formed in Bakelo near Debre Birhan (Nicholson *et al.*, 1998).

Berhane and Workneh (2003) indicated that, the very useful involvement of the government of India at every step of the development for expansion of dairy cooperatives in the country for the successes of dairying and suggested that the Anand pattern of dairy development (India) can be emulated at least around the major milk sheds in Ethiopia, for instance around Nazareth, Dire Dawa, Harar, Bahir Dar, Gondar, Awassa, Jimma and Assela. As demonstrated in India, dairy marketing cooperatives could provide farmers with continuous milk outlets, and easy access to essential inputs such as artificial insemination (AI), veterinary services and formulated feeds. Dairy cooperatives are supposed to help to trigger a series of positive developments in the subsector; hence strengthening the existing group marketing activities and formation of new cooperatives in different parts of the country (Berhane and Workneh, 2003).

2.5. Milk and milk products consumption patterns

Estimated milk production and consumption levels in Ethiopia are summarized in Table 1. Milk and milk products form parts of the diets of many Ethiopians. They consume milk either as fresh milk or in fermented or soured form. Getachew and Gashaw (2001) estimated that 68% of the total milk produced is used for human consumption in the form of fresh milk, butter, cheese and yoghurt while the rest is given to calves and wasted in the process. The consumption of milk and milk products varies geographically between the highlands and the lowlands, all segments of the population consume dairy products while in the highlands, major consumers primarily include children and some vulnerable preference, consumer's income and population size, price of the product and other factors. Today, dairying offers good opportunities for improving the standard of living of smallholders through the sale of milk as well as higher consumption of milk (Baltenweck and Staal, 2000).

Table 1: Estimated milk production and consumption levels in Ethiopia

Year	Cattle population	Milking cow	Milk production (MT)	Milk per capita (Kg) Consumption
1975	27,926,944	3,490,868	774,923	25
1980	29,643,261	3,705,408	822,600	22
1985	31,465,058	3,933,132	873,155	20
1990	33,398,818	4,174,852	926,817	18
1995	35,451,422	4,431,428	983,777	17
2000	37,259,798	4,373,810	970,986	15
2001	37,632,395	4,894,986	1,086,687	16
2002	40,838,800	5,623,331	1,248,375	18

Source: (SDDP, 1998; FAO, 2003)

2.6. Constraints of dairy production in Ethiopia

2.6.1. Dairy market problem

Even though there is a good start in participation to dairy market, the ability of poor smallholder farmers to reach markets and actively engage in them poses a development challenge. Difficult market access restricts opportunities for income generation. Remoteness results in subsistence rather than market oriented production system. The question of how to expand the market participation of smallholder livestock producers is the major challenge in developing countries. Market access poses a key bottleneck to the expansion of smallholder milk production and processing. Generally, marketing of livestock and livestock products in Ethiopia is constrained by inadequate infrastructures, seasonal supply fluctuations, absence of market information and institutional issues (SDDP, 1998).

2.6.2. Feed related constraints

Lack of adequate feed resources as the main constraint to animal production is more pronounced in the mixed crop-livestock dominated highlands as well as in the mid altitude areas of the country where most of the cultivated areas are located. These areas have high human population density that has led to intensive crop production causing continuous conversion of grazing lands to crop production. Mixed farming system was developed because of the beneficial effect resulting from the interrelationship and complementarities between crop and livestock production, hence, the role of livestock is significant in this farming system. In the mixed crop livestock production system, livestock production ensures food security and income to the farming community since crop harvest is seasonal. However, lack of grazing land has induced most smallholder farmers to resort to using crop residues as the major feed resources (Daniel, 1988), since the allocation of more land for crop production resulted in availability of crop residues as stock feed, particularly in smallholder livestock production system (Alemayehu, 1998).

The quality and quantity of feed supply for livestock in highlands and mid altitude areas is subjected to great seasonal variation. Generally, the availability of feed resources to support the

performance of a given class of animal is affected by seasonal fluctuation of rainfall, altitude and soil type. An excessive supply of feed during the rainy season is usually followed by deficit in grazing in the following dry season (Alemayehu, 1998).

2.6.3. Genetic performance

Ethiopia is endowed with large livestock population, unlike other African countries; the large cattle population of Ethiopia encompasses relatively limited numbers of exotic dairy cattle and/or their crosses. Less than 1% of the 34.5 million cattle population of Ethiopia is exotic or cross breed dairy cows. The genetic performance and the feed shortage problems are the bottlenecks of the smallholder dairy development in the country. The lack of suitable breeding stock poses major constraints. Local breeds need to be crossed with exotic high yielding breeds to increase production. However, according to (EARO, 2001; Kelay, 2002) activities to improve genetic performance for dairy production in Ethiopia were constrained by a number of factors. The same authors further explained that, climatic stress in the form of erratic and inadequate rainfall, low fodder yield, high price for concentrate and susceptibility to a wide variety of serious diseases damagingly affect the productivity of genetically improved dairy cattle specially the upgraded ones. Poor education and management expertise of farmers have also been hindrances in the implementation and maintenance of genetic improvement programs.

2.6.4. Animal health

One of the major constraints impeding the development of livestock industry in this country is animal disease. The prevalence of epidemic diseases adversely affects the productivity of the animals. The great proportion of the lowland area is infested with trypanosomiasis and its vector tsetse fly. Because of this infestation a vast area of fertile land could not be utilized. Disease commonly found in dairy cattle includes bacterial infections such as anthrax, blackleg, brucellosis, dermatitis, haemorrhagic septicemia, infectious foot rot, mastitis, metritis, pneumonia and tuberculosis. Common viral infections are bovine viral diarrhea, foot and mouth disease etc. protozoal infections commonly found are blood parasites such as anaplasmosis, babesiosis, theilriosis and trypanosomiasis (Falvey *et al.*, 1999).

Many of the animal health problems in the country result from the interaction among the technical constraints themselves. For example, poorly fed animals develop low disease resistance. To overcome health problems and boost up the production and productivity of dairy cattle an integrated farm management should be encouraged and selection for genetic resistance to diseases should be sought (SDDP, 1998). Good health care, herd management and disease control programs impact on dairy cow productivity. Examination and diagnosis should be considered for the entire herd not only individual animals (Falvey *et al.*, 1999).

2.7. Milk composition and quality

2.7.1. Physicochemical properties of raw cow milk

Milk is a combination of several suspensions of matter in water (Figure 1). It contains; colloidal suspension of tiny solid casein particles (micelles); an emulsion of globules of milk fat and fat soluble vitamins which stay in suspension; a solution of lactose, water soluble proteins, minerals salts and other substances (Homan and Michael, 1996).

Figure 1.1. Normal composition of milk

(Source: Homan and Michael, 1996)

Typically, whole milk is composed of approximately 3.7% water, 3.3-3.5% protein, 4.5-4.8% carbohydrates (primarily lactose), and 0.2% ash. The lipid fraction of milk is composed mostly of triglycerides (90%), with 1% phospholipids and small amounts of diglycerides, monoglycerides, cholesterol, cholesterol esters and traces of free fatty acids and other lipids. Bovine milk contains an anti-lipolytic enzyme (Gopal, 2003).

Temperature affects the density of a milk sample. The density of whole milk depends on the fat and protein content. Water has a density of 1 gram, but the density of fat is less than water and that of whole milk is higher than water. A milk sample of 4% fat would have a density of 1.0295 g/ml while a milk sample of 4.5% fat would have a density of 1.0321 g/ml. The density

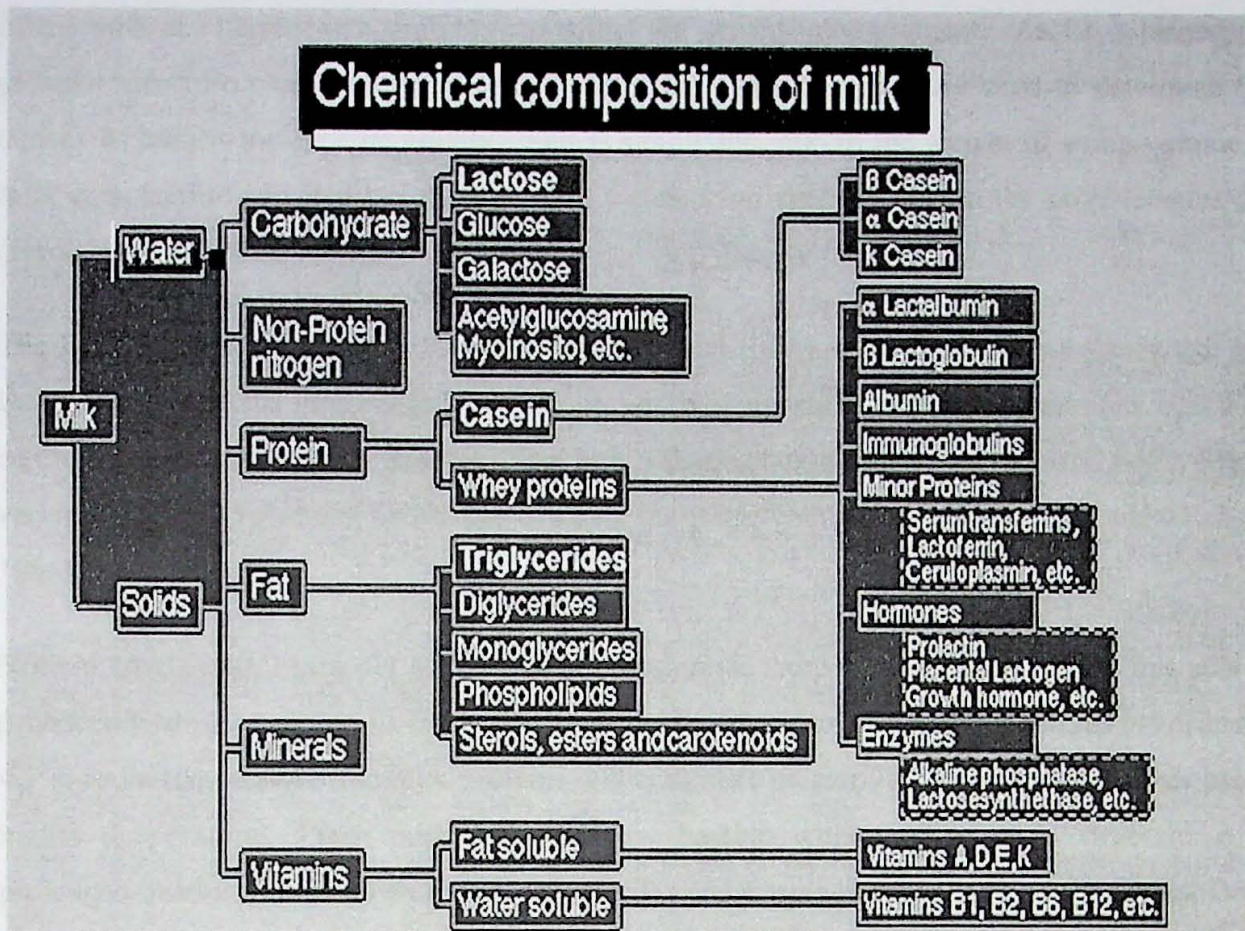


Figure 1: Chemical composition of milk

(Source: Homan and Michael, 1996)

Typically, bovine milk is composed of approximately 87% water, 3.7-3.9% fat, 3.2-3.5% protein, 4.8-4.9% carbohydrate (principally lactose), and 0.7% ash. The lipid fraction of milk is comprised mainly of triglycerides (98%), with 1% phospholipids and small amounts of diglycerides, monoglycerides, cholesterol, cholesteryl esters and traces of fat-soluble vitamins and other lipids. Bovine milk contains six milk-specific proteins (Gerrit, 2003).

Many factors affect the density of a milk sample. The density of whole milk depends on the fat and protein content. Water has a density of 1 g/ml, but the density of fat is less than water and that of solids-not-fat is higher than water. A milk sample at 4°C with 3% fat would have a density of 1.0295 g/ml while milk with a fat content of 4.5% has a density of 1.0277 g/ml. The holding

of the milk at different temperatures can affect the density measurement. As fat is heated, its globular structure changes and its density decreases. Another measure used to determine the density of milk is the specific gravity. This is simply the ratio of the weight of a unit volume of milk compared to (divided by) the weight of the same volume of water at the same temperature (Homan and Michael, 1996).

The freezing point of milk is affected by the dissolved solids. The dissolved substance that has the most effect on the freezing point is lactose, which is present in the largest quantities. Because of the dissolved solids, milk freezes about half a degree below water, i.e., at -0.525°C . Minor variations in this value can be used to evaluate the water content of milk (Homan and Michael, 1996).

Normal cow's milk has a pH of 6.6-6.8. In fresh milk there is no lactic acid, but this acid is produced when lactose in milk undergoes bacterial fermentation as it ages. When the pH drops to 4.7 at room temperature, the milk proteins will coagulate or clot. This occurs at a higher pH at higher temperatures. Fresh milk can withstand heating without changes in structure; only prolonged heating breaks down the casein micelles and causes changes in the milk sugars. Once the pH has dropped as a result of storage, milk is more likely to change when heated, with the solids coagulating (Homan and Michael, 1996).

2.7.2. Bacteriological quality of raw cow milk

Due to its complex biochemical composition and high water activity, milk serves as an excellent culture medium for the growth and multiplication of many kinds of microorganisms (Ashenafi and Beyene, 1994). Presence and multiplication of saprophytic bacteria in raw milk might change the milk composition and influence the quality of the product (Godefay and Molla, 2000). Moreover, the flavor of raw milk may be adversely affected and heat stable bacterial enzymes may continue to act in the product, particularly during long storage and adversely affect stability and/or flavor of cream and upper heat treated milk (Heeschen, 1994).

The bacterial contamination in milk emanates from a number of sources including mastitis, external udder surfaces and from the milking plant (Hagstad and Hubbert, 1986; Ashenafi and

Beyene, 1994; Slaughuis, 1996). Inadequate cooling of the milk, improper udder preparation methods, unclean milking equipment and the water used for cleaning purposes are considered as the main source of milk contamination (DeGraaf *et al.*, 1997). In order to produce milk of good bacteriological quality, dairy farmers should be aware of the sources of contamination and importance of proper milk handling, cooling and storage.

Sources and significance of bacterial contamination

For many years, it was believed that milk drawn directly from the udder of a healthy cow was a sterile fluid, that is, it contained no living microorganisms. It has been demonstrated; conclusively that freshly drawn milk usually contains bacteria. The numbers of bacteria, which are present in freshly drawn milk, vary with individual animals, quarters of the udder, environment of the animal (cleanliness of quarters), health of the animal, and other factors. It is found that the first milk withdrawn from the udder (foremilk) usually has a higher bacterial content than that drawn later in the milking process, while the strippings may show a somewhat higher count than the latter (Murphy, 1996; Walstra *et al.*, 1999).

