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**Characterization of Dairy Cattle Husbandry Practice and Performance  
under Smallholder Systems and Analysis of Milk Value Chain and  
Quality in Bishoftu and Akaki Towns, Oromia Regional State, Ethiopia**

**PhD Dissertation**

**By**

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PhD Program in Animal Production

**IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF  
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**April, 2017  
Bishoftu, Ethiopia**

**CHARACTERIZATION OF DAIRY CATTLE HUSBANDRY PRACTICE AND  
PERFORMANCE UNDER SMALLHOLDER SYSTEMS AND ANALYSIS OF  
MILK VALUE CHAIN AND QUALITY IN BISHOFTU AND AKAKI TOWNS,  
OROMIA REGIONAL STATE, ETHIOPIA**

A dissertation submitted to the College of Veterinary Medicine and  
Agriculture of Addis Ababa University for the fulfillment of the  
requirements for the degree of Doctor of Philosophy in Animal Production

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## **DEDICATION**

This dissertation is dedicated to my father Genzebu Weldegebriel and my mother Abeba Gebreyohannes, for nursing me with affection and love and for their committed partnership in the success of my life.

## STATEMENT OF AUTHOR

First, I declare that this dissertation is my bonafide work and that all sources of materials used for this dissertation have been duly acknowledged. This dissertation has been submitted in partial fulfillment of the requirements for a PhD degree at the Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University Library to be made available to borrowers under rules of the Library. I solemnly declare that this dissertation is not submitted to any other academic institution anywhere for the award of any academic degree, diploma or certificate.

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## ABBREVIATIONS

AFC	Age at First Calving
AGP	Agricultural Growth Project
AI	Artificial Insemination
APHA	American Public Health Association
ANOVA	Analysis of Variances
AOAC	Association of Official Analytical Chemists
BoARD	Bureau of agriculture and Rural development
Cfu	Colony forming units
CI	Calving Interval
CSA	Central Statistics Authority
DM	Dry matter
DDA	Dairy Development Authority
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross domestic product
pH	Hydrogen ion concentration
IDF	International Dairy Federation
IFCN	International Farm Comparison Network
IGAD	Inter Governmental Authority on Development
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Success of Ethiopian farmers' project
LPC	Laboratory Pasteurization Count
LPI	Livestock policy initiative
MAP	Modified Atmosphere Packaging
MCC	Milk collecting
MoA	Ministry of Agriculture
MP	Milk producer
MPP	Milk Processing Plant
NAIC	National Artificial Insemination Center
PI	Preliminary Incubation Count
SCC	Somatic cell count
SNF	Solids-Not-Fat
SNV	Netherlands Development Organization
SPC	Standard Plate Count
SPSS	Statistical Package for Social Sciences
TBC	Total bacteria count
TCC	Total coliform count
TNTC	Too Numerous to Count
TS	Total solid
UHT	Ultra high temperature
USD	US Dollar
VRBA	Violet Red Bile Agar

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**CHARACTERIZATION OF DAIRY CATTLE HUSBANDRY PRACTICE AND PERFORMANCE UNDER SMALLHOLDER SYSTEMS AND ANALYSIS OF MILK VALUE CHAIN AND QUALITY IN BISHOFTU AND AKAKI TOWNS, OROMIA REGIONAL STATE, ETHIOPIA**

Dessalegn Genzebu

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**ABSTRACT**

*The study was conducted from March, 2014 to June, 2016 in Bishoftu and Akaki town's smallholder dairy farms to investigate the dairy cattle performance, husbandry practice, milk value chain, raw milk quality and major constraints. Totally, 130 randomly selected smallholder farmers from two towns were included in the study. Data were collected through questionnaire, observation, focused group discussion and milk quality analysis. Statistical Package for Social Sciences was used to analyze the data. About 74.6% of the respondents used stall feeding and 25.4% stall feeding with limited grazing. Major sources of feeds were natural pasture, crop residue, conserved hay, industrial byproducts and forages. The housing system was permanent enclosure with roofed kraal. For calf feeding, 68.8% of farmers used bucket feeding, 24.2% used partial suckling and 7% used both methods. Shortage of feed (52.3%), inadequate water supply (20.8%), space limitation (4.6%) and diseases (2.3%) were identified as major constraints in both Bishoftu and Akaki smallholder dairy farms. The mean of age at first service, age at first calving, calving interval, daily milk yield, total lactation milk yield and lactation length was  $18.7\pm 3.7$  months,  $27.0\pm 3.7$  months,  $13.0\pm 2.1$  months, and  $11.6\pm 3.1$  liters per d/cow,  $3208.56\pm 108.81$  litres and  $276.6\pm 35.1$  days, respectively in Bishoftu. The mean of age at first service, age at first calving, calving interval, daily milk yield, total lactation milk yield and lactation length was  $18.7\pm 3.5$  months,  $26.9\pm 5.4$  months,  $13.8\pm 1.9$  months and  $10.8\pm 2.4$  liters per d/cow,  $3031.56\pm 46.32$  litres and  $280.7\pm 19.3$  days, respectively in*

*Akaki town. Overall mean of raw milk quality for pH, freezing point, density, added water, acidity, fat, protein, SNF, total solid, lactose and ash contents were  $6.66\pm 0.04$ ,  $0.55\pm 0.03$ ,  $1.028\pm 0.002$ ,  $2.80\pm 3.60$ ,  $0.176\pm 0.01$ ,  $3.60\pm 0.53$ ,  $3.27\pm 0.15$ ,  $7.78\pm 0.41$ ,  $11.38\pm 0.78$ ,  $3.93\pm 0.25$  and  $0.62\pm 0.05$ , respectively in the value chain points. The quality of raw milk obtained from the study areas were significantly different ( $P < 0.05$ ) except fat and lactose. Total bacteria count/ml of raw milk from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were  $7.01\pm 1.02 \log_{10}$  cfu/ml,  $7.50\pm 0.51 \log_{10}$  cfu/ml, and  $8.16\pm 0.68 \log_{10}$  cfu/ml, respectively and it was statistically different ( $P < 0.05$ ). The coliform counts/ml of raw milk found from MP, MC and MPP were  $5.66\pm 1.71$ ,  $6.81\pm 0.81$  and  $6.75\pm 0.96 \log_{10}$  cfu/ml, respectively. The somatic cell count found from MP, MC and MPP were  $4.90\pm 2.04$ ,  $5.64\pm 0.57$  and  $5.71\pm 0.55 \log_{10}$  sc/ml, respectively. Acidity percentage from MP, MC and MPP were  $0.176\pm 0.02$ ,  $0.175\pm 0.01$  and  $0.175\pm 0.01$ , respectively. Value chain actors identified include input suppliers, producers, milk collectors, processors and consumers. About 48.5% farmers deliver their milk to collection centers, 13.1% to hotels, restaurants and cafes, and 12.3% to processing plants, 11.5% to retail shops, (12.3%) neighborhood customers and (2.3%) consume at home. Low milk price, lack of access to adequate markets and lack of infrastructures hindered them from channeling their milk. It can be concluded from this study that crossbred dairy cattle kept by smallholder farmers in Bishoftu and Akaki towns contributes to the household welfare in terms of income generation. To reach a conclusive dairy husbandry practices, value chain and quality analysis estimates, it is recommended to conduct research in multidisciplinary and controlled experiments.*

**Key words:** Dairy cattle, production systems, smallholder farmers, milk value chain, milk quality

## 1. INTRODUCTION

Globally, the livestock sector accounts for 40 percent of agricultural gross domestic product (GDP), employs 1.3 billion people and creates livelihoods for one billion of the world's poor (FAO, 2006). Livestock products provide one-third of humanity's protein intake. The cow is a highly efficient 'food processor' converting grass into healthy nutritious food for humans (milk and meat). Without livestock, the millions of hectares of the grasslands in the world could not be used to cultivate crops for human consumption. Growing populations and incomes, along with changing food preferences, are rapidly increasing the demand for livestock products. In 2050 worldwide production of dairy is projected to increase to more than double from 580 to 1043 million tons (FAO, 2006).

Livestock plays vital roles in generating income, creating job opportunities, ensuring food security, providing services, contributing to asset, social, cultural and environmental values, and sustain livelihoods throughout the world (Udo *et al.*, 2011) and among the livestock subsectors, dairying is an important source of livelihood, and as a result, significant attention is being given to this subsector. Enhancement of the role of dairy production to livelihood could be achieved through intensification of smallholder dairying in developing countries. Smallholder dairying is the dominant dairy production system in much of sub-Saharan Africa. The smallholder dairying contributes about 16.5% of the national Gross Domestic Product (GDP) and 35.6% of the agricultural GDP (Metaferia *et al.*, 2011). It also contributes 15% of export earnings and 30% of agricultural employment (Behnke, 2010).

Livestock plays a central role in sustaining the livelihoods of millions of resource-poor farmers in diverse environments, ranging from pastoral and agro-pastoral systems of the lowlands to mixed farming systems of the highlands (Belete *et al.*, 2010). The livestock subsector currently support and sustain livelihoods for 80% of all rural population. The GDP of livestock related activities valued at Birr 59 billion (Metaferia *et al.*, 2011). The crop/livestock mixed production system is also characterized by some perennial milk production by dairy cows kept for multipurpose use, and feed production, utilization and

limited grazing land and crop residues play important multiple roles (Ayza *et al.*, 2013). Dairy products such as milk, butter and cottage cheese are produced and used as source of income to buy farm inputs and family needs while cattle are an asset securing farmers at the time of emergency (Ayza *et al.*, 2013).

Smallholder dairying is practised to produce milk for feeding the family and for sale, to produce manure to support crop production and to provide dairy animals for insurance and financing emergency cash needs and for social status (Chinogaramombe *et al.*, 2008). Smallholder dairy farming contributes to diversification of income and employment and spread farming risks. It also creates opportunity to make efficient use of local resources such as crop residues (Ngongoni *et al.*, 2006; Martínez-García *et al.*, 2013).

The increased demand for milk and milk products, mainly driven by rapid population growth, growing urbanization and rise in absolute income, creates significant market opportunity for the dairy farmers to increase income and improve their livelihoods (Uddin *et al.*, 2010). Ethiopia has the largest livestock population in Africa. The total cattle population of the country was estimated to be about 57million (CSA, 2015). Out of this total cattle population, the female cattle constitute about 55.38% and the remaining 44.62% were male cattle. On the other hand, 98.71% of the total cattle populations in the country were local breeds and remaining are hybrid and exotic breeds that accounted for about 0.94 percent and 0.11 percent, respectively (Mulugojjam and Aleme, 2015).

Cows are common sources of milk (83%) in Ethiopia and remaining 17% comes from camels and goats (USAID, 2010). In the country households consume 82.9% of the milk collected (produced), 10% of the milk is processed into products with longer shelf life, 6.61% is sold and 0.43% used for wages (CSA, 2009). Cattle are used for various purposes including milk and meat production, draught power and manure. The dairy production depends mainly on indigenous cattle genetic resources. The large cattle population; the favorable climate for improved high-yielding cattle breeds, and the

relatively animal disease-free environment make Ethiopia to hold a substantial potential for dairy development (Zelalem, 2012).

Despite the aforementioned attractive potential for the dairy sub-sector in Ethiopia, productivity of indigenous livestock genetic resources in general is low thereby, impeding its direct contribution towards national economy. Ethiopia produces approximately 3.07 billion litres from 16 million milking cows an average of 1.318 litres per cow per day over a lactation period of 180 days (Mulugojjam and Aleme, 2015), and the per capita milk consumption is only about 19 kg/year, which is 181 liters below the recommended 200 liters (DDA, 2011) and this is also much lower than African and world per capita average of 40 kg/year and 105 kg/year, respectively (AGP, 2013). Combinations of cultural and economic factors are main reasons of the low consumption level. Further, the annual rate of increase in milk yield (estimated to be 1.2%) lags behind the increment in human population (estimated to be about 2.7% per annum) (CSA, 2008). Dairy production has created an estimated 588,000 full-time on-farm jobs. However, Ethiopia is a net importer of dairy products with import values significantly exceeding export values. In five reference years, for instance, export values increased from about 73000 USD in 2005 to 123000 USD in 2009, while import values increased from about 5.6 million USD in 2005 to about 10.3 million USD in 2009 (a 4.7 million USD increment) (CSA, 2010).

Various authors indicated that lack of appropriate technology, training and finance services constrained to smallholder dairy farming in Eastern and Southern African countries (Chagunda *et al.*, 2006; Nkya *et al.*, 2007; Mekonnen *et al.*, 2010; McDermott *et al.*, 2010). In addition, dairy farmers are faced with major challenges, including livestock diseases, seasonal fluctuation in the quality and quantity of feed and water, low genetic potential for milk production, inadequate milk collection and marketing infrastructure, limited knowledge and skills, low price of milk, transport problem, lack of storage facilities are serious problem for highly perishable dairy products in semiarid areas (Chinogaramombe *et al.*, 2008). Moreover, factors such as use of traditional technologies, inadequate extension service, poor infrastructure, lack of marketing support services and market information, absence of producers organizations, and natural

resources degradation have contributed to un-exploitation of dairy potential and milk-quality issues. For example, the milk quality is perceived to be low, putting the domestic industry at a disadvantage against imports (Berhanu *et al.*, 2007).

Intensification of dairy production involves the adoption of a combination of cattle breeds with increased genetic potential for milk production and other complementary inputs (example feeds, disease control interventions, and improved record keeping) which also contributes significantly to the overall welfare of smallholder farmers, where milking is done manually, are highly labour intensive and heavily rely on family labour (Belete, 2010).

Value chains can either be market driven or relation-based depending on the form of governance they adopt (Farnworth, 2011). Relational value chains are those in which lead actors, such as producers in dairy cooperatives, buyers in contract farming and intermediaries determines the transactional framework within which other actors will work, resulting in producer-driven, buyer-driven, or intermediary-driven relational value chains respectively (Mutua *et al.*, 2014). Milk value chain in particular is to increase smallholder's incomes by increasing the number of households deriving their livelihood from dairy business through managing high productivity enterprises, while delivering quality and affordable dairy products to the market (SNV, 2008). Establishing a formal marketing system that relates quality to market price has a potential to enhance commercialization of the smallholder dairy sector. Such an approach provides an incentive for producers to supply products of good quality from nutritional as well as consumer health perspective (Zelalem, 2012).

Improvements in dairy production can be achieved through in identification of production constraints and introduction of new technologies or by refining existing practice in the system (Berhanu *et al.*, 2009). Assessment of the dairy production system, identification and prioritization of the constraints of production are prerequisites to bring improvement in cattle productivity and helps to use the scarce resources efficiently (Andualem, 2016).

The lack of up-to-date and location specific information on production and value chain and on their constraints is often a major limitation to productivity and production improvement endeavors emphasis in Ethiopia (Ayele *et al.*, 2003). There are few related studies which analyzed the value chain of dairy production. Such studies have focused on the dairy production and marketing. Therefore there is inadequate information about dairy husbandry practice, performances, functions and activities of dairy value chain and milk quality analysis in each of the value chain points. In Bishoftu and Akaki towns, the smallholder dairy production system and analysis of milk value chain and quality is not studied adequately and constraints are not identified and prioritized. Hence, assessment of the smallholder dairy production system in the towns is necessary in order to achieve improvements in dairy production and value chain.

To put in place appropriate remedial interventions that would lead to enhanced productivity of the dairy sector, understanding the prevailing overall dairy production system, existing value chain functions and actors involved along the stages of the value chain; and understanding the influence of these factors on quality of the commodity is very crucial.

Findings from this study are intended to furnish information may assist policy makers, NGOs and other stakeholders in designing appropriate programmes for smallholder dairy farmers and improving performance of the smallholder dairy cattle, contributes to better understanding on improved strategies for reorienting value chain of milk and market system for the benefit of smallholder farmers, traders, processors and consumers and generally the dairy sub sector in Ethiopia. Also understanding the dairy cattle production and productivity helps to design appropriate technologies which are compatible with the system. Besides filling the existing research gap, the findings of the study could be useful for planners to understand the economic impacts of smallholder dairy farmers and policy governing this activity.

Therefore the general objective of this study was to characterize the smallholder dairy cattle performance and, analyze of milk value chain and quality in the study areas with the following specific objectives.

- To characterize the smallholder dairy cattle husbandry practice and constraints in Bishoftu and Akaki towns
- To investigate the reproduction and production performance of smallholders dairy cattle;
- To investigate the existing milk value chain and quality in the study areas.

## **2. LITERATURE REVIEW**

In this section, past dairy production systems research activities in Ethiopia are briefly reviewed in the perspective of this research work mainly focusing smallholder dairy production system, husbandry practices, milk value chain, quality and improved and constraints associated with dairy development.

### **2.1. Smallholder Dairy Farming**

The development of dairy is often attributed to outstanding opportunity it poses to generate steady income for the rural household within the socio-economic parameters. Smallholder dairy farming is defined in various terms. For instance, in Philippines, smallholder farmer is someone with one to three dairy animals, often not belonging to an organized milk-collection system (Bulatao, 2009). Similarly Chungsirawat (2009), stated smallholder farmer in Thailand as someone who has one to three cross-bred cows, typically occupying less than 0.5 ha of land and represents the less-commercially managed dairy systems in the area (FAO, 2008). A smallholder dairy farm in Zambia is a farm where the number of animals per farm or per herd usually does not exceed 10 heads of cattle, milking machines are generally not used and milk is not chilled but is generally transported to the market in unrefrigerated cans (Kusiluka *et al.*, 2006).

### **2.2. Dairy Production Systems in Ethiopia**

Like most dairy systems found in the tropics, the Ethiopian dairy system includes large number from small to large-sized and subsistence to market-oriented farms. Based on climate, land holdings and integration with crop production as criterion, dairy production systems are recognized in Ethiopia; namely the rural dairy system which is part of the subsistence farming system and includes pastoralists, agro-pastoralists, and mixed crop–livestock producers; the urban and peri-urban dairy systems (Yitaye, 2008). The first system (pastoralism, agro-pastoralism and highland mixed smallholder production system) were found to contribute to 98%, while the urban and peri-urban dairy farms

produce only 2% of the total milk production of the country (Sintayehu *et al.*, 2008). The urban dairy production system involving from smallholder to highly specialized dairy farms. The peri-urban system which is found in the outskirts of the capital city and regional cities, which includes commercial to smallholder dairy farms. The rural dairy system which is part of the subsistence farming system and includes pastoralists, agro-pastoralists, and mixed crop–livestock producers (Sintayehu *et al.*, 2008). There are currently 33,500 smallholder producers out of which 80% of them own 1-3 dairy cows, 15% 4-6 and the remaining balance own 7-10 dairy cows in urban and pre-urban milk shed production systems (Land O'Lakes, 2010).

### *2.2.1. Dairy production systems in urban and peri-urban*

Urban and peri-urban dairy production systems are among the many forms of dairy production systems prevalent in the tropics and sub-tropics. Farmers in peri-urban have small size of grazing land; they use semi-grazing systems and also practice under stall feeding conditions for improved animals (Ayenew *et al.*, 2008). Cattle graze on owned or rented land. The main feed resources are agro-industrial by-products, purchased roughage and in addition they use crop residue and pasture land (Belete *et al.*, 2010). Special inputs are linked to the type of genotype and involve artificial insemination and supplementary feeds to grazing and stall-fed roughages (Yilma *et al.*, 2011). Existence of the urban and peri-urban dairy farming is mainly motivated by availability of good market filling in the large demand-supply gap for milk and milk products, need for creation of employment opportunities.

Urban dairy systems in general are located in cities and/or towns and focuses on production and sale of fluid milk, with little or no land resources, they used stall feeding practices (Ayenew *et al.*, 2008). Type of feed commonly used in this production system includes purchased concentrates and roughages of conventional and non-conventional sources (Asrat *et al.*, 2013). The primary objective of milk produced in pre-urban and urban is to generate additional cash income (Belete *et al.*, 2010). They are main milk supplier to the urban market (Ayenew *et al.*, 2008). Milk is either sold to dairy

cooperatives, on the local informal market or directly to consumers from the farmers' gates (Azage *et al.*, 2007).

As compared to other systems they have relatively better access to inputs and services provided by the public and private sectors, and use intensive management (Azage *et al.*, 2013). The production system is dominated by crossbred dairy cows and most of dairy product is characterized by market orientated and by the types of inputs particularly feeds (Sintayehu *et al.*, 2008). Milk produced under this system is handled in both plastic and metallic containers, and it is for sale to generate income and home consumption. Milk hygiene is considered vital since the production system is economically viable (Sintayehu *et al.*, 2008). The production system involves production, processing and marketing of milk and milk products that are channeled to consumers in urban centers. The peri-urban and urban dairying using improved dairy cattle with relatively better management may be considered as a key factor for the better performance and highly profitable as compared to other systems (Alemayehu *et al.*, 2012).

### *2.2.2. Dairy production in rural areas*

Dairy production is practiced almost all over Ethiopia involving a vast number of small scale, medium scale and large scale farms. The rural dairy system is part of the subsistence farming system and includes pastoralist, agro pastoralist and mixed crop-livestock producers (mainly in the highland areas). The milk produced is mainly used for home consumption and feed requirements are entirely satisfied from native pasture, crop residues, and stubble grazing or agricultural by-products (Adebabay, 2009).

The importance of the small farm sector in agriculture is emphasized in the planning of the national economy (Asaminew, 2007). In accordance with this, the overall goal of meeting food self-sufficiency in the country includes plans for increased milk production, which is based on improvements in smallholder milk production system. About 93 percent of the total milk production in Ethiopia is produced by the smallholder dairy farmers living in the villages and exercising, in most instances, traditional dairy

productions are the main source of milk even though they are kept primarily as draught power source with very little or no consideration given to improving their milk production capabilities and focuses on butter production rather than fluid milk (Alemayehu *et al.*, 2012).

### **2.3. Milk Handling, Processing and Consumption**

Ethiopian farmers particularly women have their own practices to improve the keeping quality of locally produced dairy products through sanitation of milk and milk handling equipments as well as by applying locally evolved processing knowledge (Abebe *et al.*, 2014). Milk handling is essential at each stage; at the farm, cooling centre during transport and at the processing plants (Pandey and Voskuil, 2011). Dairy products are a source of high quality animal protein. Milk and milk products forms part of the diet of many Ethiopians; they consume dairy products either as fresh milk or fermented or in soured form (Derese, 2008). The consumption of milk and milk products varies geographically between the highland and the lowlands and depending on the proximity to urban. Farmers in rural production systems were processing to increase shelf life of the product for home consumption and for marketing (Negash *et al.*, 2012a).

In the highlands, the rural people are sedentary farmers raising both livestock and crops. The main part of their diet consists of cereals and legumes. Milk is used for rearing calves, children, and whatever is obtained over and above is soured for beverage (irgo) and/or butter making. The small quantity of milk produced by the majority of the rural households in the traditional system is usually processed into butter and cottage cheese by the farm household and sold to traders or other consumers in the local markets (Belay and Janssens 2014; Negash *et al.*, 2012a).

In rural areas, dairy processing is generally based on ergo (fermented milk), without any defined starter culture or with natural starter. Milk processing is basically limited to dairy farmer level and hygienic qualities of products are generally poor (Zelalem and Faye, 2006). According to the same source, large scale producers used common towel to clean

udder or they did not at all and they do not use clean water to clean the udder and other milk utensils.

#### **2.4. Dairy Value Chain and Market Channels**

The dairy farmers have different market-outlets for the milk left out from consumption. These are to sell to neighbors in the informal marketing channel, dealers or milk groups/cooperatives (in some cases retailers). The availability of these market-outlets through the establishment of milk groups and cooperatives as well as the milk-collection centers have given dairy farmers a broader choice of marketing their milk instead of depending on local traders and neighborhood buyers (SNV, 2008). The increasing demand for cash has encouraged many smallholder farmers to sell small quantities of milk normally consumed by the farm family members or fed to calves. The smallholder milk producers supply the large-scale processors (formal market), the small-scale processors as well as a large number of small market traders known as vendors (informal market), who sell raw milk in urban and peri-urban areas (SNV, 2008).

A value chain describes the full range of activities required to bring a product from producers to its end use. This includes activities such as design, production, marketing, distribution and delivered to the final consumer (Ruijter de Wildt *et al.* 2006). Value chain actors are those involved in supplying inputs, producing, processing, marketing, and consuming agricultural products (Getnet, 2009). They can be directly involved in the value chain (rural and urban farmers, cooperatives, processors, traders, retailers, cafes and consumers) or indirect actors who provide financial or non financial support services, such as credit agencies, business service and government, researchers and extension agents (Getnet, 2009). The partners within the value chain usually work together to identify objectives: They are willing to share risks and benefits, and share in time, energy and resources to make the relationship work (Bammann, 2007). There are three important levels of value chain; (i) Value chain actors: The chain of actors who directly deal with the products, i.e. produce, process, trade and own them. (ii) Value chain supporters: The services provided by various actors who never directly deal with the product, but whose

services add value to the product. (iii) Value chain influencers: the regulatory framework, policies and infrastructures (Bammann, 2007).

Value chain analysis is essential to an understanding of markets, their relationships, the participation of different actors, and the critical constraints that limit the growth of livestock production and consequently the competitiveness of smallholder farmers (Bammann, 2007).

#### *2.4.1. Formal milk value chain*

In Ethiopia, 98% of the national milk is marketed through informal channels and is unprocessed. Whereas only 2% of the milk produced is reached the final consumers through formal chain (Vander Valk and Tessema, 2010). Input suppliers, milk producers, milk processors and consumers involved the formal milk value chain. Milk provides a typical example with growing demand for milk value added products in Ethiopia, whereas local supply is limited (Berhanu *et al.*, 2011). In the formal system milk is collected at cooperative or private milk collection centers and transported to processing plants. In this system, there are somehow milk quality tests (alcohol and clot-on-boiling tests and density) up on delivery, and therefore the quality of milk is fairly secured. Producers supplying milk in this system pay a due emphasis in the production, storage and transportation of milk if their milk has to be accepted (Yilma *et al.*, 2011).

There are stakeholders, who are not direct actors/players in the dairy value-chain, but contribute to its development. The stakeholders in question take different forms such as government; development organizations or promoters and input suppliers are necessary and have played very important roles in the development of the dairy subsector (Figure 1). The key players in the value chain are the input suppliers, farmers of various sizes, milk collection centers, processors and retail outlets. Each of the players in the value chain carry out various value adding services, the input suppliers for instance provide various veterinary drugs, milking equipment, AI services, feed among other services (Getu *et al.*, 2012). The primary producer in the dairy value chain; the farmer carries

various animal husbandry measures such as disease control measures, provision of feed to dairy cattle to ensure that the raw milk produced meets standard requirements and traded through the formal marketing channels (Getu *et al.*, 2012).

Major processors have their own collection, bulking and transportation systems. Stainless steel cans, and occasionally plastic cans, are used for bulking milk from individual suppliers and delivering it to processors' collection, bulking and cooling centers, from where it is transported in cans or by refrigerated tanks to the main processing plants. In some areas, powerful milk intermediaries (traders) have positioned themselves between the market and the milk producers. Their presence complicates the traceability of milk and brings a risk of cross-contamination and microbial overload (FAO, 2011).