Raw milk as it leaves the udder of healthy cows normally contains very low numbers of microorganisms and generally will contain less than 1000 total bacteria per ml (Murphy, 1996; Godefay and Molla, 2000). Natural flora within the udder of healthy animals is not considered to contribute significantly to the total numbers of microorganisms in the bulk milk, nor the potential increase in bacterial numbers during refrigerated storage. Natural floras of the cow generally have little influence on standard plate counts (SPC) (Hagstad and Hubbert, 1986; Murphy, 1996).

In case of mastitis counts of *Streptococci*, *Staphylococci* or coliforms will be as high as the total plate count and can be very high up to 10^7 cfu/ml. Under certain circumstances, bulk milk count may even increase up to 10^5 cfu/ml (Slaughuis, 1996).

The exterior of the udder can be an important source of contamination. But the exterior of the udder is influenced by the environment of the cows, in which cows are housed and milked (Murphy, 1996).

In temperate regions, cows are housed in winter and pastured in summer. Differences in teat contamination can be found between housing and pasturing. Both total plate and aerobic spore

counts are lower when cows are at pasture. When cows are housed, bedding material and feed stuffs can be contamination sources. In both cases (housing and pasturing) feces and dung are also an important contamination sources. Contamination of bedding material can be very high due to absorption of urine and feces (Slaughuis, 1996).

Careful cleaning of the cow prior to milking significantly reduces contamination. Clipping the flanks, escutcheon and udder reduces contamination from hair and adhering debris (Hagstad and Hubbert, 1986). A maximum reduction of teat contamination of 90% can be achieved with good udder preparation (washing with disinfectant and drying with paper towel) before milking. This depends on the initial level of contamination and the way of udder preparation. So with high initial contamination levels this 90% reduction might not be reached (Murphy, 1996).

During milking, the major source of bacteria in milk is the milk contact surfaces of milking equipment and milk cans or bulk tanks (Ashenafi and Beyene, 1994). In practice, the contribution of milking equipment to the microflora of the milk can't be accurately obtained by bacteriological counts on the milk produced, because of the variability in numbers and types of bacteria derived from cow's udder (Hagstad and Hubbert, 1986; Murphy, 1996).

Cleaning and disinfection of equipment after each milking is important for the reduction of contamination of milk from the equipment, with rinsing, about 10 % of the number of bacteria found in milk can be reduced (Murphy, 1996). In most cases, not all bacteria are removed and killed during cleaning and disinfections. Also outgrowth of remaining bacteria fixed in the wall of the container between two milking is supposed (Mehari, 1988). A milk can that is improperly washed, inadequately sanitized or sterilized or insufficiently dried, may contribute millions of bacteria to every milliliter of milk placed in it (Murphy, 1996).

After production, milk can be stored in cans and in bulk tanks before collection. Raw milk stored in cans will be transported to the dairy plant on the same day, because storage temperatures are rather high. Spoilage of this raw milk is due to Streptococci and coliforms resulting in souring of the milk. Milk storage transport are aimed at having good quality milk available where and when needed for processing (Walstra *et al.*, 1999).

Although the air of the milking environment rarely contributes a significant number of the total microbial count of milk, extremely dusty conditions may increase the counts. Milk handling personnel (milker, butter maker, cheese maker, etc.) may contribute various organisms including pathogens especially when they are careless, uninformed, or willfully negligent, directly to milk (Ashenafi and Beyene, 1994). Polluted water may also cause entry of pathogens into milk (Gudeta, 1987; DeGraaf *et al.*, 1997). The soils, while the cows are in pasture, manure, the animal coats, tails etc. are some of the possible sources of contamination of milk (Teka, 1997). Substances such as salt, water, etc., added to various dairy products, may be a source of microorganisms in large or small numbers, and of harmless or harmful types (Murphy, 1996; Walstra *et al.*, 1999).

Milk cooling

To prevent or retard growth of bacteria in milk and to maintain its quality for domestic consumption or during transport to the processing plant, it is essential to cool the fresh milk as quickly as possible (Godefay and Molla, 2000). Although milk is known to possess several natural antimicrobial systems, bacterial numbers will double in less than 4 hours in unchilled milk. The rate of microbial growth will depend on initial numbers and the temperature at which milk is held after milking and thereafter (Kurwijilla *et al.*, 1992). In the tropical countries of Africa with high ambient temperatures, lack of refrigeration facilities at the farm and house hold level imply that raw milk will acidify very fast unless and otherwise protected (Godefay and Molla, 2000). Therefore, the collection systems must be designed to move the milk to the cooling and/or processing center in shortest possible time. In addition, every effort should be made to use available systems such as water cooling, air circulation or shaded areas to reduce milk temperature (DelloCastillo, 1990).

Bacteriological quality tests

Sanitary methods of handling milk must be strictly adhered to rigidly in order to provide safe milk for human consumption. Furthermore, since milk is a good growth medium, even a small number of non pathogens can multiply considerably if the milk is not kept refrigerated. Because the consumer has no way of knowing whether or not the milk delivered to the home or purchased in the store is contaminated, a number of standard tests are carried out periodically on milk. From

the results of these tests, milk is classified into grades designated as A, B, and C (Volk and Wheeler, 1980). Tests commonly employed to determine the quality of milk include dyereduction (Methylene blue reduction and resazurine reduction), Alcohol test, Standard plate count, Coliform count, Somatic cell count, Titrable acidity, and Phosphatase tests.

Dye-reduction tests

These tests are less precise criterion for classifying raw milk according to its bacteriological quality. This calls for the need to periodically verify the quality of milk with more precise microbiological tests such as standard plate count (Ombui *et al.*, 1995).

Methylene blue reduction test

Methylene blue is a blue-colored reagent which is used to estimate the bacterial population of a given milk sample. A known dilution of the methylene blue solution is added to the milk sample and observation is made at fixed intervals until the blue color disappears. The number and species of organisms present in the milk determines the time required for the disappearance of the blue color in the milk (Teka, 1997). Normally if the number of bacterial organisms is greater, the time required to decolorize the blue color is shorter. This test is usually used for grading the quality of raw milk before pasteurization. On the basis of this test, raw milk is graded as very good: not decolorizing in 5 hours, good: decolorized in less than 4 hours, but not less than 3 hours, fair: decolorized in less than 2 hours, but not less than 1 hour, poor: decolorized in less than ½ hour (Kurwijilla *et al.*, 1992).

Resazurine reduction test

This test is also used for grading the sanitary quality of raw milk by applying the chemical reagent resazurin. The procedure is similar to that for the methylene blue test, except that this test is quicker and the result is obtained in much less time (Teka, 1997). Resazurin imparts blue color to milk when reduced to resorufin changes to pink and finally to white when reduced to dihydroresorufin. The time required for complete decolorization, reduction of the resazurin and the degree of color change is directly related to the number of bacterial organisms in the milk (Ombui *et al.*, 1995; Teka, 1997). A comparator disc reading value of 4 and above for 10 minutes

resazurin test indicates good quality but while a comparator disc reading value of less than 4 at 10 minutes indicates poor quality milk (Ombui *et al.*, 1995).

Alcohol test

When milk contains more than 0.21% acid, or when calcium or magnesium compound are present in greater than normal compounds, it coagulates on the addition of alcohol. This fact is the basis of alcohol test, which furnishes a means of judging the quality of milk (Ombui *et al.*, 1995).

Standard plate count

The standard plate count of raw milk gives an indication of the total number of aerobic bacteria present in the milk at the time of pick up. Obviously, very clean milk will have lower bacterial counts than milk collected or handled under unsanitary conditions. The standard plate count is a basis for grading milk (Volk and Wheeler, 1980). Milk samples are plated on standard plate count agar media and then incubated for 48 hrs at 32°C to encourage bacterial growth. Single bacteria or clusters grow to become visible colonies that are then counted. All plate counts are expressed as the number of colony forming units (cfu) per milliliter (Murphy, 1996). This method is used mainly to estimate the bacterial population of raw milk prior to heat treatment. It has a limited value in that it doesn't indicate the quality of microbial populations in terms of pathogens and non pathogens (Teka, 1997). The standard plate count is generally accepted as the most accurate and informative method of testing bacteriological quality of milk (Kurwijilla *et al.*, 1992; Godefay and Molla 2000). It is sensitive but also labour intensive and is inaccurate for high count milks (Slaughuis, 1996). Plate count standards have been developed to ensure satisfactory production hygiene and that the product is safe (Table 2). The plate count method has been conducted as a valuable adjunct to guide sanitarians in correcting sanitation failures and improving milk quality (IDF, 1990).

Table 2: Grade of raw milk based on SPC

Bacterial count/ml	Grade
Not exceeding 200,000	Very Good
200,000 – 1,000,000	Good
1,000,000-5,000,000	Fair
>5,000,000	Poor

Source: (Kurwijilla *et al.*, 1992)

Coliform count

Coliforms are group of bacteria, which inhabit the intestinal tracts of human and animals. They are excreted in large number with human excreta and animal droppings. They may be found in the soil, on vegetables and in untreated water (Teka, 1997). It includes all aerobic and facultatively anaerobic, Gram-negative, non-spore forming rods able to ferment lactose with the production of acid and gas at 35°C within 48 hours. Most of them belong to the genera *Escherichia*, *Enterobacter* and *Klebsiella* (Godefay and Molla, 2000). The presence of coliform organisms in milk indicates unsanitary conditions of production, processing or storage. Hence their presence in large number in dairy products is an indication that the products are potentially hazardous to the consumers' health (Volk and Wheeler, 1980; Godefay and Molla, 2000). Coliform organisms contaminate raw milk from unclean milker's hands, improperly cleaned and unsanitized or faulty sterilization of raw milk utensils especially churns, milking machines, improper preparation of the cows' flecks or dirt, manure, hair dropping into milk during milking, udder washed with unclean water, dirty towels and udder not dried before milking (Ombui *et al.*, 1995).

Coliform count is a non-regulated test that has been used historically to assess milk production practices such as milk refrigeration, milking machine sanitation, and pre-milking udder hygiene (Guterbock and Blackmer, 1984; Reinemann *et al.*, 1997; Murphy and Boor, 2000; Davidson *et al.*, 2004). Coliform count is a practical indicator of milking hygiene because it is easy and inexpensive to perform and it is often correlated with the population of other bacteria in bulk tank milk (Jayarao *et al.*, 2004; Pantoja *et al.*, 2009). However, because coliform bacteria populations

can increase rapidly under some conditions, it is important to distinguish between the level of initial contamination and increased CC that may be the result of incubation in the milk handling system after milk harvest.

Somatic Cell Count

The somatic cell count (SCC) is internationally recognized as a parameter for assessing milk quality and udder health (Degraaf *et al.*, 1997). EU standards requires that, the milk should not contain more than 400,000 somatic cells/ml. Milk markets routinely rely on somatic cell counts to ensure a quality product. Somatic cell counts levels are monitored to ensure compliance with set milk quality standards. Today, most markets in developed countries pay a premium for low SCC, good quality milk. One can appreciate the reasons, for paying a bonus for quality milk when the relationship between mastitis (high SCC) and milk composition is understood. Chemical changes in milk composition due to mastitis reduce milk quality (Rice and Bodman, 1993).

3. MATERIALS AND METHODS

3.1. Description of the study areas

Based on the milk production potential report of Arsi zone livestock production, health and marketing agency (2009) and ease of accessibility or for logistic reason, five districts (Tiyo, Digeluna Tijo, Lemuna Bilbilo, Shirka and Munessa) were selected to assess milk supply chain and to provide baseline information on physicochemical properties and microbial load of raw whole milk (Figure 2).

Tiyo district: - is located at about 167 km south east of Addis Ababa and at the foot slopes of Mount Chilalo in the eastern side. Tiyo has a total area of 65,000 hectares of land and from these; 25,060 hectares is used for crop cultivation, 9,697 hectares for grazing, 3,959 hectares for forest, 9,479 hectares is covered by bush and shrub, 10,828 hectares is barren and 5,977 hectares used for other purposes. Tiyo has diverse climatic conditions; weyna dega (52%), dega (37%), and kola (11%) agro-ecologies with altitude ranging from below 2300 to over 3200 meters above sea level. Tiyo has got 1300mm to 1350mm annual rainfall and an average temperature of 18°C to 25°C during dry season and 5°C to 10°C during wet season. The area experiences bimodal rainfall, long rainy season occurring from June to August and short rainy season from February to April. The livestock and human population of the district is summarized in table 3 and 4. It has very productive environmental conditions in terms of its climate and soil. The dominant cereals cultivated in the area are wheat and barley (FAO, 2006).

Digeluna Tijo: - is located 192 km from the capital Addis Ababa in the south east. The administrative center of this district is Sagure. The district has a total area of 92,700 hectares of land and from these; 43,873 hectares is used for crop cultivation, 15,054 hectares for grazing, 11,122 hectares for forest, and 22,651 hectares used for other purposes. The district has diverse climatic conditions; dega (78%) and weyna dega (22%) agro-ecologies with altitude ranges from 2500 to 3560 meters above sea level. The area experiences bimodal rainfall, long rainy season occurring from June to September and short rainy season from mid March to April. The livestock and human population of the district is summarized in table 3 and 4 (FAO, 2006).

Lemuna Bilbilo: - is located 223 km from the capital Addis Ababa in the south east. The administrative center of this district is Bekoji and the district has a total area of 81,400 hectares of land and from these; 70,154 hectares is used for crop cultivation, 6,746 hectares for grazing, 3,839 hectares for forest, 262 hectares of land is covered by bush and shrub, 99 hectares is barren and 300 hectares used for other purposes. The district has diverse climatical conditions; dega (80%) and weyna dega (17%) and kola (3%) agro-ecologies with altitude ranges from 2500 to 3560 meters above sea level. The area experiences bimodal rainfall, long rainy season occurring from June to August and short rainy season from mid March to April The livestock and human population of the district is summarized in table 3 and 4 (FAO, 2006).

Munesa: - is located 227 km from the capital Addis Ababa in the south east. The administrative center of the district is Kersa. The altitude of this district ranges from 1500 to 4100 meters above sea level. Munesa has a total area of 121,000 hectares of land and from these; 62,800 hectares is used for crop cultivation, 21,059 hectares for grazing, 33,074 hectares for forest, 1,608 hectares is covered by bush and shrub, 779 hectares is barren and 2,410 hectares is used for other purposes. The district has diverse climatical conditions; dega (54%), weyna dega (43%) and kola (3%) agro-ecologies. The area experiences seven and five, rainy and dry months respectively. The livestock and human population of the district is summarized in table 3 and 4 (FAO, 2006).

Shirka: - is located 257 km from the capital Addis Ababa in the south east. Gobesa is the administrative center; other towns include Gado Guna. The altitude of this district ranges from 1200 to 2500 meters above sea level. A survey on land use pattern in the district showed that; 21.4% is arable or cultivable, 6.3% pasture, 2.7% forest, and the remaining 69.6% is considered swampy, mountainous or otherwise unusable. The livestock and human population of the district is summarized in table 3 and 4 (AZLPHMA, 2009).