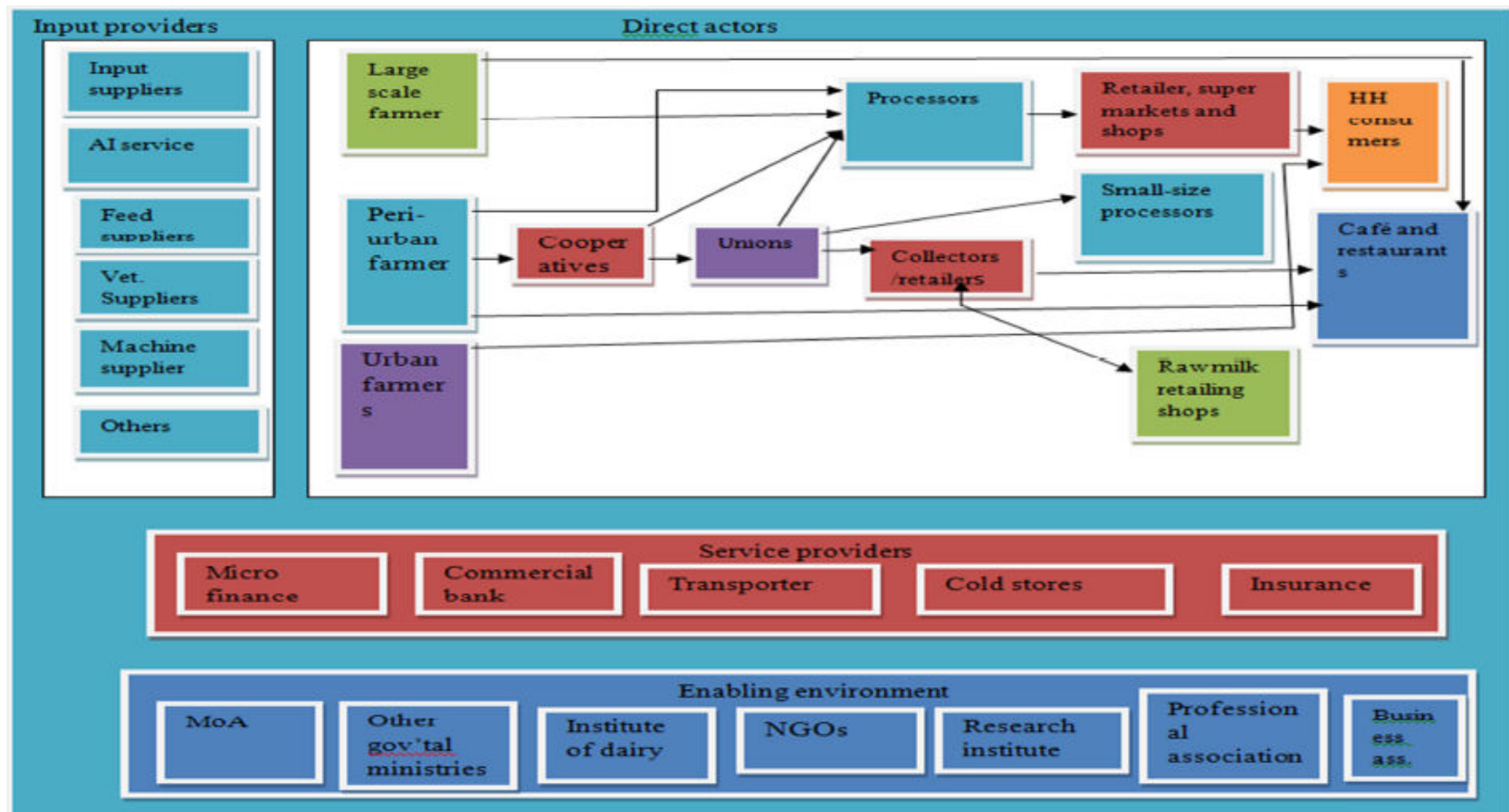


Figure 1. General frameworks for value chain actors and support system

Source; (Haile, 2009)

#### 2.4.2. *Informal milk value chain*

Informal milk marketing channels refers to channels moving raw milk to final consumers. According to Anjani *et al.* (2011), the informal market is characterized by the private milk traders or vendors who buy milk directly from producers and supply the milk directly to the urban consumers and other informal buyers such as hotels, restaurants and shops.

The Ethiopian milk marketing system is not well developed (Woldemichael, 2008). Weak linkages among the different actors in the dairy value chain are some of the important factors that contribute to the poor development of Ethiopia's dairy sector (Yilma *et al.*, 2011). As in most countries in sub-Saharan Africa, fresh milk is distributed through the informal as well as the formal marketing systems. This is because of the difficulties of marketing fresh milk in the rural areas where transportation is extremely limited and market channels have not been developed. Because of lack of an organized rural fresh milk market, milk marketing in any volume is restricted to the peri-urban areas (AGP, 2013). The development of market infrastructure and market institution is very important for inducing efficiency and incentives for the participants on the livestock value chain (Azage *et al.*, 2010).

Informal marketing dominates the system where all rural and part of peri-urban and the majority of the urban dairy producers sell liquid milk and dairy products on a house-to-house basis. One of the unique aspects of the dairy sector in many developing countries is the informal nature of the milk market. FAO (2006) reported that each year about 200 million liters of milk is handled by the informal market traders, with inadequate regulation. Fresh milk sales by smallholder farmers are important only when they are close to urban and peri-urban centers where demand for fresh milk is high (Betela, 2015). In the informal system producers supply their surplus production to their neighbors and/or in local markets, either as liquid milk or in milk products and the quality of milk and milk products is very poor mainly due to the prevailing situation where producers have limited knowledge of dairy products handling coupled with inadequate dairy infrastructure such

as refrigeration facility, clean water and limited knowledge to the hygienic handling of milk and milk products (Abebe *et al.*, 2014).

## **2.5. Dairy Cattle Husbandry Practices**

### *2.5.1. Dairy cattle housing, breeding and diseases prevalence*

In order to let the cattle adapt to the tropical climate and also to give high milk production, people have paid much attention to site selection, housing construction, dairy cattle management and disease prevention and cure. There was irregularity in type of construction. In urban and peri-urban area the roof is made of iron sheet, but the wall varies depending on economic status of the owner, some of them have built with block and the other built with wood and mud, whereas the floor was constructed in concrete, soil compact with or without beddings. Drainage system was not sufficient enough to remove slurry. Most of them dispose the slurry inappropriate place outside their compound which contaminate nearby water reserve or lake or well (Mekuria, 2016).

Throughout the dairy industry cows are housed and handled under a variety of management systems. Regardless of these differences the goal of each operation remains the same: for the cows to remain productive and healthy. Proper clean housing environment and equipment help to ensure that the animals are taken care of appropriately and that adequate facilities are available to manage the cows effectively and this is prerequisite to produce milk and milk products of acceptable quality (Asaminew, 2007).

After parturition, cows are not milked for about two weeks during which calves are kept with and allowed to suckle their dams freely. Milking commences after two weeks of calving and the calves are allowed to suckle their dams for short time before and after milking for local cattle. Bucket feeding of milk is practiced before weaning mainly by farmers who owned crossbred cows. The overall average weaning age of local calves was 11.8 months, that is, the calves suckle their dams up to the end of the lactation period

while for crossbred calves the average weaning age was 8.1 months (Asaminew and Eyassu, 2009)

Calves are housed for several reasons, the most important being protection from adverse weather conditions and predators, avoid internal and external parasites and control feeding and management. The calf house can be permanent or temporary and movable. Permanent houses should be constructed such that they are easy to clean when a new calf is introduced (Gachuri *et al.*, 2012). The most common cattle breeding system in Ethiopia is natural uncontrolled mating and AI. AI is currently in use in only few areas in Ethiopia. Smallholder dairy farms prefer AI to natural mating, but the unavailability of the AI services regularly, forces them to use natural mating (Mekonnen *et al.*, 2006).

Manure from the urban areas is also supplied to a limited extent to the peri-urban areas, particularly to crop producing farms. Therefore, contribution of manure produced as organic fertilizer was, thus, found economically important to both dairy farm owners and even to the surrounding rural farmers dairy farmers in urban and peri-urban, respectively, were using manure as source of their immediate income (Gebrekidan, 2014). Animal manure is a renewable and valuable resource that can provide vital nutrients to the soil, increasing soil health and productivity in a sustainable way. However, managing manure can often be a labor- and capital-intensive part of a livestock enterprise. Additionally, inadequate manure management can pose potential haphazard and present serious problems to both animals and humans and threat to local water quality through excess runoff with a little planning and ingenuity, however, livestock manure can become an important value-added of byproduct of dairying in just about any size operation (Page, 2014).

Disease has numerous negative impacts on dairy production in various ways such as premature death, reduced body weight, fertility, reduced yield of milk and reduced capacity for work and almost all the diseases have severe effects on overall production efficiency of animals (meat, milk, skin and loss of power) (Mulugeta and Belayneh, 2013). There are epidemics of infectious diseases with high rates of mortality, which could be controlled by vaccination; there are also parasitic, and vector born diseases. Trypanosomiasis and internal parasites are very severe, for which effective, easily

administered in expensive control or treatments have not yet been developed. Thus, livestock diseases on their own and interacting with nutritional and productivity problems cause high mortality, morbidity and restrict production in potentially productive areas (SNV, 2008). Improved animal health care is also essential as it imposes a serious source of loss.

### *2.5.2. Major feed resources and feeding systems of dairy cattle*

Urban and peri-urban farms are mostly landless and are located within or close to major towns and cities. The higher demand of milk in urban population has been a driving force for establishment of urban and peri-urban dairy farms (Habib *et al.*, 2007). In urban and peri-urban commercial dairy farms, feed accounts for more than two third of the operational cost. This is because animals are stall-fed all the times with purchased feed and fodder. Moreover, the system is highly intensive and profit motivated, the animals are fed large amount of concentrates to get more milk. However, feeding management is mostly traditional which adds to feed cost (Habib *et al.*, 2007).

In Ethiopia dairy feed resources are mainly from natural pasture, crops residues and agro-industry by products. The availability of feed resources depends on season. However, concentrate feeds, crop residues (teff straw, wheat straw and barley straw) and conserved forage (hay), are used both in wet and dry seasons. The majority of urban farms used concentrate as a supplement for dairy cattle which is less practiced in peri-urban farms. However, a by-product local beverage was commonly used as supplement to local cows both in urban and peri-urban areas (Derese, 2008). Temporal and spatial variation of the feed resources in terms of access and availability and quality is a major concern. In general feed resources availability and contributions of the ingredients vary across systems, seasons of the year and farms on the intensity of crop production and amount and distribution of the rain fall (Bedasa, 2012). Lactating cows for example are unable to meet their nutritional requirements i.e. they lose weight and body condition during lactation due to high nutrient demand for milk production (Firew, 2007). They supplement either with conventional feed that is concentrate (oilseed cakes, wheat brans,

and molasses) and/or with unconventional feeds such as forages of herbaceous or tree legumes and other non-legumes browse (Firew, 2007; SNV, 2008).

### *2.5.3. Dairy cattle's water sources and provision*

Drinking water or free water intake satisfies 80 to 90 percent of a dairy cow's total water needs. There are differences in the amount of water made available to the dairy cattle among production systems (Njarui *et al.*, 2014; Gebrekidan *et al.*, 2012). The amount of water, additional to that from feed, a lactating cow needs depends on body size (Looper and Waldner, 2007).

## **2.6. Reproductive and Production Performance of Dairy Cattle**

Reproductive and production traits which increase efficiency might have a bigger impact on the profitability of dairy farms not by higher output of products but reducing cost of inputs. Traits such as milk yield, calving interval and survival can be combined to provide selection for longevity while maintaining acceptable levels of milk production (Veerkamp and Beerda, 2007).

### *2.6.1. Age at first service*

Age at first service is a signal of heifer getting ready for reproduction and production and it is the age at which heifers attain body condition and sexual maturity for accepting service for the first time. It influences both the production and reproductive life of the female through its effect on her lifetime calf crop. According to Nibret (2012), age at first services of crossbred dairy cows under small scale dairy conditions in urban and peri-urban areas of Gondar was 15.4 months. However, *Bos-indicus* reach puberty late, as an example, the average age at puberty for the Ethiopian zebu cattle is 22.5 month and the average age at first service of Begait cattle was 30.29 months in their in-situ (Abraham, 2009).

### 2.6.2. Age at first calving

Age at first calving marks the beginning of a cow's productive life. Under controlled breeding, heifers are usually mated when they are mature enough to withstand the stress of parturition and lactation (Dayyani *et al.*, 2013). Age at first calving marks the beginning of the productive life and influences the lifetime production and reproduction performance of the cow. Early age at first calving is an important desirable economic character of dairy cows as it increases the margin of profit by increasing life time production (Levi Mgeni, 2010). Crosses with 75% Friesian and Jersey inheritances had AFC of  $38.52 \pm 1.44$  and  $39.72 \pm 1.08$  months, respectively. However the second generation of Friesian and Jersey crosses had long AFC of  $49.80 \pm 0.96$  and  $48.24 \pm 0.84$  months, respectively (Kefena *et al.*, 2013).

Nibret (2012), evaluated age at first calving of cross breed cattle breeds 32.4(0.16) months under small holder conditions in and around Gondar. The prolonged AFC of cows could be attributed to factors such as poor nutrition and management practices including poor heat detection at the time of mating the heifers. Damitie *et al.* (2015) reported the calving interval of Fogera cattle in Lake Tana Watershed, North Western Amhara, Ethiopia was 25.52 months. With good nutrition it is expected that heifers would exhibit fast growth and attain higher weights at relatively younger ages (Semfuko, 2013). A recent study reported that dietary supplementation of heifers during their period of growth reduces the interval from birth to age at first service and birth to age at first calving (Amin *et al.*, 2013).