Table 3: Households and human population of the study areas

Districts	Households/HHs			Population			Reference
	Male	Female	Total	Rural	Urban	Total	
Tiyo	12,910	3,450	16,360	82,735	4541	87,276	FAO, 2006
Munesa	11,419	1,830	13,249	129,438	14,985	165,027	FAO, 2006
Digeluna Tijo	13,120	2,126	15,246	114,765	16,462	131,227	FAO, 2006
Lemuna Bilbilo	13,184	4392	17,576	154,205	10,085	164,290	FAO, 2006
Shirka						153461	CSA, 2005

Table 4: Livestock population of the study areas

Districts	Cattle	Sheep	Goat	Poultry	Bee colony	Horse	Donkey	Mule	Reference
Tiyo	73,937	45,237	8,494	35,044	1,080	5687	11,785	246	FAO, 2006
Munesa	156,012	115,795	13,910	60,384	15,142	32,230	10,620	1,054	FAO, 2006
Digeluna Tijo	143,132	90,093	5,634	48,806	1,321	19,056	10,495	1,163	FAO, 2006
Lemuna Bilbilo	286,518	301,917	64,348	70,744	16,991	66,373	52,743	4,232	FAO, 2006
Shirka	219,897	71,180	70,457	92,995	-	14,490	20,428	8,837	AZLPHMA, 2009

3.2. Study population

The total cattle populations by breed of each district are presented in Table 5. A total of 1,154,941 cattle population were found in the study sites and from these, local and crossbred cattle population were 98.39% and 1.61% respectively (AZLPHMA, 2009).

Table 5: Cattle population by breed of the study sites

District	Cattle population					
	Local			Cross		
	Male	Female	Total	Male	Female	Total
Tiyo	40100	41500	81600	400	9200	9600
Digeluna Tijo	155600	160091	315691	75	925	1000
Lemuna Bilbilo	149190	153193	302383	300	3700	4000
Munessa	136575	136574	273149	700	2031	2731
Shirka	81780	81780	163560	26	1201	1227

Source: (AZLPHMA, 2009)

3.3. Study design

A cross-sectional study was carried out to collect data on milk supply chain and physicochemical characteristics and microbial quality of milk under smallholder production and marketing conditions. The study has two components. The first part focused on studying household characteristics of smallholders and milk supply chain. The second part evaluated microbial load and physicochemical characteristics of milk at smallholder level.

3.4. Sample size determination and sampling procedure

The sample size was determined following the mathematical model recommended by Arsham (2005) as follows:

$$N = 0.25/SE^2$$

Where N = sample size,

SE = standard error

For a SE of 3.5% the computed sample size was 204. However, during random selection of households from peasant associations in rural and groups of kebeles in urban dairying were 220 households. After determining the sample size, multi-stage sampling procedure was followed at four different stages. In the first stage, a primary sampling unit represented by two broad categories of producers rural (mixed crop-livestock production system) and urban dairy production system was selected within each study district. In the second stage, following randomization (proportional allocation), a total of nine peasant associations from mixed crop-livestock production system and five groups of kebeles from urban dairy production system were identified. In the third stage, individual households having dairy cows of any breed and size were identified and listed. In the fourth stage, individual dairy cow owner households were randomly selected from the list.

3.5. Data collection methods

3.5.1. Questionnaire survey

Group discussion was undertaken with key informants such as elders, staffs of non-governmental developmental organizations, Arsi zone cooperative promotion office, dairy union and livestock agency to investigate and have an overview about the overall milk production and marketing system of the study area. The information generated in the discussion was used for the preparation and development of the questionnaire for the formal survey. Moreover, pre-testing of the questionnaire was made before the actual data were collected on sampled households in order to modify the questionnaire and to decrease error by excluding unimportant data to be considered and revised accordingly.

Therefore, semi-structured questionnaire with closed and open ended questions were the major tools used during the survey phase of the study which included the data groups of household characteristics such as family size by sex, age, labour input including household available labour in terms of sex and age. Herd composition of the household and herd structure by age and sex. Reproductive performance: age at first calving and calving interval; production performance: milk yield, type of feed, feed source, traditional milking practices and herd management such as

feeding and watering strategy and breeding practices. Occurrence of major livestock diseases and availability of veterinary and extension services (Annex 1).

3.5.2. Field observation

Personal observations at the time of visits were made to observe the housing conditions and how animals are managed, describe some of the routine dairy activities like milk handling, processing by smallholders and primary dairy cooperatives. In addition, in order to characterize the dairy marketing system; key informants from producers, milk traders or retailers, processors and consumers were selected for discussion.

3.5.3. Laboratory investigation

Collection of raw milk samples

By following proportional allocation, five milk collection centers from a total of ten and two dairy farms from a total of four were selected based on ease of access or logistic reason. Again a total of one hundred milk samples were proportionally allocated to the selected milk collection centers and dairy farms. Milk samples were randomly collected from each collection center and dairy farms. Each sample had 100ml of milk divided into two sterile tubes, one for microbiological and the other for physicochemical analysis. Collected milk samples were transported to the Dairy Microbiology Laboratory of the Ethiopian Meat and Dairy Technology Institute (EMDTI) and analyzed within 24 hours according to the standard methods set by American Public Health Association (1992).

Chemical analysis of milk samples

The milk constituents (fat, protein, lactose and solid not fat) and physical characteristics (density and freezing point), of the milk samples were determined by using Lactoscan 90 (Aple Industries services-La Roche Sur Foron, France), 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. Then when the starting button activated, the analyzer sucks the milk, makes the

measurements, returns the milk in the sample-tube and the digital indicator shows the specified results.

Microbiological analysis of milk samples

Decimal dilutions of milk samples were plated on plate count agar (HIMEDIA) and violet red bile agar (HIMEDIA) for total aerobic plate and coliform counts, respectively following the standard procedures recommended by American Public Health Association (1992). Each plate was marked with sample number, before shaking samples and making dilutions (APHA, 1992).

Pre-test considerations for milk:

Before removal of the milk samples from its container, the content was mixed thoroughly and vigorously. The following dilution standards were selected so that the total number of colonies per plate fluctuates between 25 and 250 for total aerobic plate and between 10 and 100 for coliform counts.

For total bacterial count (TBC), dilutions rates of 10^2 to 10^7 were used while for coliform count (CC), dilutions rates of 10^1 - 10^4 were used. Separate sterile pipettes were used for the different dilutions. Sterile dilution tubes with 9 ml of sterile saline water in them were used for TBC and CC of raw milk samples from different milk collection centers.

The test procedure for TBC and CC were according to APHA (1992):

1. The dilution saline water was labeled with sample number and dilution number.
2. One ml of the milk sample was added to dilution blanks and serially diluted by taking one ml to the next dilution bottle after mixing.
3. One ml was discarded from the last dilution.
4. After thorough mixing, 1 ml of diluted milk was taken from each dilution starting from the highest dilution and put on sterile labeled petridishes using sterile pipettes. The covers of the petridishes were lifted just high enough to insert pipettes. Two plates were inoculated per dilutions.

5. About 10-12 ml of the melted (44°C to 46°C) plate count agar and violet red bile agar for TBC and coliform counts, respectively were poured into each plate by lifting gently the cover of the petridish just high enough to pour the medium.
6. The medium was gently mixed with the test portions in the petridish by rotating and tilting.
7. After the mixture was evenly spread over the bottom of the plate, it was allowed to solidify on a level surface.
8. The plates were then inverted and placed in an incubator at 37°C for 48 hours.
9. Incubating control plates for each sterilization lot of dilution blanks and medium were used to check sterility of the dilution water and medium.

Reading and interpretation of results

Total bacterial count (TBC): After incubation at 37°C for 48 hours, all colonies including those of pin point size is counted on selected plates. Results from plates, which contained 25 to 250 colonies per plate were recorded. If plates from two consultative decimal dilutions yield colony counts of 25 to 250, the counts for each dilution were computed by the following formula (APHA, 1992).

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

Where: N = number of colonies per milliliter of milk,

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.

When plates contained less than 25 colonies, the results were read as less than 2.5×10^2 (in 1:10 dilution). If more than 250 colonies developed on the highest dilution plate, the count was recorded as more than 250 times the reciprocal of dilution (APHA, 1992).

In case of crowded plates (more than 250 colonies); if there were fewer than 10 colonies per square centimeter, colonies in 12 squares; select representative, 6 consecutive squares horizontally across the plate and 6 consecutive squares at right angles were counted being careful not to count a square more than once. When there were more than 10 colonies per square centimeter, colonies in 4 successive representative portions were counted. In both instances, the average numbers of colonies found per square centimeter were multiplied by the area of the plate used to determine the estimated number of colonies per plate. When computing the total bacterial count (TBC) and coliform counts; only the first two significant digits were reported to avoid creating a fictitious impression of precision and accuracy.

Coliform count (CC): After incubation of the plate for 24 hours, purplish red colonies with bile precipitations around them were counted as coliforms. Results from only those plates, which contained between 10 and 100 colonies were recorded. Interpretations were similar with that of TBC.

Direct microscopic somatic cell count (DMSCC): The number of somatic cell in raw milk provides a measure of the presence and extent of mastitis or certain other abnormal milk secretions. Stained cells are discernible under the microscope and can be enumerated as a way of assessing one aspect of raw milk quality. In this method, only intact somatic cells are counted and the only those cells are that meet specific morphological characteristics (Fitts and Laird, 2004).

Procedures:

1. Wash the slide with hot water
2. After thoroughly mixing the sample, measure 0.001ml portions by using syringe.
3. Rinse the measuring tube in fresh tap water (25⁰ to 35⁰C), before and after each use and between successive samples.
4. Make a smear in 1cm² and dry the slide by air.
5. Fix the slide by using 99.7% ethanol and wait for 15 minutes.
6. Allow the samples to stain by thyladine blue (a levowitz-weber stain) and kept for 5 minutes.
7. Wash the slide with tap water and air dry.
8. Place a one drop of oil-immersion and examine the films in 100X magnification power.

Reading and interpretation of the result:

1. Count cells in twenty fields.
2. Total number of somatic cell counts can be calculated by using the following standard formula.

$$\text{Total SCC in 20 fields} = \frac{M \times 1000}{0.0346}$$

Where M: is a total count of cells in twenty fields

3. In order to get the Number of somatic cells in one particular sample, we have to divide the total counts of cells in to twenty.

3.6. Data management and analysis

Data collected were entered in to Microsoft Excel (2003) spread sheet and different analytical techniques were employed to analyze the available data using appropriate statistical software; SPSS version 15 (SPSS, 2005). For most of the data obtained from survey; such as demographic characteristics, land and family size, herd characteristics and composition and husbandry practices were reported by using simple descriptive statistics. Analysis of variance (ANOVA): was used to test the variability of different variables; age at first calving, calving interval, amount of milk produced from different breeds of cattle (cross or local) across the study sites (districts). The results of microbial counts were normalized by transforming to Log10 and these transformed values; total bacterial count, coliform count, somatic cell count, the chemical composition values; fat, SNF, protein, lactose and total solids and physical characteristics; density, freezing point and added water were analyzed by using General Linear Model (GLM). Statistical analyses such as mean comparison were made by using LSD multiple range tests for some variables of interest. Significant differences were considered as ($p < 0.05$).

4. RESULTS

4.1. Demographic characteristics of the respondents

4.1.1. Age and sex distribution

Out of the total interviewed dairy producers (N=220), 68.6% are males and the rest 31.4% are females. Most of the respondents (54.5%) are aged between 41-60 years and the ones older than 60 years represented only 9.6%. From the total respondents, the Orthodox Christian (67.3%) population dominates over Muslim (17.7%) and Protestant (15%) population (Table 6). In the present study, the average dairy farming experience is 14.81 years.

Table 6: Demographic characteristics of the respondents

Variables	Frequency (%)
Age (years)	
21-40	79 (35.9)
41-60	120 (54.5)
61-80	21 (9.6)
Sex	
Male	151 (68.6)
Female	69 (31.4)
Religion	
Orthodox	148 (67.3)
Protestant	33 (15.0)
Muslim	39 (17.7)
Total	220 (100)

4.1.2. Family and land size

Out of the total interviewed dairy producers, 65% are rural dairy producers who have their own land for crop cultivation and grazing, while the rest 35% are urban dairy producers and didn't

have own land either for grazing or crop cultivation. About 76.2% of rural dairy producers have land size ranging from one to five hectares, while 16.8% and 7.0% of rural dairy producers have land size ranging from six to ten and eleven to fifteen hectares of land, respectively. More than half of the respondents, 58.6% have a family size of six to ten while respondents that have a family size of one to five and eleven to fifteen were 28.7% and 12.7%, respectively (Table 7). Average land holding per household for rural dairy producers and family size per household was 4.31 and 6.89, respectively.

Table 7: Family and land size of the dairy producer

Variables	Frequency (%)
Land size (ha) (N=143)	
1-5	109 (76.2)
6-10	24 (16.8)
11-15	10 (7.0)
Family size (N=220)	
1-5	63 (28.7)
6-10	129 (58.6)
11-15	28 (12.7)

4.1.3. Herd size and composition

The herd size and composition of the study districts are summarized in Table 8. The total cattle populations of different breeds and classes from interviewed dairy producers in Lemuna Bilbilo and Tiyo districts were 759 and 353, respectively. On the other hand, the total cattle populations of Digeluna Tijo, Munesa and Shirka districts were 562, 306 and 603, respectively. Moreover, the highest and lowest average per household herd size was recorded from Digeluna Tijo (17.6) and Tiyo district (5.7) respectively.

Table 8: Cattle population and composition owned by the study participant HHs

Cattle class by breed	Cattle heads at each district					Overall
	Lemuna Bilbilo (N=62)	Digeluna Tijo (N=32)	Tiyo (N=62)	Munesa (N=32)	Shirka (N=32)	Sum (%) (N=220)
Local breeds						
Lactating cows	84	48	14	57	244	447 (17.3)
Dry cows	37	48	4	24	13	126 (4.9)
Heifers	62	59	2	20	26	169 (6.5)
Oxen/Bulls	165	97	79	70	101	512 (19.8)
Male calves	31	9	11	15	13	79 (3.1)
Female calves	24	18	9	22	86	159 (6.2)
Cross breeds						
Lactating cows	125	79	99	31	37	371 (14.4)
Dry cows	42	24	31	19	4	120 (4.6)
Heifers	90	68	19	13	18	208 (8.1)
Oxen/Bulls	42	59	44	11	33	189 (7.3)
Male calves	33	24	19	11	15	102 (3.9)
Female calves	24	29	22	13	13	101 (3.9)
Total	759	562	353	306	603	2583 (100)
Per HH herd size	12.2	17.6	5.7	9.6	18.8	11.7 ± 4.9

4.2. Dairy cattle husbandry practices

4.2.1. Feeds and feeding management

Types of feed and feeding system are the major component of dairy husbandry and considered as one of the crucial inputs in dairying. Out of the total respondents, 66.82% fed a mixture of roughages and concentrates while the rest 33.18% of the respondents fed their animals mainly of roughages from different sources. The feeding systems used in the study areas were indoor feeding (zero grazing), grazing and a mixture of both systems. Slightly higher number of

respondents used only grazing (39.55%) over those who used only zero grazing (33.18%) and using a mixture of both systems (27.27%).