### 2.6.3. Calving interval

Calving interval is a function of calving-to-conception interval or days open, which is considered to be the most important component determining the length of calving interval, and gestation length (Dayyani *et al.*, 2013). For optimum economic benefits, it is desirable to have shorter parturition intervals to attain higher lifetime productivity of the female animal (Zewdie, 2010).

The calving interval of local and crossbred dairy cows in the in Chacha town was found to be  $23 \pm 4.3$  months of which for local cows  $24.94 \pm 4.1$  months and for crossbred  $22 \pm 4.4$  months, the overall calving interval was prolonged, and on the other hand, crossbred cows calving interval was shorter and better than local cows (Mulugeta and Belayneh, 2013). The average calving interval of Zebu X Holstein-Friesian crossbred dairy cows in Jimma town was  $21.36 \pm 3.84$  months (Belay *et al.*, 2012). Nibret (2012) reported for calving interval of crossbred dairy cows in Gondar town, was 12.9 months under Small Holder Conditions. The estimated average calving interval for crossbred dairy cows reported in urban and secondary town dairy production systems in Adama milk shed, East Shoa Zone, Oromia National Regional State, Ethiopia  $14.0 \pm 0.1$  months (Nigusu and Yoseph, 2014).

The days open period should not exceed 80-85 days if a calving interval of 12 months is to be achieved. Longer calving interval might be indicative of poor nutritional status, poor breeding management, lack of own bull and artificial insemination service, longer days open, diseases and poor management practices (Belay *et al.*, 2012; Haftu, 2015).

#### *2.6.4. Milk yield*

Milk production potential of temperate breeds in the tropical environments is higher than the indigenous breeds. The average milk yield /day / cow from both pregnant (8.73 liter) and non-pregnant (11.4 liter) of pure breed Holstein-Frisians were reported by Zekarias and Shiferaw (2012) in Jima town. Ketema (2014) evaluated daily milk yield of crossbreed dairy cows was found to be  $4.73 \pm 3$  liters at kersa Malima woreda. Fikrineh *et al.* (2012) reported that the average daily milk yield of local cows was about 1.71 liters compared with about 8.95 liters from crossbred cows in the Mid Rift Valley of Ethiopia. Nardos (2010) also reported that the average milk production of local and crossbred cows in Mekelle city was about 2.5 and 13 liters, respectively per head per day. The proportion of exotic inheritance contributes to differences in lactation milk yield. A study conducted by Yitaye (2008) the total average daily milk yield excluding the amount of milk directly suckled by the calf of local and Friesian x local cows was  $2.8 \pm 0.47$  and  $7.8 \pm 0.19$  litres

per cow, respectively. Various factors contribute to variations in milk yield. These include feeding systems, breed, calving season, parity number, and effects of location (Gillah *et al.*, 2012).

#### *2.6.5. Lactation length*

Different reports indicated a wide variation in lactation length of cows in different areas. The average lactation length of crossbred cows in North Showa zone, Ethiopia was with 333.9 days (Mulugeta and Belayeneh, 2013), lactation length of crossbred dairy cattle in North-eastern Amhara Region, Ethiopia was about 241 days (Solomon *et al.*, 2009), lactation length of crossbred dairy cows 331.57±12.77 days in Mekelle, Tigray (Kumar *et al.*, 2014b), 188 days for Begait cattle in Western and central Zones of Tigray (Abraham, 2009) and (Girma and Verschuur, 2014) reported the average lactation length of cross breed cow was 240 days around in East Shoa zone. The short lactation length might be due to the reason of poor nutritional status, poor breeding management, diseases and poor management practices (Belay *et al.*, 2012).

### **2.7. Constraints of Smallholder Dairy Production**

In the context of smallholder livestock production systems, a constraint is ‘any barrier that prevents livestock keepers from achieving their goal to improve their livelihoods’. Constraints occur in many different forms, but theory and evidence both suggest that binding constraints in most systems are often very few in number. They can be classified in different ways, but they range from bio-physical, resource and technical constraints to those associated with socio-cultural factors, infrastructure and policy (Ayele and Derek, 2011). Seasonal availability and costs of feeds and feeding system could be among the major contributing factors to urban and peri-urban dairy production systems (Sintayehu *et al.*, 2008). The smallholder dairy production system is also constrained by water shortages. As a result of water shortages during the dry season, free water intake of lactating dairy cows is reduced and limits milk production and reduce health status (Guendel, 2006). Other problems of smallholder milk production system include lack of cash, shortage of labor, poor milk marketing and low prices especially for fresh milk,

inefficient milk processing practices and poor handling, poor milk quality products, and diseases were the constraints affecting milk production and productivity (Ayenew *et al.*, 2009).

Feed shortage problems in terms availability of quality, quantity and costs of feeds were also noted as major constraints in development of dairy production (Sintayehu *et al.*, 2008). Feeds are generally not available in sufficient quantities owing to overgrazing of lands and uncertain weather conditions. Inadequate animal feed resources as one of the important challenges of Ethiopian dairy sector was also reported by other worker (Yilma *et al.*, 2011). These constraints are generally observed to result in low milk yield, high stock mortality, longer parturition intervals and low animal weights. Climatic condition, poor nutritional status and low level of management contribute to a high incidence of cattle diseases, especially in the crossbred cattle (Kumar *et al.*, 2014b). Furthermore, the heavy burdens of different animal diseases generate a wide range of biophysical and socio-economic impacts that may be both direct and indirect, and may vary from localized to global (Perry and Sones, 2009).

## **2.8. Compositional, Physical and Microbial Properties of Milk**

### *2.8.1. Milk quality*

Milk is yellowish white non-transparent liquid secreted by the mammary glands of all mammals. It contains in a balanced form of all the necessary and digestible elements for building and maintaining the human and animal body (Pandey and Voskuil, 2011). Milk has been known as nature's most complete food (Park, 2009; Olatunji *et al.*, 2012). It contains immune-globulins which protect the newly born against a number of diseases (Hemalatha and Shanthi, 2010). Milk has distinct physical, chemical and biological characteristics, which justifies its high quality for consumption. These characteristics present a favorable environment for the multiplication of various bacteria (Hemalatha and Shanthi, 2010). Milk quality can also refer to the properties of milk based on one or a combination of butterfat content, bacterial counts (microbial quality) and physical

appearance of milk relating to color, smell and presence of foreign or dirt particles (Lore *et al.*, 2006). Milk that is received at collecting centers or processing plants is graded based on its quality. This grading helps in deciding whether to accept or reject the milk. Broadly speaking milk quality also refers to the good and bad attributes of a milk sample (Lore *et al.*, 2006).

### 2.8.2. Chemical composition of milk

A very important aspect of raw milk quality is its composition. The principal components of milk are water, fat, protein, ash and lactose. However, the exact composition of cattle milk varies with individual animals, breed, season, diet, feeding system, stage of lactation and microbial quality (Pandey and Voskuil, 2011; Kittivachra *et al.*, 2007).

As a general rule, any ration that increases milk production usually reduces the fat percentage of milk (Soyeurt *et al.*, 2007; Schennink *et al.*, 2008). Different breeds differ in their milk protein and fat contents. Jersey milk has higher protein and fat contents than Friesian (Schennink *et al.*, 2008).

Milk composition and production are the interaction of many elements within the cow and her external environment (Asaminew, 2007). Milk composition varies between species, breeds and individual animals depending on the management systems. However, it is generally accepted that the dairyman can alter many of these factors to achieve milk production and increase profit. The gross milk composition of cows contains 87.2% water, 3.7% fat, 3.5% proteins, 4.9% lactose and 0.7% ash (Park, 2009). Dehinenet *et al.* (2013) reported protein percentage for crossbred milk was (3.12%). Negash (2012b) reported that  $5.48 \pm 0.19\%$  fat,  $9.10 \pm 0.09\%$  SNF and  $3.46 \pm 0.04\%$  protein raw milk in the Mid-Rift Valley of Ethiopia.

### 2.8.3. Factors affecting milk composition

The composition of milk is not fixed since many factors influence the end product. Milk composition is affected by various factors, including stage of lactation, breed differences,

number of calving (parity), seasonal variations, age and health of animal, feed and management effects including number of milking per day and herd size (Lujerdean *et al.* 2007; Jenkins and McGuire, 2006). At farm level, this may be due to problems with feeding, udder health or incomplete milking. Unbalanced diets and mastitis are also known to decrease and lactose contents in severe cases fat. The lactose content of milk is moderately constant between dairy breeds, protein varies to some degree but fat varies widely. The age of the cow is closely related to the number of lactations, as an increase in number of lactations is associated with decrease in fat and solid not fat (SNF) content of milk (Almaz, 2014).

#### *2.8.4. Physical properties of milk*

Milk, at its normal state, has unique physical properties, which are used as quality indicators. The density of milk, among others, is commonly used for quality test mainly to check for the addition of water to milk or removal of cream (Almaz, 2014). High-quality milk should be white in appearance, have no objectionable odors, and be free of abnormal substances such as pesticides, added water or antibiotic and antiseptic residues. Titratable acidity is determined in the dairy industry mainly for two reasons: (a) to check the freshness of milk and milk products and (b) to control the manufacture of cultured (fermented) dairy products (McCarthy and Singh, 2009). The initial acidity of milk from individual cows varies within the range 0.08–0.25% lactic acid but the titratable acidity of fresh bulk milk seldom falls outside the range of 0.14–0.16% (McCarthy and Singh, 2009).

The specific gravity of milk is the ratio of the density of milk to density of water. The specific density should range between 1.028 g/ml -1.036g/ml at 15–20°C and values below 1.028 usually indicate the presence of added water. The specific gravity in milk is lowered by addition of water and cream and is increased by addition of skim milk or removal of fat. The pH of normal bovine raw milk is about neutral milk at 25<sup>0</sup>C. It is between 6.5 and 6.7, with 6.6 being the most common value. Differences in pH and

buffering between individual lots of fresh milk reflect compositional variations (McCarthy and Singh, 2009).

#### 2.8.5. *Microbial properties of milk*

In most developed dairy countries, milk quality is defined by the somatic cell count (SCC) and the bacterial count (“standard plate count”) in pre-pasteurized bulk tank milk. Somatic cells are composed of white blood cells and occasional sloughed epithelial cells. Regulations require that bacteria and somatic cell counts of Grade “A” raw milk must not exceed 100,000 Standard Plate Count (SPC) and 750,000 Somatic Cell Count (SCC), respectively. Raw milk must also meet other quality standards; it should be free of drug residues, free of added water and free of sediment, contaminants and other abnormalities (Murphy, 2008).

The number of bacteria in aseptically drawn milk varies from animal to animal and even from different quarters of the same animal. On average, aseptically drawn milk from healthy udders contains between 500 and 1000 bacteria per ml of milk. Many countries have milk quality regulations, including limits in the total number of bacteria in raw milk, to ensure the quality and safety of the final product (Worku *et al.*, 2012). High initial counts (more than 500,000 bacteria per ml of milk) are evidence of poor production hygiene (Oliver, 2010). However most countries have put 200000cfu/milliliter as the acceptable bacterial limit and the United States has a standard of 100000 bacterial cells per milliliter (Lore *et al.*, 2005). In proportion to the numbers present, existence of coliform bacteria in milk is suggestive of fecal contamination and unsanitary practices during milk production (Abebe *et al.*, 2012).

High bacteria counts > 10,000 cfu/ml suggests that bacteria are entering milk from a variety of possible sources. The most frequent cause of high somatic cell count is poor cleaning of milking systems. Most herd milk contains between 200,000 to 500,000 somatic cells/ml of milk. These herds are losing at least 8% in potential milk production. Thus, methods of mastitis control that reduce somatic cell count (SCC) will not only

improve milk yield and composition but will also decrease economic losses due to mastitis. Coliform counts >100 cfu/ml suggest poor milking practices, dirty equipment, contaminated water, dirty milking facilities, and/or cows with subclinical or clinical coliform mastitis (Oliver, 2010). It is widely accepted that individual cow SCC greater than 150,000 cells/ml or individual heifer SCC greater than 120,000 cells/ml indicates presence of infection (O'Brien, 2008).

Table 1. Interpretive criteria for bulk tank milk monitoring (cfu/ml)

<b>Parameter</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>
Bulk tank SCC	<200,000	200,000-400,000	>400,000
Standard plate count (SPC)	<5,000	5,000-10,000	>10,000
Preliminary incubation count (PIC)	<10,000	10,000-20,000	>20,000
Lab pasteurized count (LPC)	<100	100-200	>200
Coliform count	<50	50-100	>100

Sources: (Oliver, 2010)

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 (Worku *et al.*, 2012). Bacterial contamination of raw milk can originate from different sources: air, milking equipment, feed, soil, faeces and grass can affect the quality, safety, and consumer acceptance of dairy products (Coorevits *et al.*, 2008). It is hypothesized that differences in feeding and housing strategies of cows may influence the microbial quality of milk (Coorevits *et al.*, 2008).

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 (Zelalem and Faye, 2006). The presence of high numbers of coliforms in milk

provides an index of hygienic standard used in the production of milk, as unclean udder and teats can contribute to the presence of coliforms from a variety of sources such as manure, soil, feed, personnel and even water (Bille *et al.*, 2009).

#### 2.8.6. Sources and microbial load of raw milk

Milk may contaminate and increment in microbial load along at different critical points of milk marketing from farmer to the consumer level. Poor milking practices, dirty udders or teats, damaged teats, and poor operator hygiene can all lead to increased contamination of raw milk (Blowey and Edmondson, 2010). Higher microbial loads observed in raw milk could probably be due to lack of knowledge about clean milk production, use of unclean milking utensils and plastic containers for collecting and keeping milk, initial contamination of the milk samples either from the udder of the cow or the milkers' hand and the poor hygienic quality of milking area as well as further contamination during transportations (Gurmessa, 2015). This could be due to cross contamination of milk during transportation, lack of sanitation of storage container and lack of temperature control (Amistu *et al.*, 2015).