4.2.2. Water source and watering practice

In the study areas, dairy producers had three different water sources for their own animals; wells, river and pipe water. More than half of the respondents, 55.91% used river while 35.91% and 8.18% used wells and pipe water respectively. On the other hand, 53.18%, 42.27% and 4.09% of the respondents gave water once, twice and thrice per day respectively, while 0.46% of the respondent watered their dairy cattle on *adlibitum* basis. In rural (mixed crop-livestock production system), the common water sources are either river or wells and when there is a river in the nearby the herder will directly take the animals to the river. If river is not available, the owners' bring the water from wells by using jerry cans (Figure 3).

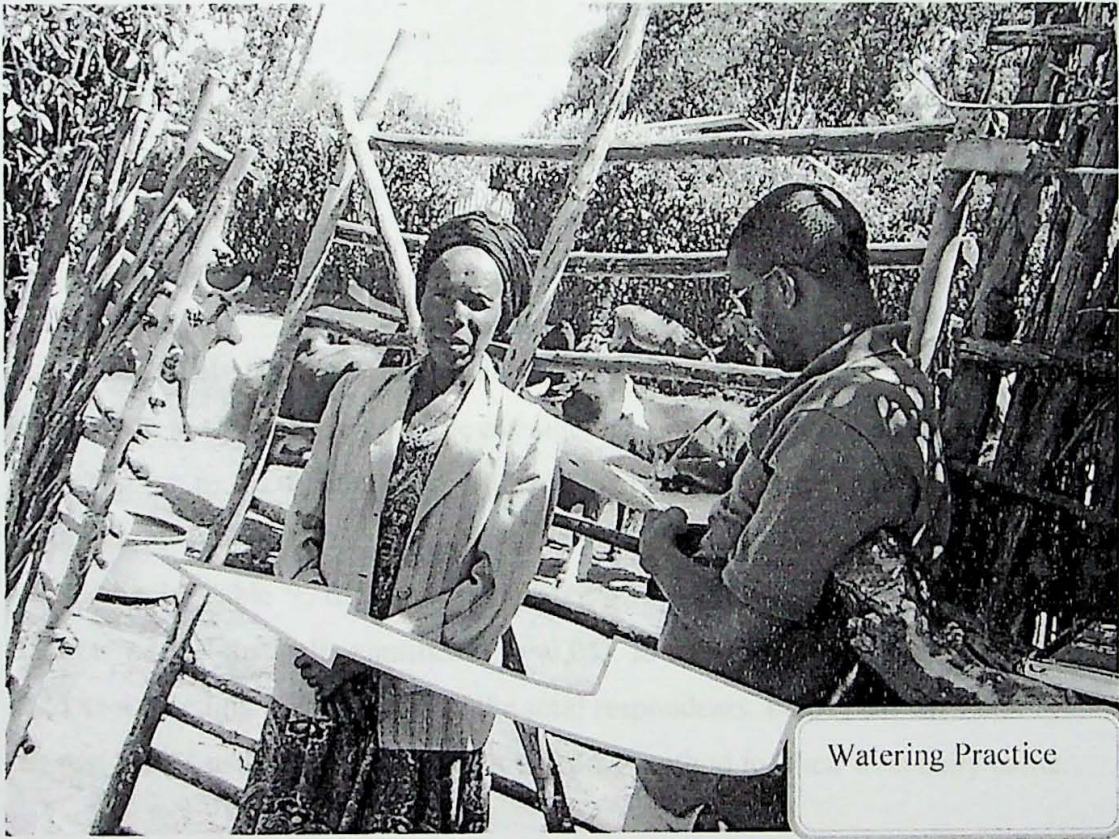


Figure 3: Common watering practice in the study area

4.2.3. Housing systems

Most of the households in the rural dairy production system (mixed crop-livestock) kept their cattle within their own residence compound (Figure 4a), while considerable proportions used open barn/shed. By contrast, in urban dairy production systems, most of the dairy producers had a separate shelter for their animals (Figure 4b).



Figure 4a

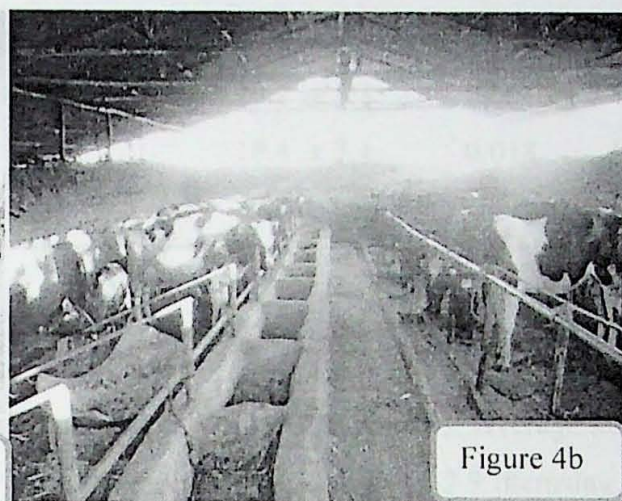


Figure 4b

Figure 4: Housing type

4.2.4. Reproductive performance

Age at first calving and calving interval were used to assess the reproductive performance of dairy cattle in the study areas. The average age at first calving was ranged from 39.1 months in Tiyo district to 45.4 months in Munesa district. Similarly, the longest calving interval was recorded in Munesa district (19.7 months), while the shortest was in Tiyo district (15.6 months). As shown in Table 9; differences in calving interval and age at first calving across different districts were statistically significant ($p < 0.05$). In the study areas, both AI and natural service are used as a breeding method. Out of the total respondents, 68.6% use artificial insemination while the rest 31.4% use natural service as a breeding method for their own dairy cattle.

Table 9: Mean results of CI and AFC across different districts

Districts	N	Reproductive performance traits (Mean $\pm$ SD)			
		AFC (months) (p=0.000)	LSD	CI (months) (p=0.000)	LSD
Lemuna Bilbilo	62	41.6 $\pm$ 4.3	0.001	16.3 $\pm$ 5.1	0.490
Digeluna Tijo	32	42.1 $\pm$ 5.2	0.228	19.7 $\pm$ 4.6	0.001
Tiyo	62	39.1 $\pm$ 4.1	0.001	15.6 $\pm$ 4.5	0.001
Munesa	32	45.4 $\pm$ 9.7	0.001	19.7 $\pm$ 5.3	0.001
Shirka	32	43.7 $\pm$ 10.9	0.019	18.4 $\pm$ 7.4	0.018
Total	220	41.8 $\pm$ 6.9		17.4 $\pm$ 5.5	

4.2.5. Milk production

Table 10 presents the average milk production of local and cross breed dairy cows. Average milk production for local dairy cattle ranged from 2.0 liters/day in Shirka district to 2.9 liters/day in Lemuna Bilbilo district. However, these differences in milk production across the study sites were statistically insignificant ($p>0.05$). On the other hand, average milk production for crossbred dairy cattle ranged from 8.6 liters/day in Shirka district to 12.5 liters/day in Tiyo district and this difference in volume of milk production across the study areas were statistically significant ($p<0.05$).

The primary purpose of milk production for most of the respondents (81%) was both for sale and household consumption. By contrast, 19% of the respondents were producing milk solely for household consumption.

Table 10: Average milk production of local and cross breed dairy cattle

Districts	Average milk production (Mean $\pm$ SD)				
	N	Local (liters/day)	N	Cross (liters/day)	LSD
		(p=0.069)		(p=0.000)	
Lemuna Bilbilo	34	2.9 $\pm$ 1.0	56	10.4 $\pm$ 3.5	0.007
Digeluna Tijo	14	2.5 $\pm$ 0.7	27	9.2 $\pm$ 3.3	0.001
Tiyo	18	2.6 $\pm$ 0.8	54	12.5 $\pm$ 4.9	0.001
Munesa	30	2.5 $\pm$ 0.9	10	9.8 $\pm$ 2.9	0.051
Shirka	14	2.0 $\pm$ 0.6	21	8.6 $\pm$ 3.4	0.000
Total	110	2.6 $\pm$ 0.9	168	10.6 $\pm$ 4.2	

4.2.6. Milking and milk handling practices

Milking is predominantly done by women or adult females (85%) while 5, 4 and 6% were done by household adult males, children and combination of all household members respectively. Most of the households milk outdoors (65%) and 98% of the respondents told that they practiced twice per day milking (early in the morning and late in the afternoon). Once and trice per day milkings is also mentioned by few respondents, respectively in local and crossbreed cows. All the interviewed dairy producers indicated that they wash their hands and 84% wash udder of the cow before milking. Some 40% of the respondents also indicated that they use towel for whipping the teats of milking cows (Figure 5b). Large proportion of respondents (76%) use plastic vessels as milk container. Earthen pots and metallic utensils (Figure 5a) are used respectively by 22% and 2% of the respondents.

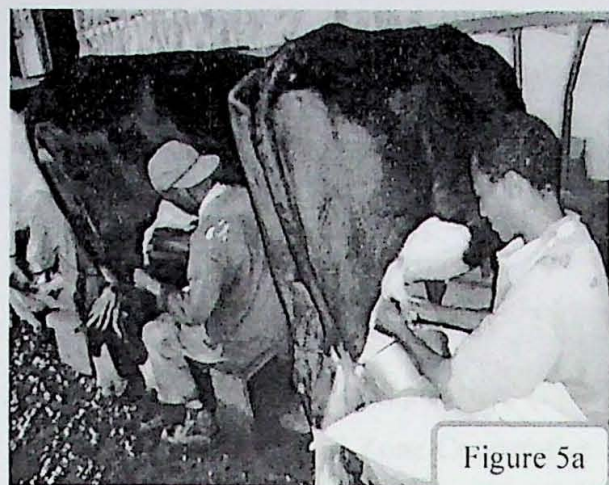


Figure 5a

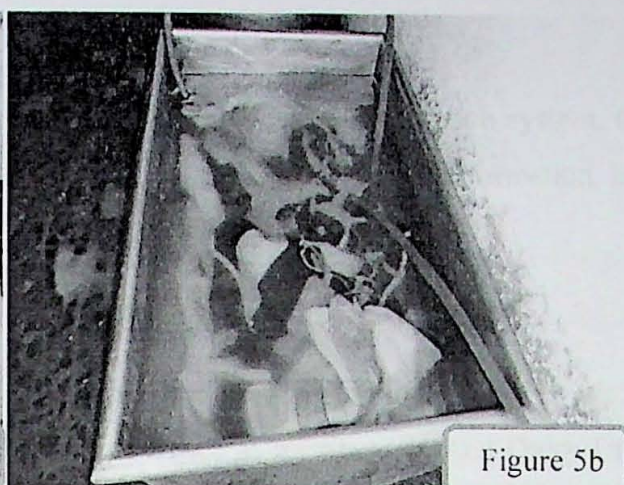


Figure 5b

Figure 5: Milking practice

4.2.7. Animal diseases and access to veterinary services

Dairy producers encounter animal diseases of different origin; parasitic, bacterial, reproductive disorder and miscellaneous causes. The most prevalent animal diseases are parasitic diseases (50%), while Black leg was the second most prevalent disease (26.4%). In the study areas, 7.3% and 10% of the respondents replied as hypocalcaemia and mastitis are common animal diseases, respectively. Moreover, 6.36% of the respondents replied reproductive disorder is also common in their farm.

Out of the total respondents, 75% get access veterinary services either from government or private veterinary clinics while the rest 24.5% didn't get veterinary facility either from government or private. Shortage of experts, lack of adequate transport facility in some parts of the districts and affordability of veterinary drugs and services are some of the reasons mentioned by those households that didn't get veterinary service either from government or private.

4.2.8. Access to extension services

Out of the 220 interviewed dairy producers some 28.6% said that they received limited training on animal husbandry. Thirty three percent of the respondents also mentioned their exposure to extension training on clean milk production.

4.2.9. Record keeping

Record keeping was almost non-existent in rural mixed crop-livestock production system. Only 6% of the urban dairy producers keep some production and reproduction information in an unstructured way on note books.

4.3. Milk processing

All visited primary dairy cooperatives (PDC) have small scale processing units and they are also legally registered at Arsi Zone Cooperative Promotion Office as members of Arsi Dairy Union. All processing units have a cream separator and complementary equipments. They also possess milk churner a basic equipment for milk processing. Overall in terms of basic facilities, all have the minimum required facility for milk processing units. The number of members of dairy producers in each PDC ranged from 11 of Gora Fana to 85 of Lemu Ariya PDC. Out of the total 532 members, 83% are male while the remaining 17% are female (Table 11).

Table 11: Arsi dairy union member primary dairy cooperatives

Name of PDC	Distance from Assela Town (Km)	Number of Members			Organization Supporting	Processing unit
		Male	Female	Total		
Gora Fana	3	11	0	11	Arsi dairy union	Yes
Assela Town	0	47	30	77	Arsi dairy union	Yes
Dosha	5	41	6	47	Arsi dairy union	Yes
Bilalo	12	65	5	70	Arsi dairy union	Yes
Goba Lencha	37	52	3	55	Arsi dairy union	Yes
Lemu Ariya	45	65	20	85	Arsi dairy union	Yes
Lemu Michael	47	58	16	74	Arsi dairy union	Yes
Bekoji	56	77	7	84	Arsi dairy union	Yes
Meraro	66	26	3	29	Arsi dairy union	Yes
Total	-	442	90	532	Arsi dairy union	Yes

4.4. Milk marketing

The dairy producers are involved both on formal and informal milk marketing system (Figure 6). However, more actors are involved in the formal milk marketing channel; milk producer, milk collector, retailers and processors are the main actors' involved before it reaches to the final consumer. However in the case of informal milk marketing channel, the chain is short and there are fewer actors. Out of interviewed dairy producers, 79.1% are involved in informal dairy marketing who sell milk either directly to the consumers (67.7%), retailers (0.50%) or hotels and institutes (10.91%). On the other hand, 20.91% of the respondents supply their milk only to the milk collection centers. Some proportion of milk collected by the milk collection centers is directly sold to urban consumers, cafeterias or institutes while the major share was sold to the milk retailers. Especially of those milk collection centers that are located not more than 12 km from Assela town; Dosha, Bilalo and Assela town PDCs have demand from two milk retailers, Hamres agro-industry and Saron dairy. The demand for milk market is lower during the fasting season for the above three PDCs and irrespective of the season for the rest six PDCs who are members of the Arsi dairy union and as a result higher proportion of milk is processed and butter becomes the main source of income to the cooperative societies.

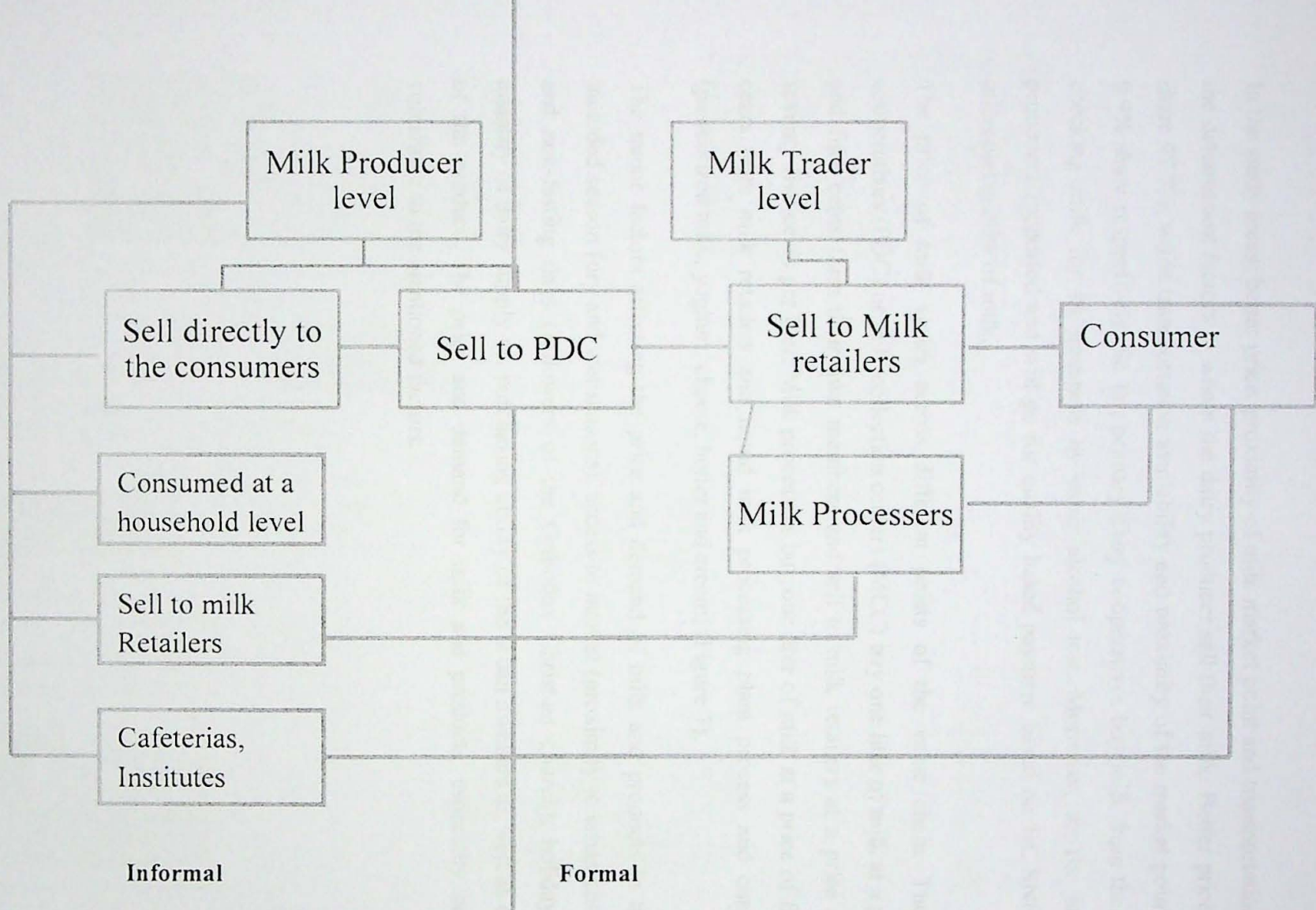


Figure 6: Milk marketing systems in the study areas

In the study areas; better price, proximity of milk market point and transportation availability are the determinant factors to whom the dairy producer sell their milk. Better price takes the major share 97.7%, while transportation availability and proximity of the market point takes 1.4% and 0.9% share respectively. So far, primary dairy cooperatives buy milk from their members after checking milk for its freshness by using alcohol test. Moreover, all the interviewed dairy producers supported and will go for quality based payment based on fat, SNF percentage and microbial quality of milk.

The price of milk varies across different points of the value chain. The primary dairy cooperatives (PDC) or milk collection centers (MCC) buy one liter of milk at a price of four birr and fifty cents from their own members and sell to milk retailers at a price of four birr and seventy five cents per liter. Milk processors buy one liter of milk at a price of five birr and fifty cents from milk retailers and liquid milk processing plant process and change to products (pasteurized milk, yoghurt, cheese, butter and cream) (Figure 7).

The major factors affecting the price and demand of milk and products in the studied areas included season (dry and wet seasons), access to market (proximity to urban consumers), fasting and non-fasting days (followers of the Orthodox Christian church), holidays and festivals, quantity of dairy supply vs. purchasing ability of the urban dwellers as well as quality vs. origin of the product. The price and demand for milk and products, especially butter, are highly vulnerable to the mentioned factors.

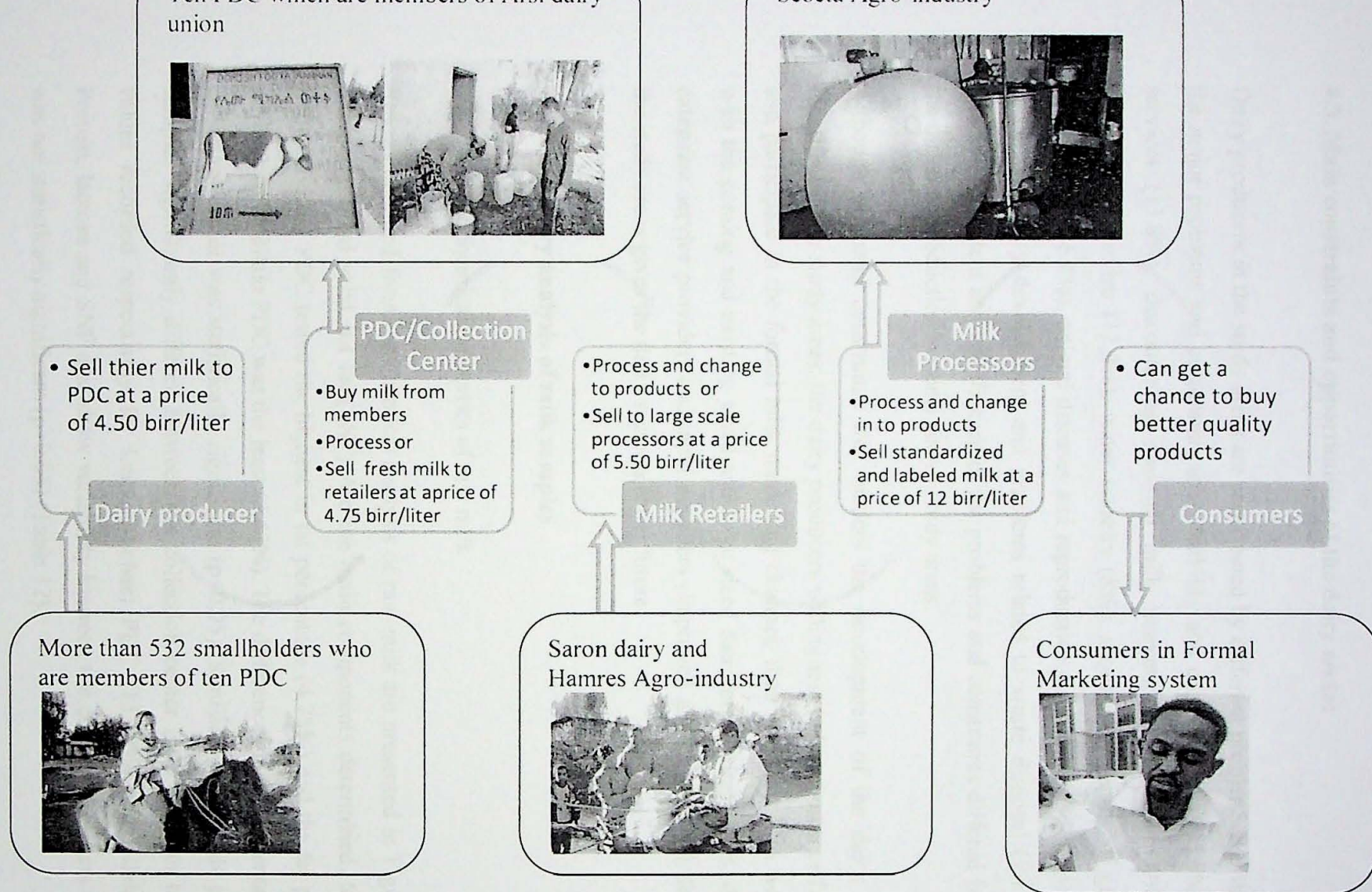


Figure 7: Main actors on formal milk marketing channel and their role in milk transaction

4.5. Main constraints and opportunities of the dairy sector

Dairy producers in the study areas are constrained by different problems and they also prioritized the major problems and constraints as availability and costs of feeds (33.9%), poor veterinary services (13.8%), discouraging seasonal milk marketing systems (13.4%), poor artificial insemination service (12.9%), water scarcity (8%), shortage of supply of genetically superior dairy animals (6.4%), animal diseases and reproductive disorders (5.8%) limitations of land for sustainable dairy development and problems related to waste disposal (for urban producers) (5.8%). The extent and significance of the problems and constraints differed between and within the different production systems and/or study areas.

Although potential constraints that hinders the development of the dairy sector have been identified in the study areas, the dairy producers willingness to be members of dairy cooperatives and participate in the formal milk marketing channel, their willingness to work in cooperation with the coming and existing small and large sized dairy processing plants, the commitment of extension service providers and input suppliers (improved genetic material, feeds, AI, drugs) in the study areas gives the dairy sector a better future.

4.6. Laboratory analysis of milk samples

4.6.1. Physicochemical properties of raw milk

Results obtained from the chemical analysis of raw milk are presented in Figure 8. Fat, protein, lactose, ash and solid not fat (SNF) Are the main components determined. Milk samples from Lemu Michael PDC tested the highest in fat percentage (4.75%) and the fat percentage of milk samples from Bilalo PDC was the least (3.43%). The differences in fat percentage across the milk collection center was statistically significant ($p < 0.05$). Similarly total solids percentage of milk samples significantly differed between the collection center ($p < 0.05$) with highest and lowest values recorded respectively for Lemu Michael PDC (13.19%) and Bilalo PDC (12.03%). Protein, lactose and SNF also show variability between the collection centers but this difference was not statistically significant ($p > 0.05$) (Table 12).

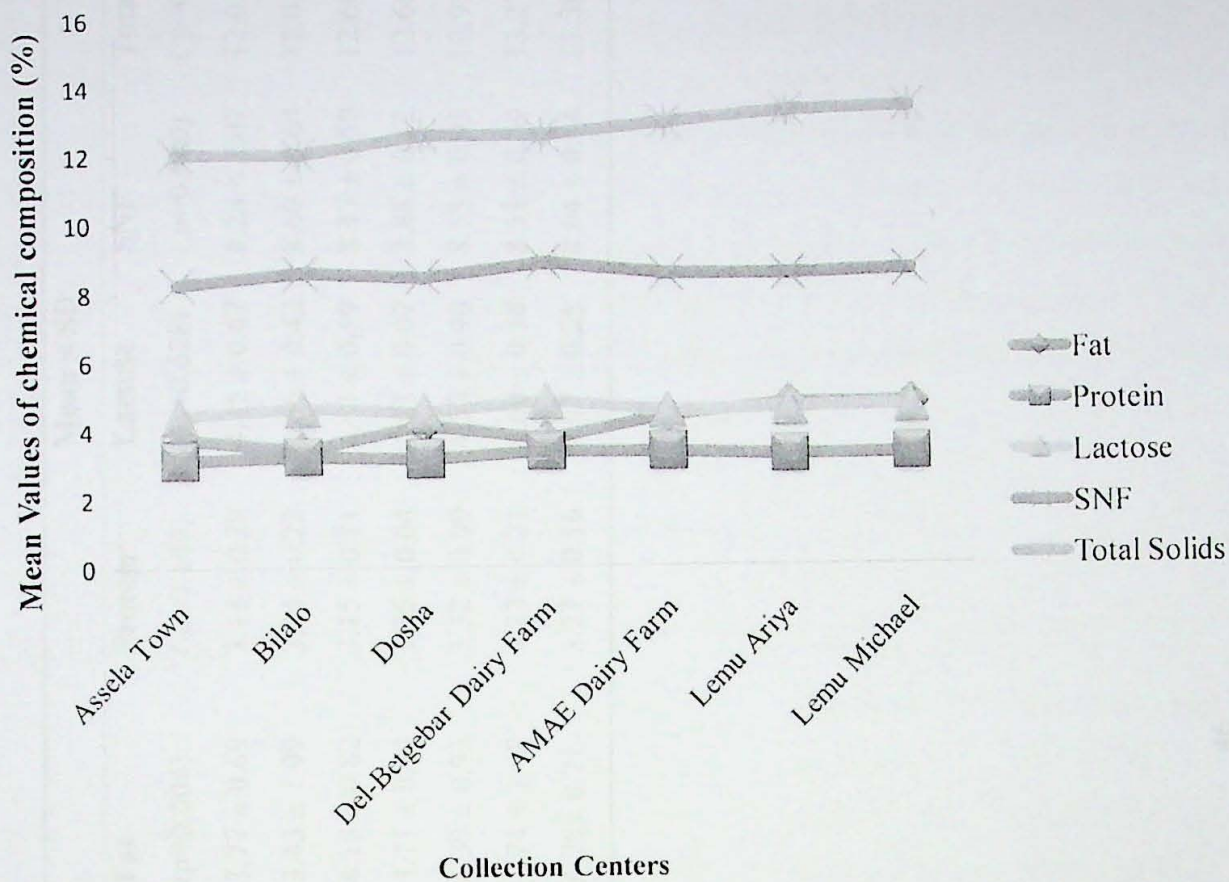


Figure 8: Mean values of chemical composition

Table 12: Mean results of chemical analysis of raw milk

Collection Centers	No. of Observations	Mean $\pm$ SD				
		Fat (p=0.004)	Protein (p=0.104)	Lactose (p=0.628)	SNF (p=0.460)	Total Solids (p=0.035)
Assela Town PDC	22	3.77 $\pm$ 0.69	3.13 $\pm$ 0.39	4.45 $\pm$ 0.67	8.28 $\pm$ 1.07	12.05 $\pm$ 1.64
Bilalo PDC	13	3.43 $\pm$ 1.09	3.24 $\pm$ 0.23	4.66 $\pm$ 0.42	8.60 $\pm$ 0.64	12.03 $\pm$ 1.16
Dosha PDC	13	4.13 $\pm$ 0.82	3.15 $\pm$ 0.11	4.51 $\pm$ 0.59	8.47 $\pm$ 0.50	12.60 $\pm$ 1.05
Dil-Betegbar dairy farm	13	3.71 $\pm$ 0.59	3.35 $\pm$ 0.04	4.83 $\pm$ 0.07	8.88 $\pm$ 0.12	12.60 $\pm$ 0.59
AMAE dairy farm	13	4.39 $\pm$ 0.93	3.32 $\pm$ 0.09	4.53 $\pm$ 0.90	8.55 $\pm$ 0.95	12.95 $\pm$ 1.04
Lemu Arya PDC	13	4.74 $\pm$ 1.48	3.23 $\pm$ 0.21	4.60 $\pm$ 0.38	8.53 $\pm$ 0.59	13.27 $\pm$ 1.28
Lemu Michael PDC	13	4.75 $\pm$ 0.71	3.27 $\pm$ 0.16	4.67 $\pm$ 0.28	8.64 $\pm$ 0.44	13.39 $\pm$ 0.85

Table 12 illustrates the results of analysis of the physical characteristics of raw milk. The difference in milk density from Bilao, Lemu Arya and Lemu Michael PDCs (1.029) to that of Assela Town and Dosha PDCs (1.027) were statistically insignificant ($p>0.05$). Milk samples from Dil-Betegbar dairy farm did not show adulteration at all, while milk samples from other collection centers showed adulteration with water. The highest adulteration percentage was recorded from Assela town PDC (5%). The highest freezing point (-0.48) was recorded from Bilao PDC while the least freezing point was observed from Dil-Betegbar dairy farm (-0.58). However as indicated in Table 13, differences in density, rate of adulteration and freezing point across the collection centers were statistically insignificant ($p>0.05$).