Alganesh *et al.* (2007) reported the overall mean total bacterial count of cows' sampled from a small scale producer in East Wollega Ethiopia was 7.60 log<sub>10</sub> cfu/ ml in milk. Worku *et al.* (2012) who reported bacterial count 7.36 -7.88 log<sub>10</sub> cfu/ml from raw cows' milk in Borana, Ethiopia; Assamnew and Eyassu (2011) reported 7.58 log<sub>10</sub> cfu/ml in Bahir Dar Ethiopia, and Mosu *et al.* (2013) 7.07 log<sub>10</sub>cfu/ml in Debre Zeit town, Ethiopia. The mean count was 7.35±0.180 log<sub>10</sub> cfu/ml in dairy farms was 7.41 log<sub>10</sub> cfu/ml in milk vending shops and 7.42 log<sub>10</sub> cfu/ml in homes/cafeterias (Shunda *et al.*, 2013).

#### 2.8.7. Control of milk contamination

Physicochemical and microbiological analyses are an important tool to monitor the quality of dairy products (Hettinga, *et al.*, 2008). Microbiological quality control is to

provide fluid milk from disease-free udders (physiologically healthy animals) to milk processing plants to manufacture wholesome milk and milk products (Barbuddhe and Swain, 2008). Chilling the milk fast ensures a longer shelf life and it tastes better if it is chilled quickly and stays cool. If milk does not stay cool, it will sour and separate (Martin *et al.*, 2007). Microbial control includes minimization of microbial sources in the farm environment, minimization of microbial transmission, prevention of microbial growth, and infection of animals. Many aspects of farm management (e.g. feed management, facility hygiene and milking operations) are involved in the control of the microbial contamination of bulk tank milk. However, the total bacterial count will also be affected by factors that are independent of farm management, such as seasonal variations (Wiley, 2009).

Hygienic milk production, proper handling and storage of milk, and appropriate heat treatment can reduce or eliminate pathogens in milk (Kurwijila, 2006). To ensure a good microbial quality of bulk tank milk, quality assurance systems for dairy farms are being developed and bacteriological schemes are being implemented in payment systems of farm raw bulk milk (IDF, 2006). The most commonly used microbial quality tests for milk and milk products include determination of total bacterial count (TBC) or standard plate count (SPC) and coliform count (CC) (Zelalem, 2012; Amistu *et al.*, 2015; Demissu, 2014). Provision of microbiological quality parameters of raw milk and milk products plays an important role in quality control. It is necessary to minimize technological and economic losses in milk processing and obtain a longer shelf life (Gurler *et al.*, 2013).

It is indicated that total bacterial count is a good indicator for monitoring the sanitary conditions practiced during production, collection, and handling of raw milk (Fatine *et al.*, 2012). To meet increased raw milk quality standards, producers must adopt production practices that reduce mastitis and reduce bacterial contamination of bulk tank milk. Use of effective management strategies to minimize contamination of raw milk and proven mastitis control strategies will help dairy producers achieve these important goals (Oliver, 2010). The use of detergents and good quality water for cleaning the equipment

could be expected to remove milk remains, including microorganisms, and thereby affect the microbiological quality of the milk. Use of disinfection, either chemical or hot water, would mostly reduce the numbers of microorganisms (Ngasala, 2013; Byarugaba *et al.*, 2008).

### **3. MATERIALS AND METHODS**

This section generally describes information on the area description, study population and sampling procedure. Furthermore, the laboratory analysis of raw milk and field research methods employed to collect the data and statistical procedures used to analyze and summarize the information gathered were described.

#### **3.1. Description of the Study Areas**

The study was conducted from March, 2014 to June, 2016 in Bishoftu and Akaki town's smallholder dairy farms. The two towns were selected purposively among the many towns due to role the commercialization of the dairy sector, proximity to Addis Ababa and its accessibility for the research.

##### *3.1.1. Bishoftu*

Bishoftu town is found in East Shewa Zone, Oromia Regional State, located about 45 km South-east of the capital city, Addis Ababa and very close to the other major urban centers like Adama and Modjo. The area is located at 9°N latitude and 40°E longitude at altitude of 1850 m.a.s.l. Annual rain fall of 866 mm of which 84% is in the long rainy season, June to September with annual minimum and maximum temperature of 11 and 29°C, respectively (NMSA, 2010). The town includes 9 urban and 5 peri urban kebeles. The domestic animals reared in Bishoftu town cattle population takes the first rank with 30887, followed by 43138 poultry, 9322 equine, 9294 sheep and 4753 goats. Farmers in this area own 17128 thousand cows under smallholder, medium and large dairy farms of which around 5565 are dairy cattle (all crossbreds) and 14664 liters milk is delivered to the processing plants daily in the town (City Administration Agricultural Desk, 2014).

### 3.1.2. Akaki

Akaki is located 25km away from Addis Ababa at 9°-10°24' North latitude and 37°56'-40° 35' East longitude with an altitude range of 1500-3100 meter above sea level. Its annual temperature ranges from 15°C - 27°C. The mean annual rainfall of the district is 800-900 mm and the short rain occurs during February, March and April and the long rain extends from June up to August. The report shows that of all the domestic animals raised in the district, cattle population takes the first rank with 91,040, followed by 39,055 goats, 39,048 sheep, 22,676 donkeys, 6,136 horses, and 2,015 mules. Farmers in this area own 22 thousand cows of which 39.6 % are dairy cows (all crossbreds) and 61.4 % local breeds, used for draught and meat production (Vernooij *et al.*, 2010). The town includes 11 urban and 3 peri urban kebeles (personal communication).

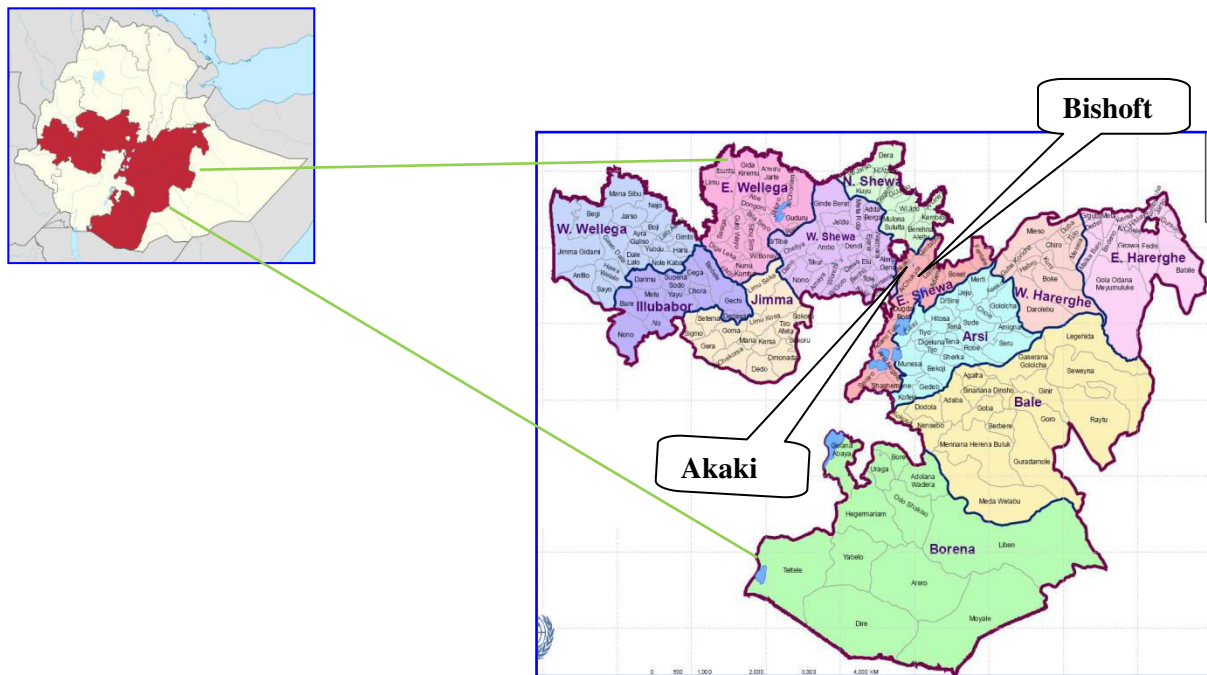


Figure 2. Map of the study areas

### **3.2. Study Population and Sampling Methods**

The smallholders keeping crossbred dairy cattle were the study population. Bishoftu and Akaki towns and *kebeles* under each town were selected purposively on the basis of milk production potential, distribution of crossbreeds and the presence of various dairy marketing actors that contributes to value addition of the dairy commodities in the areas. Dairy cattle owners were selected via simple random sampling techniques using the data list available at the respective towns' office of agriculture and rural development and city administration agricultural desks. Thus, six *kebeles* were selected from the two towns. Accordingly, from Bishoftu town 25, 20 and 16 smallholders were selected from kurkura, Babogaya and Gudino, respectively. In the case of Akaki town, 24, 22 and 23 stallholders were selected from kebele 01, 02 and 03, respectively. Generally, a total of 130 smallholders included in the study. Sample size was determined based on the formula recommended by Arsham (2005) for survey studies:  $n=0.25/SE^2$  with the assumption of 4.38% standard error. Where, n = sample size; SE= standard error of the population. Accordingly, a total of 130 smallholder farmers were selected.

### **3.3. Data Collection Methods**

The data used for this study were collected from primary and secondary sources. Primary data on the dairy production and marketing system were collected from the milk producers up to the end consumers and from city administration's agricultures desks and milk processing plants through pre tested structured questionnaires, observations and group discussions. Secondary data were collected from different documents and publications. Five data collectors with education level of diploma (3) and degree (2) were hired and those enumerators were well skilled with the subject, area and also understood local language and social set up. In addition, the enumerators were trained for three days in data collection techniques and how to maintain its quality and reliability. The questionnaire was prepared and contained information related to:

1. Demographic and socio-economic characteristics of the farm households (age, marital status education level, family size, income sources, farming experience, etc.).

2. Farming activity (land size, livestock holding, cattle herd size, occupation and cropping),
3. Dairy management (dairy cattle breeding, milking, milk handling and transporting, calve rearing, major feeds and feeding systems, housing, disease occurrence and healthcare, recording),
4. Production and reproductive performance of the cattle. Reproductive traits considered were age at first service, age at first calving, calving interval, calf crops while the production performance included were daily milk yield, total lactation yield and lactation length.
5. Milk value chain analysis; information on milk production, milk flows; market and linkages and the actors involving in the dairy value chain.

The last part of the survey addressed questions related to major constraints encountered by the smallholders and to the prospects of the dairy value chain activity. The questionnaire was pre-tested and adjustment was made on important suggestions from key informants and the enumerators.

Focus group discussions consisting of 5 knowledgeable individuals were made per *kebelle* to complement the survey work and the researcher facilitated the discussions at two towns and carried out with four groups of smallholder dairy farmers and milk value chain actors (10-15 people were participated in each group) composed of different age and the groups were formed for the focus group discussion in each study area. Besides the primary data, secondary data were collected from different sources of previous studies that included both published and unpublished documents obtained from relevant regional bureaus, zonal agricultural offices, districts' dairy cooperatives and other development offices and personal communications. Available literature and web pages were also searched to consolidate the document. Checklists for field observation were used to check different dairy farm condition in practice at the study areas regarding housing, animal healthcare, hygiene, feed and water provision and milking routines.

### **3.4. Laboratory Analysis of Milk**

#### *3.4.1. Milk sampling and handling*

Raw cow milk in plastic containers, cans and bulk tanks, were thoroughly mixed to disperse the milk fat before collection of milk sample for physiochemical analysis. Plungers and dippers were used in sampling from milk containers. A total of 52 (40 from smallholder farmers, 8 from milk collectors and 4 from processing plants) raw milk samples were randomly taken. Approximately 50 ml milk was aseptically collected from each sampling unit, as per the procedure described by O'Connor (1995) filled and sealed into sterile bottles, in such a way that no air bubbles remained in the bottles for microbial analysis. All samples were drawn from pooled containers containing milk that was milked on that particular day which was delivered to collection center and processing plants. All samples were coded for identification and stored in a cool box with ice packs until the physical, chemical and microbial analysis at Ethiopia Meat and Dairy Industry Development Institute with help of dairy laboratory technicians.

#### *3.4.2. Physical and chemical analysis of raw milk*

Ekomilk analyzer (Model: Bulteh 2000, Bulgaria) reliable, automated multi-parameter milk analyzer providing rapid test results for chemical composition of milk (fat, protein, lactose and solid not fat) and physical characteristics (milk density, freezing point, added water).

#### *3.4.3. Determination of pH*

The pH (Hydrogen ion concentration) meter was calibrated with standard buffers 4 and 7 before measuring the pH of the mixture. For determination of pH in the products, a method of AOAC (2000) was adopted and digital pH meter was used. Sample solution was taken in the beaker and directly inserted the electrode into the solution. When the

first reading was completed, the electrode was wiped with distilled water and dried-up with tissue paper. Similarly, all other samples were determined accordingly.

#### 3.4.4. Titratable acidity

The titratable acidity of raw milk samples was performed by putting ten ml of milk was pipetted into a beaker, and then 3-5 drops of 0.5% phenolphthalein indicator was added. Then the sample was titrated with 0.1N NaOH until pink color persists. Acidity was expressed as percentage of lactic acid (O'Mahoney, 1988).

$$\text{Lactic acid \%} = \frac{(\text{mlNaHO})}{10} \dots\dots\dots(1)$$

### 3.5. Microbial Analysis of Raw Milk

The microbial analysis including total bacterial count (TBC), total coliform count (TCC), and somatic cell count (SCC) were considered following standard procedures (Francesconi, 2006).