Table 13: Mean results of physical characteristics of raw milk

Collection Centers	No. of observations	Mean $\pm$ SD		
		Density ($p=0.184$)	Added water ($p=0.267$)	Freezing point ($p=0.471$)
Assela Town PDC	22	1.027 ± 004	5.00 ± 11.21	-0.54 ± 0.07
Bilalo PDC	13	1.029 ± 003	2.03 ± 5.17	-0.48 ± 0.32
Dosha PDC	13	1.027 ± 001	1.93 ± 2.36	-0.55 ± 0.02
Dil-Betegbar Dairy Farm	13	1.028 ± 002	0.00 ± 0.00	-0.58 ± 0.09
AMAE Dairy Farm	13	1.028 ± 003	0.15 ± 0.42	-0.57 ± 0.02
Lemu Arya PDC	13	1.029 ± 001	2.34 ± 3.99	-0.56 ± 0.04
Lemu Michael PDC	13	1.029 ± 001	1.34 ± 1.82	-0.56 ± 0.03

4.6.2. Microbiological quality of raw milk

The mean results of total bacterial, coliform and somatic cell counts are presented in Figure 9. Total bacterial counts ranged from 5.82 cfu/ml in Lemu Michael PDC ($3.31 \times 10^6 \pm 4.65 \times 10^6$) to 4.55 cfu/ml in Dosha PDC ($2.03 \times 10^5 \pm 4.21 \times 10^5$). The mean results of milk samples analyzed for coliforms showed highest coliform count from Lemu Ariya PDC (3.19 cfu/ml) or ($5.50 \times 10^3 \pm 5.05 \times 10^3$) and lowest coliforms count from Bilalo PDC (1.96 cfu/ml) or ($1.42 \times 10^2 \pm 2.54 \times 10^2$) and differences in total bacterial and coliform count across the collection centers are

statistically significant ($p < 0.05$). Observed somatic cell count ranged from 4.59 SCC/ml ($1.80 \times 10^5 \pm 2.62 \times 10^5$) in Bilalo PDC to 5.81 SCC/ml ($2.91 \times 10^5 \pm 3.84 \times 10^5$) in Lemu Michael PDC and these differences in somatic cell count across the collection centers was statistically significant ($p < 0.05$) (Table 14).

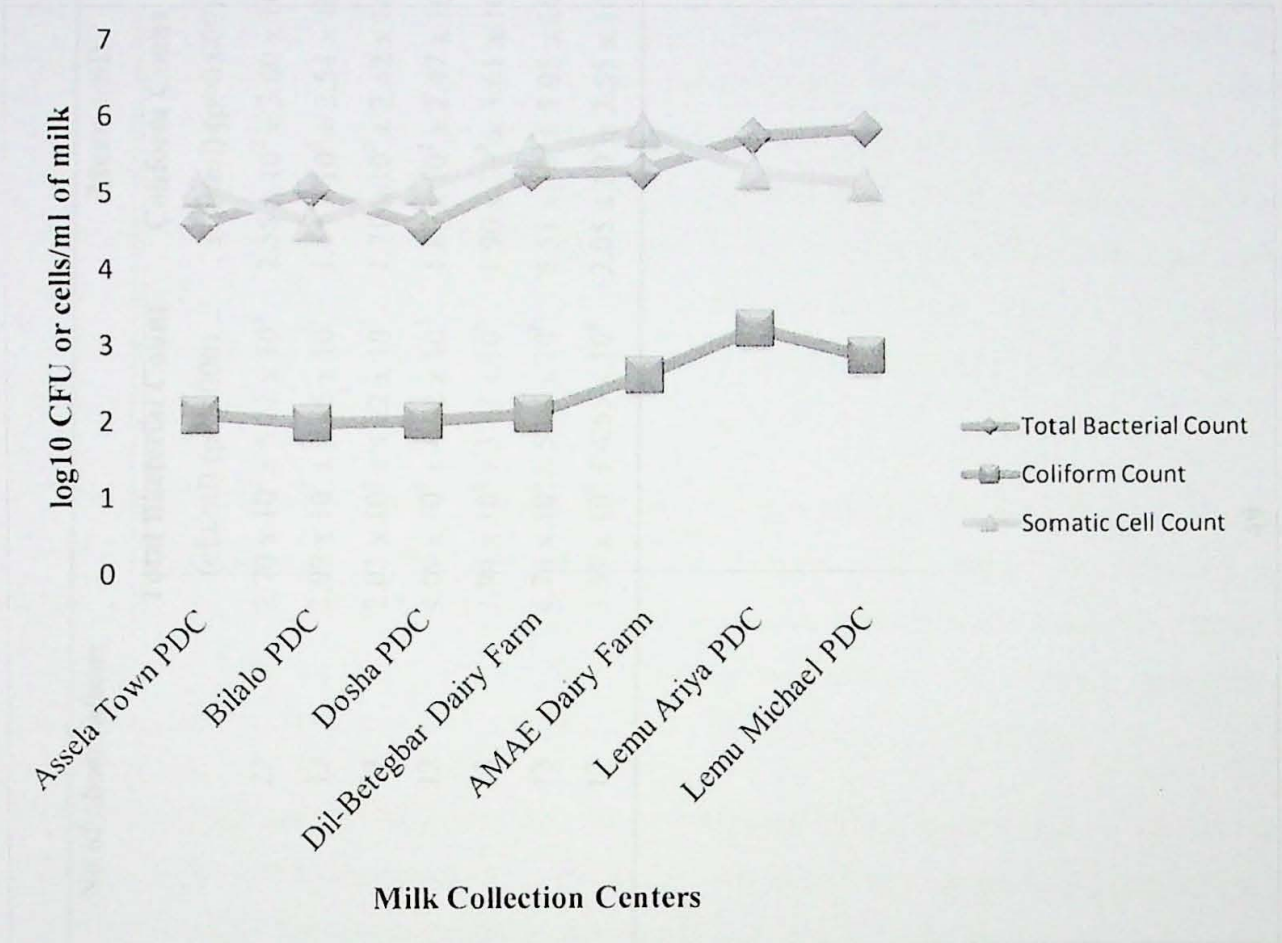


Figure 9: Mean values of total bacterial, coliform and somatic cell count

Table 14: Microbial load and somatic cell count of raw milk

Collection centers	No of observations	Mean $\pm$ SD		
		Total Bacterial Count (cfu/ml) (p=0.000)	Coliform Count (cfu/ml) (p=0.000)	Somatic Cell Count (cells/ml) (p=0.009)
Assela Town PDC	22	$2.70 \times 10^5 \pm 5.31 \times 10^5$	$2.56 \times 10^2 \pm 3.60 \times 10^2$	$4.02 \times 10^5 \pm 5.45 \times 10^5$
Bilalo PDC	13	$2.09 \times 10^5 \pm 3.55 \times 10^5$	$1.64 \times 10^2 \pm 2.54 \times 10^2$	$1.80 \times 10^5 \pm 2.62 \times 10^5$
Dosha PDC	13	$2.03 \times 10^5 \pm 4.22 \times 10^5$	$1.71 \times 10^2 \pm 2.52 \times 10^2$	$4.28 \times 10^5 \pm 3.69 \times 10^5$
Dil-Betegbar dairy farm	13	$4.09 \times 10^5 \pm 4.92 \times 10^5$	$1.83 \times 10^2 \pm 2.47 \times 10^2$	$4.67 \times 10^5 \pm 5.79 \times 10^5$
AMAE dairy farm	13	$1.94 \times 10^6 \pm 3.61 \times 10^6$	$1.90 \times 10^3 \pm 3.61 \times 10^3$	$9.93 \times 10^5 \pm 9.00 \times 10^5$
Lemu Ariya PDC	13	$4.76 \times 10^6 \pm 5.05 \times 10^6$	$5.51 \times 10^3 \pm 5.05 \times 10^3$	$3.91 \times 10^5 \pm 4.35 \times 10^5$
Lemu Michael PDC	13	$3.31 \times 10^6 \pm 4.65 \times 10^6$	$2.05 \times 10^3 \pm 3.55 \times 10^3$	$2.91 \times 10^5 \pm 3.84 \times 10^5$

5. DISCUSSION

In the present study, sex distribution (68.6% males and the rest 31.4% females) is in line with Sintayehu *et al.* (2008) who reported 77% male and 23% female household members. However, the age distribution of respondents (54.5% aged between 41-60 years) is disagreed with the report of Sintayehu *et al.* (2008) who reported, most of the respondents ranged in age between 25 to 40 years (31.5%) and 41 to 50 years (32%). Average per household land size in the present study is fairly larger as compared to the report of Sintayehu *et al.* (2008) who reported 1.97, 0.59, 1.12 and 0.87 hectares of land in Shashemene, Awassa, Dale and Dilla districts respectively. Similarly the mean average family size in the present study is higher as compared to Sintayehu *et al.* (2008) who reported overall mean of family members in urban and rural areas within the age groups of 11 and 25 years was 3.17 and 1.63, respectively and within the range of 25 to 40 years of age was equal to 2.54 and 1.53 respectively.

The average cattle herd size per household in the present study (11.74 ± 4.93) is higher than the reports of Kedija (2007), 5.69 in Mieso district and Sintayehu *et al.* (2008), 3.80 in Sahasemene-Dilla area. The age and particularly sex composition of herd are regulated largely by the main functions of herd (Wilson, 1986). Herd structure can indicate the owner's management objectives, birth or death rate, and herd productivity in the system (ILCA, 1990).

The present study agreed with Sintayehu *et al.* (2008) in which they reported most of respondents (70%) in rural mixed crop-livestock production system and 85% of urban dairy producers, kept their cattle within their own residence compound and in a separate shelter for their animals respectively. Sheltering cattle, not only protects animals from extreme environmental hazards, but also ease some other husbandry practices. Therefore, cow sheds must be designed in such a way that routine activities like feeding, watering, milking, waste management and other activities can be easily and effectively handled. Though this is the principle behind housing, certain factors prohibit farmers to do so (Sintayehu *et al.*, 2008).

The present study is in agreement with Kurtu (2003) who reported 72% of the rural livestock keepers in Harari region make use of natural pasture. On the other hand Kedija (2007) reported 100 % of respondents in Mieso district were fed principally on natural pasture or pasture on non-

arable lands maintained under rain-fed conditions, that it makes green feed available. In line with that of most mixed crop–livestock production systems of Ethiopia, dairy producers in the present study used crop residues as a main feed resource. Crop residues are also the major source of feeds for most African countries as reported by Aregheore and Chimwano (1992) in Zambia; Boitumelo and Mahabile (1992) in Botswana; Ayoola and Ayoade (1992) in Nigeria; and Mdoe *et al.* (1992) in Tanzania. In these systems, annual food crops particularly cereals and root crops are dominant, and crop farming is highly integrated with livestock production, particularly with cattle rearing.

The present study is agreed with the reports of Sintayehu *et al.* (2008) as the majority (45.8%) of the households in the mixed crop–livestock system obtained water from rivers and Kedija (2007) who reported 5% of the respondents used pipe water. On the other hand, Kedija (2007) reported relatively higher number of respondents (74%) used pipe water and lesser number of respondents (18%) used wells as a source of water for their animals. However the availability of these water resources depends on the season and distance from the household. Ruminants require water to maintain their body water content, for metabolism. Availability of water also affects voluntary feed intake (Coppock, 1994).

The present study agreed with Sintayehu *et al.* (2008), who reported 35.6 and 68% of the respondents watered their animals once in wet and dry season, respectively. On the other hand, the present study disagreed with Kedija (2007) who reported almost all the respondents watered their cattle once in a day in wet season and once in two days in dry season and Sintayehu *et al.* (2008) reported 21% of the respondents watered their animals in adlibitum basis. Frequency of watering to dairy animals varies from one production system to another, which is affected by different factors, among which season of the year, accessibility, performance and/or breed of the cow and type of predominant feed and feeding systems are some to be mentioned.

Age at first calving (41.84 ± 6.96 months) in the present study is shorter than the reports of Workneh and Rowland (2004), 47.61 months for agro-pastoral production system, Kedija (2007), 52.49 months in Mieso district, Mulugeta (1990) reported 4-5 years, Coppock (1994), reported 4 to 4.5 years in Borana pastoral system. In addition, the result obtained is also shorter than the report by Kurtu (2003) who reported 52 months from Harar milk shade. However, the result

obtained in the present study agreed with Mukasa-Mugerwa (1989), reported 3.6 year for *Bos indicus* found in a number of traditional systems. AFC from Tiyo district was significantly better than the other four districts and this fact is in line with the report by Mukasa-Mugerwa (1989) who indicated that heritability of age at first calving is generally low, indicating that this trait is highly influenced by environmental factors, feed and health. Age at first calving is more affected by environmental factor than heritability.

Calving interval (17.4 ± 5.5 months) in the present study is higher than the findings of Workneh and Rowland (2004) in which they indicated calving interval of cows in pastoral area of Oromia region was 15.5 months. However, calving interval in the present study agrees to the overall calving interval of cows taken in the region, 18.6 months. Moreover, calving interval in the present study falls within the range of calving interval for Ethiopian zebu cattle (12-22 months) reported by Mukasa-Mugerwa (1989).

Artificial insemination service users (68.6%) in the present study is higher as compared to the report of Sintayehu *et al.* (2008) who reported 10 and 50% of the households in the mixed crop-livestock and urban dairy production system respectively, used AI as a sole source of genetic improvement in Shashemene-Dilla area. However, the result obtained in the present study is lower than the report of Kelay (2002), 75% of households in Addis Ababa used AI as a sole source of genetic improvement. Genetic improvement of cattle does not come free of charge, but once attained it is generally there without the need for further effort (Wiener, 1994). Provision of genetically potential dairy cattle and/or good breeding services as per the demands of producers is one of the prerequisites for the development of dairying in the study areas.

Milk production of 2.56 ± 0.92 liters in local breeds of dairy cattle in the present study is in line with the report of Sintayehu *et al.* (2008), per household milk production ranged from 1.97 to 2.84 liters in rural/mixed crop-livestock system who keeps local dairy cattle. However, milk production of local dairy cattle in the present study is lower than the report of Kedija (2007), an average per household milk production of 2.37 and 4.80 liters in dry and wet season respectively. Similarly, milk production of crossbred dairy cattle in the present study is lower than the report of Sintayehu *et al.* (2008), per household milk production ranged from 10.21 to 15.90 liters in Shashemene-Dilla area. These figures suggest that only those dairy producers, which relatively

keep better performing dairy cows, are able to benefit much more from dairying and provide good service to the community by providing milk to the urban population. Therefore, a comprehensive intervention program has to be in place with respect to genetic improvement, feeds and feeding systems, animal health care and other management aspects for the benefit of all dairy producers in the current study area.

The present study is in line with the report of Kedija (2007); in which she reported animal diseases pose a major threat to cattle production in Mieso district. However, the types and ranking of diseases occurred in the present study is differed from the previous reports.

The findings of the present study showed that, higher number of respondents get veterinary services over the reports of Sintayehu *et al.* (2008) and Kedija (2007) who reported 32.5% of the total respondents and 99% of respondents from rural kebeles of Mieso district have problems in accessing veterinary services respectively. Hence, poor animal health service and lack of improved management are the major constraints for dairy development, resulted in poor performance across the production systems (Ibrahim and Olaloku, 2002).

The present study disagreed with the report of Yitaye (2008), in which he reported more than half (53.5%) of the peri-urban farmers and 16% of urban farmers had attended some form of training on dairy cattle management. Moreover, Sintayehu *et al.* (2008) reported only 35% of the respondents got extension services from the OoARD in Shashemene-Dilla area.

The present study is in line with the previous reports by Getachew *et al.* (1993) and Sintayehu *et al.* (2008), in which milking is predominantly handled by household wives or adult females. Milking in different parts of Ethiopia is primary handled by women, however, there are few exceptions such as the Fogera area of Amhara region where milking is entirely performed by males (Belete, 2006). Households that milked their cows twice per day (early in the morning and late in the afternoon) is higher as compared to the report of Yitaye (2008), in which he reported 83.8% of the farmers milked their cows twice a day, while fewer households (16.2%) milked their cows thrice a day in the North western highlands.

The present study agrees with the report of Alehegne (2004) in which he reported, most farms (85.2%) do not use towels for cleaning purposes of cow's udder. Similarly, Zelalem and Faye

(2006) reported that about 79% of small scale (SS) and 91% of large scale (LS) producers wash the udder of the cow before milking.

The large proportion of respondents using plastic milk utensils corroborates with the reports of Sintayehu *et al.* (2008). Frequency and methods of cleaning of milking utensils and types of material used by the urban dairy producers are better for hygienic milking procedures. Proper milk handling practice is a prerequisite prior to consumption, marketing and/or further processing purposes. Utensils that are used for milking, fermenting, churning, or consumption of milk must be properly cleaned.

In the present study, record keeping is almost non-existent in mixed crop-livestock production system which is in agreement with the reports of Sintayehu *et al.* (2008) in Shashemene-Dilla area. They reported 79 and 94% of the urban and mixed crop-livestock producers, respectively do not keep records. Record keeping in modern dairying is a prerequisite for any decisions and control over certain production and reproduction performance of dairy cattle in the farm and to measure the profit of any market-oriented farms. Despite this principle, record keeping in the area is not practiced most likely due to lack of adequate experience and/or aware of the benefits.

The frequently cited constraints of dairy sector in the present study are in agreement with the reports of Yitaye (2008) and Sintayehu *et al.* (2008) in North western Ethiopian highlands and Shashemene-Dilla area respectively. A limited availability and high costs of feeds in connection with a shortage of farm land, poor access to waste disposal, poor market infrastructure and marketing systems, a lack of improved dairy cows, poor extension, training, artificial insemination and animal health services, a shortage of credit services and a general gap in the knowledge about improved dairy production, processing and marketing systems have been pointed out by different authors as bottle necks for the development of the dairy sector.

Dairying in the studied areas is most likely to develop if major constraints of smallholder dairy producers that encompass feed supply, access to land, good marketing systems, and management problems could be tackled through provisions of veterinary, artificial insemination (AI), credit, extension, and training services at reasonable time and cost. Moreover, as market is the driving force to the production and productivity of dairying, encouraging private investors to establish

dairy processing plants in the area may be an option as a permanent market outlet for both rural and urban dairy producers through an organized milk collection schemes.

In the present study milk processing at a household level agrees with the previous reports by Tschay (2002) in which, processing is usually done by using traditional technology and the products are butter, ghee, *ayib* and sour milk. The majority of dairy producers used traditional churning material and this observation is similar to the case for the central highlands where clay pot churn is mostly used (O'Mahoney and Peter, 1987), whereas it is different from the case of East Wollega where most of women used gourd for churning and storage of milk (Alganesh, 2002).

Moreover, in agreement with the previous report at Borana pastoralist community, all the visited primary dairy cooperatives have small scale processing units. Processing is usually a way to increase the shelf life of milk and changing the milk into different products to take the advantage of lower milk price at times of surplus production.

Formal dairy marketing in the study area is established by producers, few cooperatives, traders and processors and consumers. Similarly, Sintayehu (2003) reported the presence of milk processing plants in Addis Ababa results in emerging formal marketing systems in the Addis Ababa milk shed. In contrast, Nigussie (2006) reported because of the absence milk processing plants, there is no formal milk marketing in Mekelle urban dairy system. The present study also agrees with the report of Kurtu (2003) in which, differences in distance to milk market places in the Harar milk shed affect the price of milk. Milk is transported to towns on foot, by donkey, by horse or by public transport, and commands a higher price there than when sold in the neighborhood (Siegefreid and Berhanu, 1991).

The criteria for selection of selling outlets in the present study agrees with the report of Sintayehu *et al.* (2008), by which proximity and better price takes the major share. In contrary to Sintayehu *et al.* (2008) report on milk pricing, 7.5% of the respondents in Shashemene-Dilla area followed quality based pricing, dairy producers in the present study areas didn't follow quality based pricing yet. However, all the interviewed dairy producers accept the idea and will go for quality based pricing for the future.

In the present study, major factors that determine demand and price of milk is agrees with the previous reports by Yitaye (2008) and IPS (2000), poor infrastructure and poor logistics for collection, transport and sale of milk and milk products coupled with seasonal fluctuation of market prices due to relatively more supply and refrain more people from taking milk and milk products during fasting are observed to form a bottle neck in the further development of the dairy sector. Therefore, under difficult market conditions like these, the processing of dairy products into ghee and Metata Ayib and selling those in times of a greater seasonal demand is a promising option (Yitaye, 2008).

The composition of raw milk in the present study was compared favorably with the composition of milk in Brazil, which contained fat 3.63%, lactose 4.43 % and total solids 12.2% (Lui's *et al.*, 2009) and milk composition reported from Iran by Shojaei and Yadollahi (2008) contained, 2.8% fat, protein 3.1% and 8.3% SNF. The present study also revealed lower mean values for protein (%) than reported by (Lui's *et al.*, 2009). However, fat, lactose and total solids percentages in the present study are lower as compared to the reports of Lingathurai *et al.* (2009), Alganesh (2002) and Samia (2009). The mean results of raw milk freezing point in the present study agrees with those reported by Tetra Pak Processing Systems (2003), Samia (2009) and Elmagli and El Zubeir (2006). On the other hand, density of milk analyzed milk samples agrees with the previous reports by Samia (2009) from Sudan and Shojaei and Yadollahi (2008) from Iran. Types of breed kept, differences in forage and feeding systems, milking frequency, milking method, seasonal changes and lactation period exert effect on the physicochemical parameters of raw milk (Suman *et al.*, 1998).

In most countries where the risk of contamination during milking, transporting, storage etc is low, the TBC of raw milk is also low (Gebrhardt and Nicholes, 1975). It was indicated that the TBC in milk of developed countries falls between 7.5×10^5 to 2×10^5 cfu/ml (Gebrhardt and Nicholes, 1975). The TBC provides an estimate of the total number of aerobic bacteria present in raw milk. TBC does not provide information about specific hygienic failure or the identity of specific microbial groups in the milk; it indicates changes in the production, collection, handling, and storage environment (Chambers, 2002).

The mean total bacterial counts of raw milk in the present study is better than the previous reports by Alganesh (2002), 7.4×10^7 and 2.0×10^7 in two districts of East Wollega, Zelalem and Faye (2006), 8.18 ± 0.23 , 8.34 ± 0.17 and 8.63 ± 0.23 for research center, small and large scale dairy farms in central highlands of Ethiopia. According to the American and European community member states, the acceptable limit for TBC for raw milk are between 2×10^5 and 4×10^5 cfu/ml (APHA, 1992; Heeschen, 1997). However, the mean results of milk samples from Lemu Ariya and Lemu Michael PDC, Dil-Betegbar and AMAE dairy farm shows greater TBC than the upper limit set by American and European community. The higher bacterial count found in the present study agrees with those reported by Mohamed and El Zubier (2007). However, bacterial count of dairy farms and primary dairy cooperatives which exceeded the international standard for raw milk indicated that, the hygienic and sanitary control measures and the health supervision applied in those dairy farms and dairy producer households were not satisfactory. This might be due to either the milk producing animals (intrinsic factor) and/or milkers hygiene are weak or completely lacking (El Zubier *et al.*, 2006).

Moreover, factors that could contribute a lot to the contamination of milk in this study include insufficient pre-milking udder preparation, insufficient cleaning of milkers' hands and milking utensils, use of poor quality and non-boiled water for cleaning of udder, milk equipments and storage containers; additional handling of milk into different plastic containers and sieves may cause higher milk contamination, since as the number of plastic containers and sieves increased the chance of contamination is also increased and most plastic containers have characteristics that make them unsuitable for milk handling. Since plastic containers scratch easily and provide hiding places for bacteria during cleaning and sanitization and plastic containers are poor conductor of heat and hence will hinder effective sanitization by heat (Shalo, 1990); the proximity of milk collection centers to the main roads which would expose milk to contamination by dust particles and lack of cold chain facility from the initial point of production to upon arrival to the milk processing plant.

The mean coliform counts of raw milk in the present study is better than the previous reports by Rai and Dawvedi (1990) from India (7.7×10^5 cfu/ml), Kurwijilla *et al.* (1992) from Tanzania (10^5 cfu/ml), Ombui *et al.* (1995) from Kenya (5×10^4 cfu/ml), Godifay and Molla (2000) from Ethiopia (7×10^4 cfu/ml) and Bonfoh *et al.* (2003) from Mali (10^6 cfu/ml). On the other hand, the

present study showed higher coliform count than the standards set by an American and European community member states, acceptable limit for coliform counts for raw milk, 150 cfu/ml (APHA, 1992; Heesch, 1997), Van Kessel *et al.* (2004), reported 40% of the observed samples had CC between 10 and 100 cfu/ml. mean CC of bulk tank milk has been reported to be 31, 37 and 70 cfu/ml by Boor *et al.* (1998), Rysanek and Babak, (2005) and Jayarao *et al.* (2004) respectively.

Identification and management of farm factors that determine milk contamination with coliforms has the potential for protecting human health and improving the quality of milk and dairy products. The higher coliform could be resulted from, contamination of milk from manure, bedding materials, contaminated water, soil and inadequately cleaned milking utensils (Van den Berg, 1988; Kalogridou-Vassiliadou, 1991). In the study areas, animals are kept in open muddy kraals and unhygienic conditions and possibly exposes milk to high risk of contamination, which in turn increase the coliform count. Coliform count is especially associated with the level of hygiene during production and subsequent handling since they are mainly of faecal origin (Van den Berg, 1988; Omoro *et al.*, 2001).

The mean results of somatic cell count agrees with Lui's *et al.* (2009) who reported SCC of 6.43×10^5 cells/ml from Brazil. Moreover, the present study revealed somatic cell count which is similar to the mastitis diagnostic threshold limit (6.50×10^5 cells/ml) of Kenyan dairy herds (Omoro *et al.*, 1999). This may explain the high background SCC content observed in the present study.

Major determinants of the hygienic quality of milk are the concentrations of somatic cells and microorganisms (Heesch, 1997). Practices, which are considered advisable before each milking are forestripping, and udder and teat cleaning. Forestripping is recommended due to the fact that prior to milking, the highest concentration of somatic cells and microorganisms is in the milk of the teat cistern (Harmon, 1994). Thus, the removal of this milk results in significant reduction in the counts of these elements in the milked milk.

In cooperative societies' case, smallholders keep their dairy cattle in freestalls which is reported better milk quality than herds or dairy farms housed in stallbarns. Herds housed in freestalls reported less bulk milk SCC, greater milk yield, tended to have lower estimated incidence of clinical mastitis, and had less prevalence of subclinical mastitis. Many studies have reported the

relationship between selected management practices and bulk milk SCC (Fenlon *et al.*, 1995; Wilson *et al.*, 1997; Barkema *et al.*, 1998).

A positive association between SCC and CC was observed in AMAE dairy farm, which has been consistently reported in previous studies (Goldberg *et al.*, 1991; Jayarao *et al.*, 2004; Rysanek and Babak, 2005; Pantoja *et al.*, 2009) and suggests that milking of mastitic cows can increase CC. Theoretically, it is possible for a single infected cow to cause an increased bulk tank milk CC. Mammary glands experimentally infected with *Escherichia coli* have been demonstrated to shed as many as 10^5 to 10^8 cfu/ml during short periods (Erskine and Bartlett, 1993; Van Werven *et al.*, 1997).