#### 3.5.1. Standard bacterial count (SBC)

The standard plate count of raw milk samples was performed by putting one ml of milk sample into a sterile test tube having 9 ml peptone water. After mixing, the sample was serially diluted up to 1:10<sup>-7</sup> and duplicate samples. Each culture was constituted of one ml of the diluted solution poured on a petridish, on which 12-15 ml of “Standard Plate Agar” was added. When the solution in the petridish solidifies, it was put into incubator at 32°C for 48 hours. Bacteria (or clusters) that grew and became visible colonies were counted using a colony counter and expressed as number of colony forming units per milliliter (cfu/ml) of milk. When the colonies were found to be too many, compromising the accuracy of counting, the same procedure was repeated using higher dilution levels (APHA, 1992).

### 3.5.2. Coliform count (CC)

The coliform count was the test used to estimate the number of bacteria that originate from manure or a contaminated environment. One ml of milk sample was added into sterile test tube having 9 ml peptone water. After mixing, the sample was serially diluted up to  $1: 10^{-7}$  and duplicate samples (1ml) were pour plated using 12-15 ml Violet Red Bile Agar solution (VRBA). After a thoroughly mixing, the plated sample was allowed to solidify and then incubated at  $30^{\circ}\text{C}$  for 24 hours. Finally, colony counts were made using colony counter (Marth, 1978). The corresponding total coliform count (TCC) and total bacteria count (TBC) were computed from duplicate plates containing between 25-250 colonies. Plates containing less than 25 colonies were taken as less than 25 estimated counts and plates containing greater than 250 colonies for all dilutions were recorded as too numerous to count (TNTC) (Maturin and Peeler, 2001).

For both tests the media were prepared according to the guidelines given by the manufacturers as indicated by American Public Health Association (APHA, 1992). After counting and recording bacterial colonies in each petridish the number of bacteria in milliliter milk was calculated by the following formula given by APHA (1992).

$$N = \frac{\sum \text{Colony}}{[(1 \times n_1) + (0.1 \times n_2)]d} \dots \dots \dots (2)$$

- Where: N = number of colonies per milliliter of milk  
 $\sum C$  = sum of colonies on plates counted,  
n1= number of plates on lower dilution counted,  
n2 = number of plates in next higher dilution counted and  
d = dilution from which the first counts are obtained.

### 3.5.3. Somatic cells count

Somatic cells count was conducted following the procedure described by Francesconi (2006). About 0.01ml milk was spread homogeneously over a microscope slide by using a sterile-standardized loop. Once the milk layer has dried up, Ethanol 96% was added. After waiting for 15 minutes, Tolouidin Blue 0.2% was added. The slide was then kept on open air for 5 minutes, after which it was washed with tap running water, dried and then observed by using a microscope at 100 times magnification. Somatic cells in twenty different fields (A) were counted. Given the dimension of the microscope zoom (F; in this case = 0.0346) and the somatic cells count (N).

$$N = A \times 10000/F \dots\dots\dots(3)$$

### 3.6. Statistical Analysis

Data collected from survey and laboratory results were entered, checked and managed using Microsoft excel. The coded data were analyzed through Statistical Package for Social Science (SPSS version 20) software. Statistical methods like descriptive statistics (mean, standard deviation, percent and charts) were performed. The data collected from TBC, SCC and CC were first transformed into natural log to normalize them before analysis for statistical difference of means using analysis of variance, whereby the analysis of variance was used to examine the differences in variable along the milk value chain in the two towns. Differences were considered to be significant at the level  $P < 0.05$ . Associations of different variables were analyzed by using correlation coefficient (R). Significant log mean differences were separated based on Least Significant Difference (LSD) mean separation technique and means were declared significant at ( $p < 0.05$ ). The statistical models used in the present study included:

**Model: I** Smallholder dairy production system in Bishoftu and Akaki

$$Y_{ij} = \mu + P_i + e_{ij} \dots\dots\dots (4)$$

Where,  $Y_{ij}$  = Variables (productive and reproductive performance of dairy cattle)

$\mu$  = overall mean

$P_i$  = the effect of study areas

$e_{ij}$  = random error

**Model II.** Specific to raw milk quality analysis in the value chain points

$$Y_{ij} = \mu + T_i + e_{ij} \dots \dots \dots (5)$$

Where;  $Y_{ij}$  = Observed value for (physical, chemical and microbial properties)

$\mu$  = Overall mean

$T_i$  = Effect of value chain points where  $i = 1$  is milk producers (MP),  $i = 2$  is milk collectors (MC) and  $i = 3$  is milk processing plants (MPP)

$e_{ij}$  = random error

## **4. RESULTS**

In this section, the results of questionnaire survey, milk value chain and quality analysis are presented and described from a total of 130 interviewed households, who possessed crossbred dairy cattle and milk quality analyzed 52 samples collected from the milk value chain points.

### **4.1. Characteristics of Households**

#### *4.1.1. Age, sex, occupation and marital status of dairy cattle producers*

Information on the family size, age group, marital status, type of employment and land size in the study areas are presented in Table 2. The study revealed that the majority of the respondents were male while one third of them were female. Majority of respondents irrespective of gender could read and write as indicated in Figure 3. Household heads are just the ones who control household resources. Age of the respondents ranged from 30 to 60 years old. The proportion of married, single, divorced and widowed respondents were 84.6%, 6.2%, 7.7% and 1.5%, respectively.

Table 2. Percentage of respondents' socio-economic characteristics in the study areas

Parameter	Town		Overall
	Bishoftu (N=61)	Akaki (N=69)	
<b>Sex</b>			
Male	67.2	66.7	66.9
Female	32.8	33.3	33.1
<b>Age Category</b>			
<=30	6.6	-	3.1
31-40	29.5	36.2	33.1
41-50	39.3	37.7	38.5
51-60	14.8	14.5	14.6
>60	9.8	11.6	10.8
<b>Marital status</b>			
Married	86.9	82.6	84.6
Single	9.8	5.8	7.7
Divorced	3.3	11.6	7.7
<b>Occupation</b>			
Govn't employee	3.3	29.0	16.9
Retired Govn't	-	10.1	5.4
Daily laborer	24.6	14.5	19.2
Farmers	63.9	39.1	50.8
Others	8.2	7.2	7.7

#### 4.1.2. Family size and land holding of dairy producers

The mean values of the family size and land size in the study areas are presented in Table 3. The overall average land size in the surveyed areas was 0.71 ha per household, but this is significantly different ( $P < 0.05$ ) in Bishoftu and Akaki. The average family size of the smallholders was 5.49 people per household. Family size of sample households significantly ( $P < 0.05$ ) varied across the towns in this study.

Table 3. Mean of family size and land holding in the sampled households

Parameter	Town		Overall (Mean±SD)	P-value
	Bishoftu (Mean±SD)	Akaki (Mean±SD)		
Family size	5.1±1.10	5.8±2.05	5.49±1.8	0.02
Land size (ha)	1.25±1.02	0.23±0.89	0.71±1.08	0.00

SD= Standard deviation

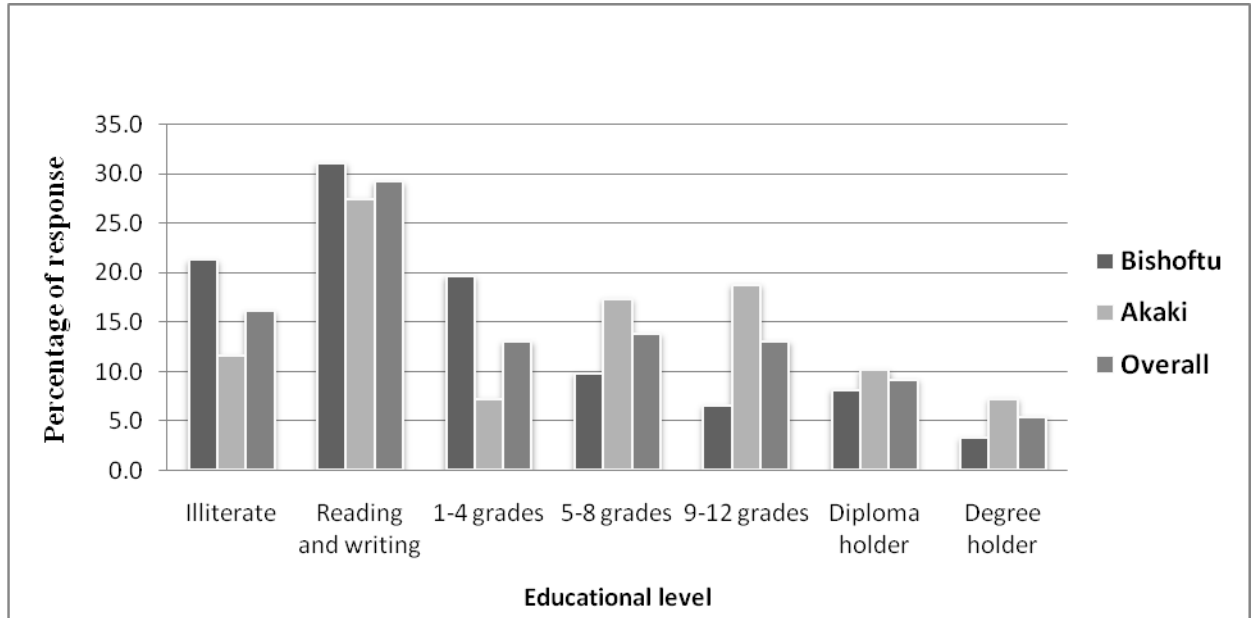


Figure 3. Educational level of the respondents (%)

#### 4.1.3. Source of household income

The study showed that dairy production was the major source of income in Bishoftu and Akaki (Figure 3). The farmers were also involved in cropping, livestock rearing and government employment. Although they were able to earn an income from these, it did not comparable to what they were earning from dairy considering that they were paid for everyday they delivered. They also used manure from the kraals to their farm land as fertilizer and fuel. The contribution of non-dairy farming activities to the household income was higher in Akaki than in Bishoftu farms (Figure 4).

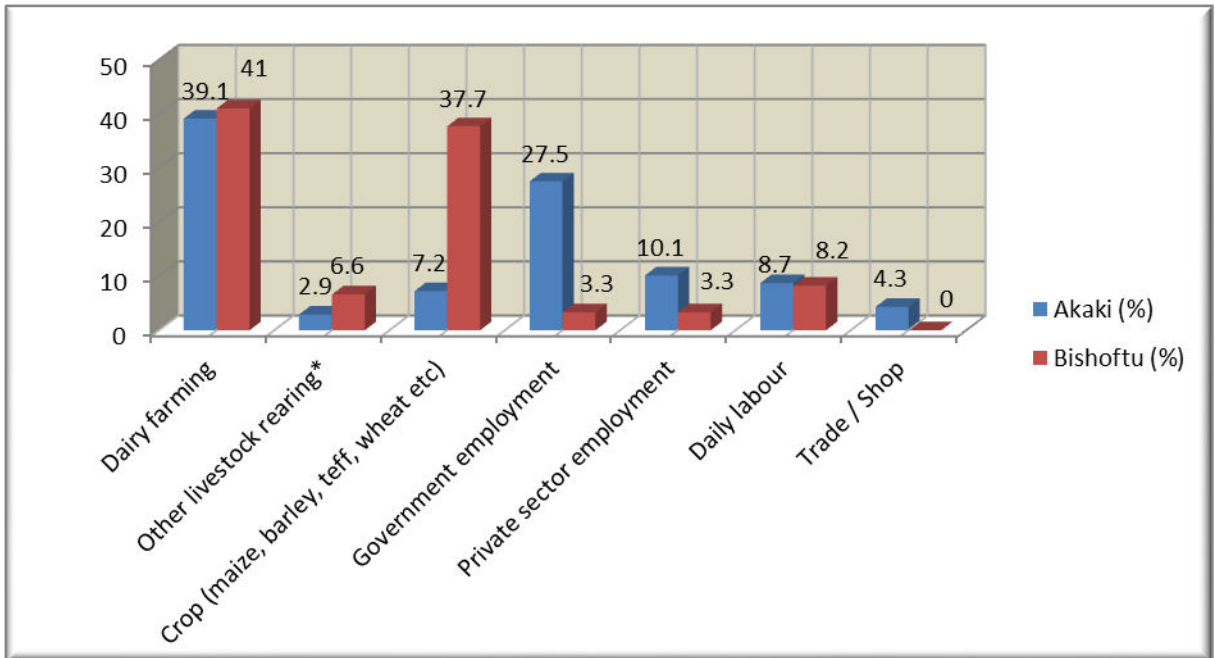


Figure 4. Percent of the households' sources of income

#### 4.1.4. Farmers' experiences and extension services

Table 4 indicates the farming experiences and extension services for respondents that had been involved in dairy farming. Extension services were given on general dairy farm management; dairy cattle feeding, dairy cattle healthcare services, heat detection, proper milking and milk handling, milk marketing, pasture establishment and record keeping provided by the districts offices of agriculture and rural development and different organizations. Most of the smallholders started the dairying by purchased the crossbred cattle themselves in both towns.

Table 4. Dairy farming experiences and extension services (% respondents)

attributes	Category	Town	
		Bishoftu (N=61)	Akaki (N=69)
Sources of dairy animals	Credit by government	6.6	15.9
	Credit by NGO	1.6	0
	Purchased him/herself	86.9	78.3
	Inherited (given by)	3.3	4.3
	from relatives		
	Donated	1.6	1.4
Farming experience	<3 years	11.5	46.4
	3–5 years	45.9	30.4
	>5 years	42.6	23.2
Access to extension services	Yes	90.2	46.4
	No	9.8	53.6
Training received	Yes	88.5	42.0
	No	11.5	58.0
Access to market information	Yes	73.8	40.6
	No	26.2	59.4

N=Number of smallholders

#### 4.1.5. Division of labor among smallholders

Within the smallholders dairy production value chain, there were numerous tasks to be completed. The dominant source of labour for dairy farming activities across the towns was family labour while the contribution of hired labour was minimal. The labour division for dairy cattle management is indicated in Table 5. Milking, milk processing, sale of milk products, and barn cleaning were mainly the jobs of women in the towns. Live animal sale and stall feeding was mainly the job of men in Bishoftu and Akaki. Moreover; herding activity was also mainly performed by men and women.

Table 5. Labor division among family members in the study areas (%)

Activities	Town							
	Bishoftu (N=61)				Akaki (N=69)			
	Men	Women	Children	Hired	Men	Women	Children	Hired
Herding	37.7	41.0	16.4	4.9	46.4	39.1	4.3	10.1
Milking	24.6	72.1	3.3	0.0	27.5	69.6	0.0	2.9
Milk processing	10.0	78.3	11.7	0.0	25.0	75.0	0.0	0.0
Barn cleaning	8.2	52.5	34.4	4.9	35.3	61.8	0.0	2.9
Sale of dairy products	13.1	70.5	16.4	0.0	42.0	55.1	0.0	2.9
Sale of animals	68.9	26.2	4.9	0.0	84.1	15.9	0.0	0.0
Feeding animals	45.9	19.7	24.6	9.8	49.3	43.5	4.3	2.9

N=number of smallholder farmers

#### 4.1. 6. Livestock holding and cattle herd composition

The mean livestock herd size per household is presented in Table 6. There was difference in livestock holding for cattle, chicken and donkey among Bishoftu and Akaki towns. Goat and horse were not reared by the selected farmers in Akaki town. In both towns, farmers possessed more cattle than other livestock species.

Table 6. Mean ( $\pm$ SD) livestock holdings in the study areas

Livestock species	Town		Overall
	Bishoftu (N=61)	Akaki (N=69)	(N=130)
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Cattle	8.43 $\pm$ 5.59	6.26 $\pm$ 2.84	7.28 $\pm$ 4.47
Sheep	2.25 $\pm$ 3.90	1.22 $\pm$ 3.17	1.70 $\pm$ 3.56
Goat	0.56 $\pm$ 1.79	-	0.26 $\pm$ 1.26
Chicken	6.92 $\pm$ 7.14	1.45 $\pm$ 8.45	4.02 $\pm$ 8.30
Donkey	1.92 $\pm$ 1.39	0.03 $\pm$ 0.17	0.92 $\pm$ 1.35
Horse	0.13 $\pm$ 0.47	-	0.06 $\pm$ 0.32

N=Number of respondents; SD= standard deviation

#### 4.1.7. Dairy cattle herd structure

The mean numbers of crossbred (*Holstein-Friesian*) dairy cattle breed in different categories are shown in Table 7. In general, the dairy cattle herds were composed of pregnant cows, lactating cows, dry cows, heifers, bulls, female calves, oxen and male calves. There was significant difference ( $P<0.05$ ) among the towns in the mean number of pregnant, lactating, dry cows, heifers and female calves.

Table 7. Dairy cattle herd structure at Bishoftu and Akaki areas

Cattle herd structure	Bishoftu	Akaki	Overall
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Pregnant cows	0.23 $\pm$ 0.46	1.39 $\pm$ 0.91	0.85 $\pm$ 0.94
Lactating cows	0.51 $\pm$ 0.83	2.46 $\pm$ 1.02	1.55 $\pm$ 1.35
Dry cows	0.03 $\pm$ 0.18	0.36 $\pm$ 0.75	0.21 $\pm$ 0.58
Heifers	0.33 $\pm$ 0.60	0.71 $\pm$ 0.82	0.53 $\pm$ 0.75
Bulls	0.07 $\pm$ 0.31	0.17 $\pm$ 0.42	0.12 $\pm$ 0.37
Oxen	0.03 $\pm$ 0.18	0.13 $\pm$ 0.71	0.08 $\pm$ 0.53
Male calves	0.11 $\pm$ 0.32	0.23 $\pm$ 0.49	0.18 $\pm$ 0.42
Female calves	0.21 $\pm$ 0.52	0.71 $\pm$ 0.69	0.48 $\pm$ 0.66

SD; Standard deviation

#### 4.1. 8. Purpose of keeping dairy cattle

Farmers kept cattle for multi-functional roles, consumption /meat and milk/, income generation and reproduction. Most of the respondents considered that the reason for keeping crossbreed cattle was to generate income from the sale of milk, home consumption and assets. Moreover; they kept for meat, manure and for sale of calves/heifer (Figure 5).

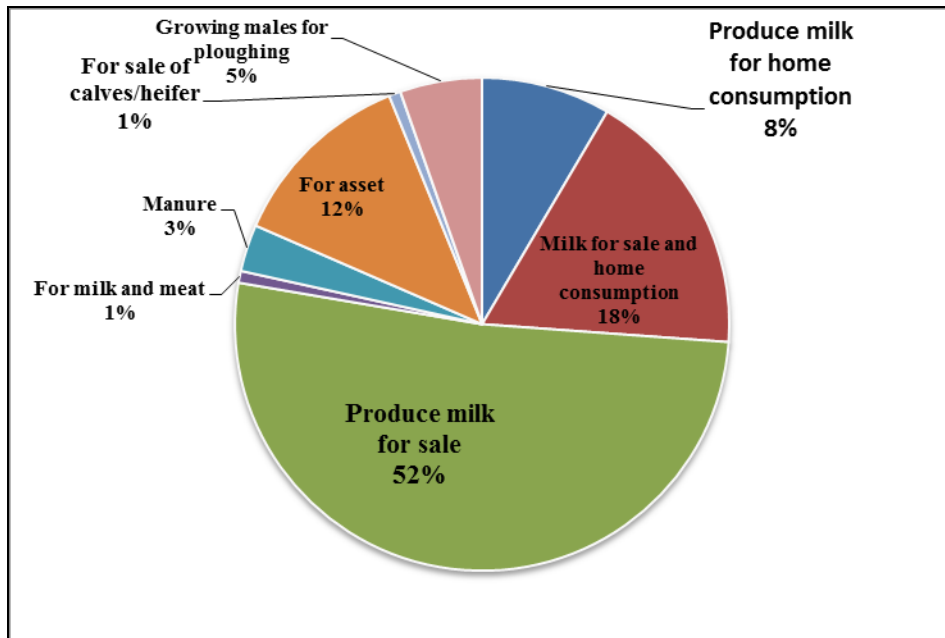


Figure 5. Purpose of keeping cattle (N=130)

## 4.2. Dairy Cattle Husbandry Practices

### 4.2.1. Breeding system

The common mating systems in the study area are AI and natural mating. Results in Table 8 showed that the majority of the interviewed dairy cattle owners used artificial insemination (AI) and some of them use both AI and bull services. Few respondents use only natural breeding (bull) services to their crossbreed cows. The higher use of the artificial insemination service was observed because rearing bull was costly and on the other hand the farmers wanted to upgrade their dairy cattle via introduction of exotic blood. Although animals showed typical signs of estrus, 78.9% owners in Bishoftu and 60% in Akaki were faced with the failure of artificial insemination. Major possible problems of failure of AI reported by the respondents were; heat detection problem, distance to AI centre, and absence of AI technician and inefficiency of AI technician. In Bishoftu, the farmers were charged 39.3 Birr per insemination. Akaki had the lowest insemination charges as farmers paid a mean Birr 26.15 per insemination.

Table 8. Method of dairy cattle mating practices (% of respondents)

Breeding systems	Categories	Town		Overall (N=130)	
		Bishoftu	Akaki		
Breeding system	Natural mating	6.6	5.8	6.2	
	Artificial insemination	50.8	46.4	48.5	
	Both	42.6	47.8	45.4	
Access of AI services	Yes	96.7	97.0	96.9	
	No	3.3	3.0	3.1	
Distance to the AI center	<1Km	10.2	4.6	7.3	
	2-4Km	37.3	89.2	64.5	
	5-7Km	25.4	6.2	15.3	
	>7Km	27.1	0.0	12.9	
Failure of AI	Yes	78.9	60.0	68.9	
	No	21.1	40.0	31.1	
Problems for AI failure	Heat detection problem	11.1	6.5	8.8	
	AI technician inefficiency	31.1	26.1	28.6	
	Distance from AI center	15.6	17.4	16.5	
	Absence of AI technician	28.9	37.0	33.0	
	Other	13.3	13.0	13.2	
	Alternative taken for the AI failures	Private crossbred bull	54.5	38.1	46.5
		Using own crossbred bull	4.5	11.9	8.1
Using own local bull		9.1	-	4.7	
Using crossbred bull at communal		11.4	4.8	8.1	
Using local bull at communal grazing area		4.5	-	2.3	
Extending the mating time		15.9	45.2	30.2	

N= number of smallholder

#### 4.2.2. Dairy cattle housing and cleaning

Table 9 showed the farmers' percentage used housing system and cleaning, types of house and material used for the floor among the two study areas. The majority of milk producers in Bishoftu and Akaki were reported that they followed the housing system of permanent enclosure. The house type of roofed kraal and the material used for wall construction was wood and iron sheet for the roof. While comparing the farmers in both

areas, it was seen that the farmers used the concrete. Due to easy to clean, the concrete floor is preferable over the mud floor. It is difficult to clean the mud floor. The economic ability of the farmers plays a key role whether they use concrete or mud floor. All most all the farmers cleaned the animal house at least once per a day. In the remaining of the farmers, it was done only occasionally, either once per week two times per week or three times per week.

Table 9. Dairy cattle housing conditions under smallholder farmers (% of respondents)

Housing condition	Categories	Town	
		Bishoftu (N=61)	Akaki (N=69)
Housing system of dairy farms	Permanent house	88.5	87
	Temporary house	11.5	13
Type of house	Roofless kraal	9.8	0
	Roofed kraal	78.7	100
	Tethered at the yard	11.5	-
	Wood + Iron sheet	72.1	66.7
	Bricks + Iron sheet	4.9	33.3
Material used for housing	Wood + plastic	23.0	-
Material used for the floor	Earthen/mud floor	26.2	8.7
	Concrete	54.1	87
	Stones	19.7	4.3
Frequency of removal waste material	Every day	93.4	89.9
	Two times per week	3.3	5.8
	Three times per week	3.3	5.8

#### 4.2.3. Milking management and hygiene practices

Milking process primarily is done mostly by women using hands in the animal house (Table 10). During the field observation, dairy cattle houses were always dirty full of cow manure or dusts. The smallholders sometimes wash their hands with cold water and rarely wash the udder and/or teats. The majority of the respondents clean their milk utensils once per day. Even though washing hands and milking vessels used as hygienic practices, washing of udder before and after milking was exercised only by few respondents. About 53.2% of the respondents use hands to dry the udder of cows, while 42.1% of them use

udder cloth and 4.8% disposable towel of the respondents used for a group cows. All of the farmers milked their cows twice per day in both areas.

Table 10. Milking management and hygiene information (% of the respondents)

Variable assessed		Town		Overall (N=130)
		Bishoftu (N=61)	Akaki (N=69)	
Frequency of milking	Two times	100	100	100
Washing hand before milking	Yes	98.4	97.1	97.3
	No	1.6	2.9	2.3
Type of water used for udder/teats washing	Water alone	19.7	39.1	30
	water + soap	80.3	60.9	70
They dry their hands	Yes	75.9	60.9	68
	No	124.1	39.1	32
Udder washing during milking	Yes	98.4	97.1	97.7
	No	1.6	2.9	2.3
They washed it	before milking only	55	82.1	69.3
	after milking only	1.7	-	0.8
	both before and after milking	43.3	17.9	29.9
Material used for cleaning udder	Udder cloth	64.4	22.4	42.1
	Disposable towel	-	9	4.8
	Massage with bare hand	35.6	68.7	53.2
Frequency of washing udder cloth	Daily	93	34.5	69.4
	Weekly	7	27.6	15.3
	Never	-	37.9	15.3
Water used for washing udder cloth	With warm water	54.8	22.2	45
	With boiled water	11.9	38.9	20
	With cold unboiled water	33.3	38.9	35

#### 4.2.4. Milking container and sanitary practices

In the present study, milking containers and sanitary practices are shown in Table 11. Majority of milk producer farmers used plastic made milk containers during milking and transportation to milk collection centers and processing plants. Almost all of the smallholder dairy farmers (89.2 %) washed milking utensils before and after every used.

About 45.4% of the respondent washed their milk container with cold water and soap while 30.7% used hot water and soap. After cleaning the containers, they kept on rafts, hanging them and on the ground.

Most of the farmers (80%) had used water from piped line while 13.1% got their water from community ground pump and 6.9% from river for milk containers cleaning purpose. Water from non tap sources used for different purposes can definitely contribute to poor quality milk and milk products.

Table 11. Milking container handling and sanitary practices (%)

Variable assessed		Town		Overall (N=130)
		Bishoftu (N=61)	Akaki (N=69)	
Containers used for delivery/transportation	Plastic	100	75.4	86.9
	Stainless steel cane	-	24.6	13.1
Handling of milk containers after cleaning	On rafts	54.1	55.1	54.6
	Hanging them	14.8	11.6	13.1
	On the ground	31.1	33.3	32.3
Source of water for cleaning	Piped/ tap water	68.9	89.9	80
	River/ stream	6.6	7.2	6.9
	Ground water	24.6	2.9	13.1
Types of water used for cleaning the container	Cold water alone	21.3	14.5	17.7
	Hot water alone	13.1	-	6.2
	Cold water & soap	26.2	63.7	45.4
	Hot water and soap	39.4	21.8	30.7
Frequency of washing the container	Before every use	19.7	-	9.2
	After every use	3.3	-	1.5
	Before & after every use	77	100	89.2

#### 4.2.5. Calf rearing and weaning practices

Management practices for crossbred calves in the study areas are given in Table 12. In the current study, the respondents used bucket feeding, partial suckling and both methods.