Based on the above report and following information, the following are recommended:

- Dairy producers should be supported through services related to feed supply, milking machine, veterinary, AI and other extension services.
- Appropriate dairy extension should be given at all stages from production to consumption.
- Establishing milk chilling center and subsidizing the cost taken for milk collection from the members of the FDC will help in improving the quality of milk.
- Training to about milk production and general husbandry practices should be given to the dairy producers.
- Extension programmes to be conducted at primary dairy cooperative and private dairies to participate in dairy processing in the area.
- Quality based payment should be introduced based on composition and standard quality of milk.
- Further investigation is recommended to identify possible source of bacteria found in the samples to their producers that have higher levels of SCC.

6. CONCLUSION AND RECOMMENDATIONS

The difference in production system, types of breeds and management conditions, reproductive and productive performance of dairy cattle and constraints of the dairy subsector were highly variable in the study areas. Contribution of milk production and marketing depends largely on assured supply of accompanying inputs such as feed, veterinary services, improved milk marketing facilities and availability of extension services. As a result of the absence of large scale dairy processing plant in the area, informal milk marketing is the predominant marketing system. The sanitary measures taken at the smallholder level and different stages in the milk supply chain were generally unsatisfactory and cause deterioration and contamination of the products. For rural dairy cooperative societies, milk transported for long distance before it reaches to milk collection center has negative impact in the quality of milk. Moreover, milk chilling center is not available anywhere in the present study area. Though there is high variability in milk microbial and compositional qualities among and within different collection centers and dairy farms, quality based payment is yet not practiced.

Based on the above facts, the following recommendations are forwarded:

- Dairy producers should be supported through services related to feed supply, marketing systems, veterinary, AI and other extension services.
- Adequate sanitary measures should be taken at all stages from production to consumption (from farm to table).
- Establishing milk chilling center and minimizing the time taken for milk collection from each members of the PDC will help in improving the quality of milk.
- Training on clean milk production and general husbandry practices should be given to the dairy producers.
- Encourage smallholders to be members of primary dairy cooperatives and private investors to participate in dairy processing in the area.
- Quality based payment should be introduced based on compositional and microbial quality of milk.
- Further investigation is recommended to identify contaminants at species level by giving due attention to those pathogens that have human health hazard.

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8. ANNEXES

Annex 1. Questionnaire format used

Part I. General information

1. Name of the kebele:
2. Name of the village:
3. Name of the milk cooperative
4. Membership ID:
5. Farm owner's sex: _____ age: _____
6. Number of farm family members: total _____ adults _____ children _____

Sex	Number under age group (years)				
	< 5	6 – 10	11 – 15	16 – 65	> 65
Male					
Female					

7. Religion
 - a. Orthodox
 - b. Catholic
 - c. Protestant
 - d. Muslim
 - e. other _____
8. Land holding (ha):
9. Experience in dairy farming (in years):
10. Is agriculture your fulltime activity? a. yes b. no
11. Do you have someone to follow up the farm when you retire? a. yes b. no
12. Indicate the reasons why you produce milk?
 - a. For sale and household consumption
 - b. For household consumption only
 - c. For sale only

Part II. Dairy farm management

13. Dairy herd structure

Category	Local	Crossbred	Total
Bull calf (<6 mo)			
Heifer calf (<6 mo)			
Heifers (6 to 18 mo)			
In-calf heifer (>18 mo)			
Milking cows			
Dry cows			
Bulls			
Oxen			
Total			

14. What kind of feeding system do you use? a. Grazing b. In door feeding

15. Are you willing /able to invest in more animal feed in order to increase the quality and quantity of your milk? Yes/ no , why _____

16. Which of the following feed types do you use to feed your dairy animals?

- a. Stover b. Mineral block c. Bran d. Oil-seed-cakes e. Hay
f. Local brewer's yeast g. crop residue e. other _____

17. What is your water source for your dairy cattle?

- a. Wells
b. River
c. Tap water

18. How often do you give water to your dairy animals?

19. What is the age at first calving at your farm (months)?

20. What is the calving interval at your farm (months)?

21. What is the annual mortality rate at your farm?

22. Which animal diseases do you often encounter?

- d. Black leg
- e. Anthrax
- f. Parasites
- g. Rabies
- h. TB
- i. Brucellosis
- j. Mastitis
- k. Other _____

23. Do you have access to veterinary service? a. yes b. no

24. If yes, who provides the service? a. cooperative b. government c. private

25. Do you have to pay for the veterinary service? a. yes b. no

26. Where do you buy vet drugs? a. cooperative b. government c. private

27. Do you have access to AI service? a. yes b. no

28. If your answer for question number 27 is yes, who provides the service?

- a. cooperative
- b. government
- c. private

29. If your answer for question number 27 is no, what do you think the limiting factors and what should be done to improve the AI service?

30. Do you want to replace your local cows with crossbreds? a. yes b. no

31. If yes, how do you intend to do this?

Part III. Milk Production

32. How often do you milk your local cows? a. Once b. twice

33. How often do you milk your crossbred cows? a. Once b. twice

34. What is the average daily milk production of your local cow?

35. What is the average daily milk production of your crossbred cow?

36. Which family member is involved in the dairy farm work?

- | | | | |
|---------------|-------|---------|----------|
| a. Milking | males | females | children |
| b. Feeding | males | females | children |
| c. Processing | males | females | children |
| d. Marketing | males | females | children |
| e. Herding | males | females | children |

f. Other males females children

37. Can the family members mentioned above read?

g. Males a. Yes b. no

h. Females a. Yes b. no

i. Children a. Yes b. no

Part IV. Milk quality issues

38. Did you receive training on clean milk production? a. Yes b. no

39. If yes, who provided the training?

a. Government b. NGO c. Cooperative

40. Have you implemented what you learned? a. Yes b. no

41. Do you wash your hands before milking? a. Yes b. no

42. Do you wash the udder of the cow before milking? a. Yes b. no

43. Do you use towel to clean the udder? a. Yes b. no

44. Where do you milk your cows? a. indoor b. outdoor

45. What is your milking vessel made of? a. plastic b. metal c. traditional

46. How many times per day do you deliver milk to the MCC? _____

47. If you deliver milk once-a-day, how do you take the AM and PM milk? a.

mixed b. separately c. PM only d. AM only

48. Do you encounter milk rejection due to inferior quality milk? a. Yes b. no

49. If yes, how often in a month?

b. During the dry season _____

c. During the wet season _____

d. During fasting season _____

e. During non-fasting season _____

50. Did you receive training on dairy animal husbandry? a. Yes b. no

51. If yes, who provided the training?

a. Government b. NGO c. Cooperative

Part V. Market

52. Milk utilization

Purpose of milk	Seasons			
	Dry	Wet	Fasting	Non-fasting
Household consumption (processing)				
Market				
Other				

53. Do you sell milk to buyers other than the cooperative? a. Yes b. no

54. If your answer for question number 52 is yes, to which group do you sell?

- a. Directly to consumers
- b. To retailers/private milk collectors
- c. To hotels/shops/institutions
- d. Other routes

55. In deciding for whom to sell your milk, what factors do you consider?

- a. Price b. closeness in distance c. transportation availability
- d. other

56. Milk price

Product	Seasonal price			
	Dry	Wet	Fasting	Non-fasting
Milk (per liter)				

57. Do you sell other products than dairy at the market or other outlets?

- a. Yes b. no

58. If yes, what proportion of your income does dairying constitute?

59. Quality based payment means that you will get a higher price if your milk meets certain standards like fat content and freshness. What do you think of it?

60. How far is your home from the following places (in km/minutes on foot)?

- a. Market b. Water source c. MCC d. Nearest all-weather road

General questions

Part VI. General questions

1. Mention the main problems in dairy production and marketing activities.
2. What should be done to solve these problems?

Annex 2: Medias used for bacterial culture

1. Plate count agar (for total bacterial count), 500g (HIMEDIA, India)

Preparation:

- ❖ Dissolve 17.5 g in 1000 ml distilled water.
- ❖ Heat to boiling to the medium completely.
- ❖ Sterilize by autoclaving at 15lbs pressure (121°C) for 15 minutes.

Standard formula

Ingredients	Composition (g/l)
1. Casein enzymatic hydrolysate	5.0
2. Yeast extract	2.5
3. Dextrose	1.0
4. Agar	9.0

Finally pH (at 25°C), 7.0 ± 0.2

2. Violet red bile dextrose agar (VRBD agar), 500 g (for coliform counts) (HIMEDIA, India)

Preparation:

- ❖ Dissolve 41.53 g in 1000 ml distilled water.
- ❖ Heat to boiling to the medium completely.
- ❖ Cool to 45°C and immediately pour into sterile petriplates containing the inoculum.
- ❖ If desired autoclaving at 15lbs pressure (121°C) for minutes.

Standard formula

Ingredients	Composition (g/l)
5. Peptic digest of animal tissue	7.0
6. Yeast extract	3.0
7. Lactose	10.0
8. Bile salts mixture	1.5
9. Sodium chloride	5.0
10. Neutral red	0.03
11. Crystal violet	0.002
12. Agar	15.0

Finally pH (at 25⁰C), 7.4 ± 0.2

Annex 3. Field and Laboratory Work in Picture



Data collection/surveying



Discussion with community Elders



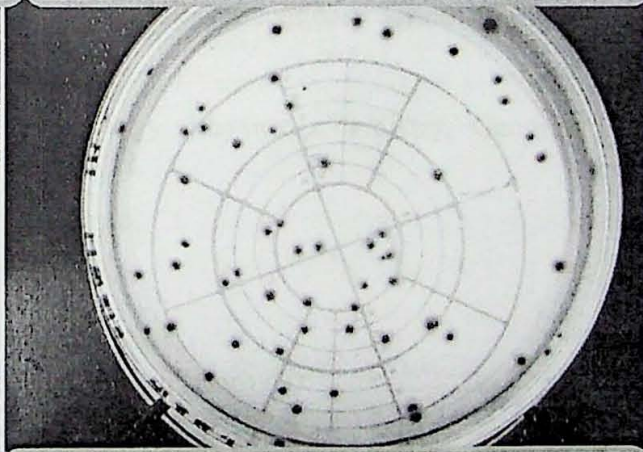
Milk Sample collection from PDC



Direct microscopic SCC in Lab.



Culturing of milk samples



Cultured plates after 48 hours

9. European Standard

Curriculum Vitae



PERSONAL INFORMATION

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Telephone	+251-911-532833
Fax	+251-344-409304
E-mail	fishomarshet@yahoo.com.au
Nationality	Ethiopian
Date of birth	23, February, 1984

EDUCATION AND TRAINING

Dates (from – to)

- Name and type of organization providing education and training

- Principal subjects/occupational skills covered

- Title of qualification awarded

September 1990 to June 1995

Abyot Godana Elementary School (Dangila)

English, Mathematics, Science and Geography

Certificate

Dates (from – to)

- Name and type of organization providing education and training

- Principal subjects/occupational skills covered

- Title of qualification awarded

September 1996 to June 1997

Biteweded Mengesha Jembere Junior Secondary School (Dangila)

English, Mathematics, Biology, Physics, Chemistry, Geography and History

Certificate

Dates (from – to)

- Name and type of organization providing education and training

- Principal subjects/occupational skills covered

September 1998 to August 2001

Dangila Senior Secondary School (Dangila)

English, Mathematics, Biology, Physics and Chemistry

• Title of qualification awarded	High School Diploma
• Level in national classification	Ethiopian School Leaving Certificate Examination (ESLCE)
Dates (from – to)	September to June 2002
• Name and type of organization providing education and training	Addis Ababa University, Faculty of Science, Addis Ababa
• Principal subjects/occupational skills covered	Freshman Courses
Dates (from – to)	September 2003 to August 2007
• Name and type of organization providing education and training	Addis Ababa University, Faculty of Veterinary Medicine
• Principal subjects/occupational skills covered	Pre-Medicine Courses: Anatomy, Embriology, Histology, Physiology, Microbiology, Parasitology and Pathology. Medical Courses: Surgery, Small and Large animal Medicine and Obstetrics and Gynecology, Veterinary Public Health, Veterinary Pharmacology and Epidemiology. Animal Production Courses: Animal Breeding and Genetics, Dairy and Beef Production, Apiculture, Fisheries and Aquaculture and Sheep, Goat and Camel Production.
• Title of qualification awarded	Doctor of Veterinary Medicine (DVM)
Papers Produced	In 2006: - A review on viral diagnostic techniques. In 2007: - Seroprevalence study of bovine brucellosis and reproductive and production performance of dairy cows in the breeding stock of the National Artificial Insemination Center, Ethiopia.
Dates (from – to)	September 2009 to July 2011
• Name and type of organization providing education and training	Addis Ababa University, School of Graduate Studies
• Principal subjects/occupational skills covered	Research Methods and Applied Statistics, Tropical Animal Production, Biotechnology in Animal Production, Food Animal Management, Animal Products Processing and Marketing, Food Animal Health and International Trade in Livestock Products.
Title of qualification awarded	MSc in Tropical Animal Production and Health (MSc)

• Research area	Dairy Microbiology
• Research title	Assessment of Major Skin Diseases of Ruminants in Alamata District, Ethiopia
• Research area	Epidemiology and Medicine
• Research title	A Cross-sectional Study of Goat Mange in Tanqua Abergelle District, Ethiopia.
• Research area	Epidemiology and Medicine
Dates (From-to)	From September 2010 to May 2011
• Research title	Assessment of Milk Supply Chain and Evaluation of Physicochemical Characteristics and Microbial Load of Raw Milk in Selected Districts of Arsi Zone, Ethiopia.
• Research area	Dairy Microbiology
LANGUAGES	
MOTHER TONGUE	AMHARIC
OTHER LANGUAGES	ENGLISH
• Reading skills	VERY GOOD
• Writing skills	VERY GOOD
• Verbal skills	VERY GOOD
SOCIAL SKILLS AND COMPETENCES	I am very sociable, open minded who like sharing ideas with every person.
TECHNICAL SKILLS AND COMPETENCES	Basic computer skills
ARTISTIC SKILLS AND COMPETENCES	Music, Dancing and Writing Short Stories
DRIVING LICENSE	Yes
TECHNICAL PAPERS PRODUCED	
2005/06	A Review on Viral Diagnostics
2007/08	A Review on Trypanosomiasis A Review on Diagnostic Approaches for Bacterial Pathogens A Review on Hemorrhagic Septicemia
2008/09	A Review on Organ Transplantation and Graft Rejection A Review on Amino Acids and their Biological Use
2009/10	A Review on Camel Milk Production: Yield and Bioactive Components

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10. SIGNED DECLARATION SHEET

“I the undersigned declare that, the thesis is my original work and has not been presented for a degree in any other University and that all sources of materials used for the thesis have been duly acknowledged”

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Signature _____

Date of submission 20/06/2011

This thesis has been submitted for examination with our approval as University advisors

Research Advisors

Mekonnen Hailemariam
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