Male calves are not economical to be kept, and farmers sale them cheaply or cull them from stock as soon as possible.

Table 12. Calf rearing practice in the study areas (% respondents)

Activities of calf rearing	Town		
	Bishoftu (N=61)	Akaki (N=69)	Overall (N=130)
<b>Calf milk feeding</b>			
Bucket feeding	82.0	56.5	68.5
Partial suckling	3.3	43.5	24.6
Both	14.8	-	6.9
<b>Male calf</b>			
Sell	70.5	92.8	82.3
Fatten them	14.8	7.2	10.8
Sell as sire	9.8	-	4.6
draught/draft	4.9	-	2.3

N=Number of stallholder

#### 4.2.6. Calf crop, heifer replacement and culling age of cows

Mean calf crop, weaning age and culling age of the crossbred dairy cows are shown in Table 13. The crossbred dairy cows give  $4.98 \pm 1.44$  calves on average in their average culling age of 11.86 years. Calf crop determined by the calving interval of cows in a herd which means that the long calving interval results to reduced calf crop. Smallholder farmers like to keep all cows, even those with low milk production or which never conceive. Good herd management requires the culling of unproductive animals from the herd and replace with improved heifers from different source. Farmers prefer to keep only female calves as future replacement cows and the average weaning age of calves were 2.68 months. The farmers reported on the source of heifers to replace the culling cows (Figure 6).

Table 13. Mean culling age of cows, calf crop and weaning age of calves

Parameters	Bishoftu (N=61)	Akaki (N=69)	Overall (N=130)
	Mean±SD	Mean±SD	Mean±SD
CWA (month)	3.28±0.99	2.16±0.79	2.68±1.05
CAC(yrs)	11.39±2.89	12.28±1.92	11.86±2.46
CC (N)	6.13±1.19	3.96±0.65	4.98±1.44

CAW= calf weaning age, CAC=culling age of cow, CC= calf corps

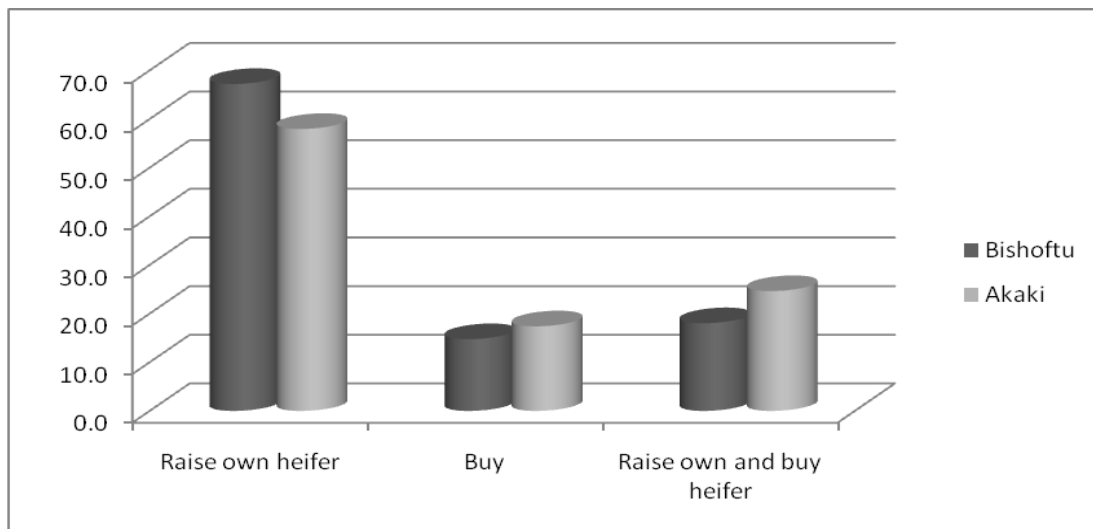


Figure 6. Heifer replacement by the farmers in the study areas

#### 4.2.7. Dairy cattle disease prevalence and health care services

The farmers faced with different dairy cattle diseases, inadequate drugs in government veterinary clinics and expensive drugs in the private owned vet clinics. The farmers got the medicines from local government veterinary extension assistants and they bought medicine from the private veterinary clinic and the distance of the veterinary services they traveled are shown in Table 14. The major diseases pointed out by the smallholders that affect dairy production and productivity in Bishoftu and Akaki includes anthrax, liver

fluke, external parasites, foot and mouth disease, mastitis and lumpy skin disease and black leg under smallholder management system (Figure 7).

Table 14. Sources and distance of veterinary services in the towns (% of households)

Variables	Town		Overall
	Bishoftu (N=61)	Akaki (N=69)	
<b>Who provide vet services</b>			
Government actors	54.1	50.7	52.3
Private actors	45.9	49.3	47.7
<b>Distance to veterinary service</b>			
<1km	37.7	24.6	30.8
1-5km	57.4	47.8	52.3
6-10km	4.9	27.5	16.9

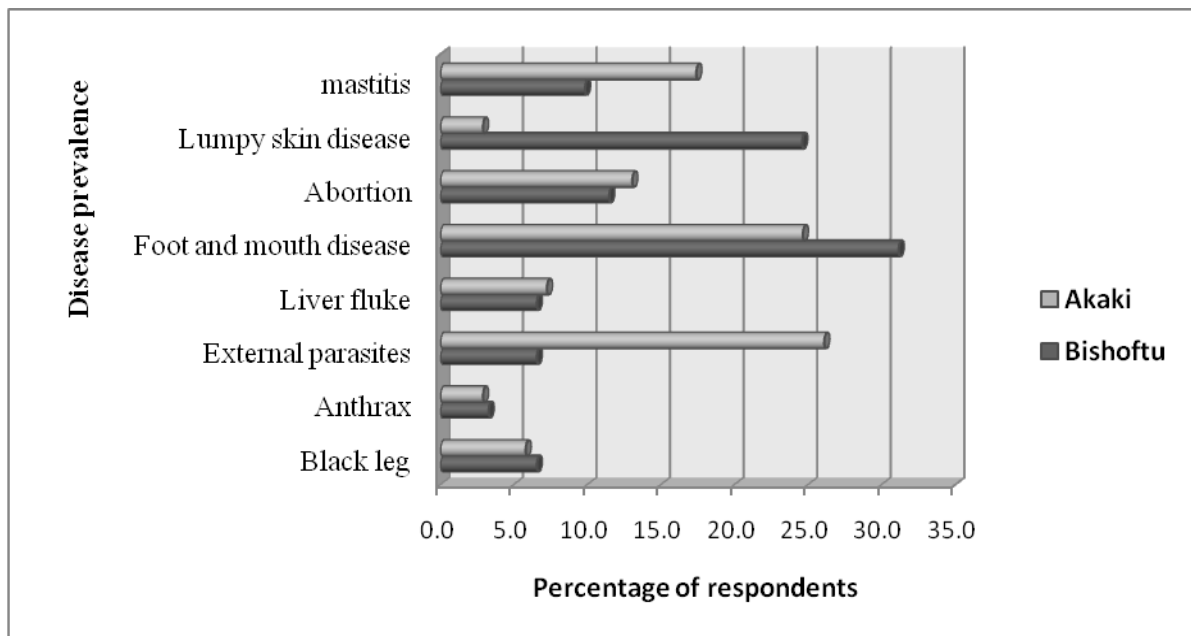


Figure 7. Diseases and associated problems reported by farmers (%)

#### 4.2.8. Feed resources and feeding strategies

Combinations of feeding systems were the characteristics of the study areas. About 74.6% of the respondents use stall (intensive) feeding and 25.4% practice a combination (stall and free grazing) of feeding system. The farmers also indicated that the major sources of

feed for cattle in the study areas were natural pasture, crop residue, conserved hay, industrial byproducts and forages (Table 15). They provided concentrates to dairy cows irrespective of the physiological status of the animal. This could be due to the rise up of feed (concentrates) prices. The availability of feed resources in the area depends on seasons. However, concentrate feeds, crop residues (teff straw, wheat straw and barley straw) and conserved forage (hay), were used both in wet and dry seasons. Few farmers used mineral licks as a supplement for dairy cows.

Table 15. Reported feed resources and feeding system of smallholder dairy (%)

<b>Major feeds and feeding practices</b>	<b>Town</b>		
	<b>Bishoftu (N-61)</b>	<b>Akaki (N-69)</b>	
Natural pasture	16.1	23.2	
Crop residues/straw	11.2	30.4	
Hay	18.5	18.1	
Fodder trees/forages	13.1	5.8	
Industrial by product	41.1	18.1	
<b>Dairy feeding system</b>	<b>Bishoftu</b>	<b>Akaki</b>	<b>Overall</b>
Stall feeding	65.6	82.6	74.6
Stall feeding with limited grazing	34.4	17.4	25.4
<b>Major feed supply for dairy cattle</b>			
Own farm produced	6.6	4.3	3.1
Purchased	26.2	89.9	60.0
Both farm produced and purchasing	67.2	5.8	36.9
<b>Other supplement</b>			
Mineral /salt licks	57.4	10.1	32.3
Concentrates	1.6	2.9	2.3
Mixture of above	9.8	55.1	33.8
No supplements provide	31.1	31.9	31.5

SHD =smallholder dairy, N= Sample of respondents

#### 4.2.9. Sources and distance of water for cattle

Farmers had diverse methods of collecting water to provide their dairy cattle from different sources. The water sources were rivers, borehole, ponds and piped water (Table 16). The main source of water in dry season and rainy season were obtained from pipe

water in both areas. The distance to water tended to affect the frequency of watering cattle. More than half of the farmers watered at home. The households who lived far from the source of water reported that they drove the animals to drink water once/day, or the water was carried to their home using carts. The farmers were faced with water related problems such as scarcity, unhygienic/impurity and parasites such as leaches (Figure 8).

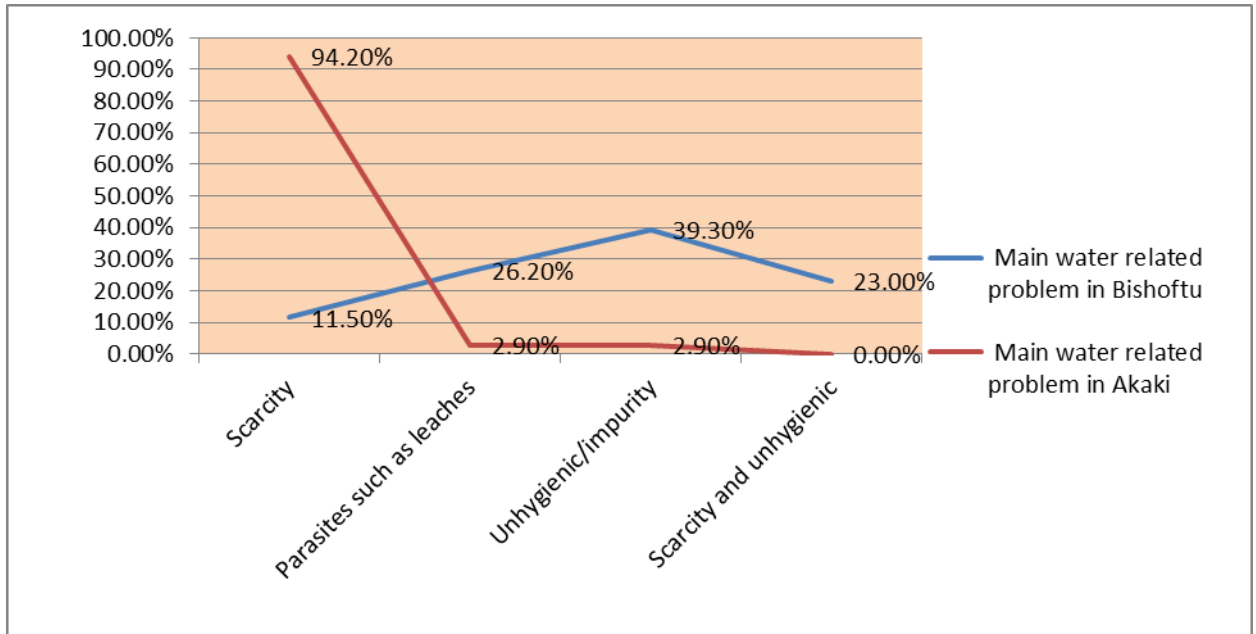


Figure 8. Main water related problem in the study areas

Table 16. Sources and distance of water at different seasons (% of respondents)

Categories	Town			
	Bishoftu (N=61)		Akaki (N=69)	
	Wet season	Dry season	Wet season	Dry season
<b>Source of water</b>				
River	4.9	3.3	27.5	24.6
Borehole	6.6	6.6	-	2.9
Pipe water	65.6	67.2	72.5	72.5
Borehole and spring water	11.5	-	-	-
Pipe water and spring water	11.5	-	-	-
River and pipe water	-	23	-	-
<b>Distance for water</b>				
watered at home	55.7	55.7	100	100
<1km	37.7	11.5	-	-
1-5 km	6.6	32.8	-	-

#### 4.2.10. Record keeping practices

Majority of the households (60%) kept records relating milk sales mainly because they want to be sure they are getting a correct payment at the end of the half month and AI services. Whereas (40%) of the households didn't keep any records (Figure 9). Simple recording tools can be developed and the farmers can be trained in utilization of this information to make decision for better dairy cattle management and thereby optimize the utilization of the available resources in the study areas.

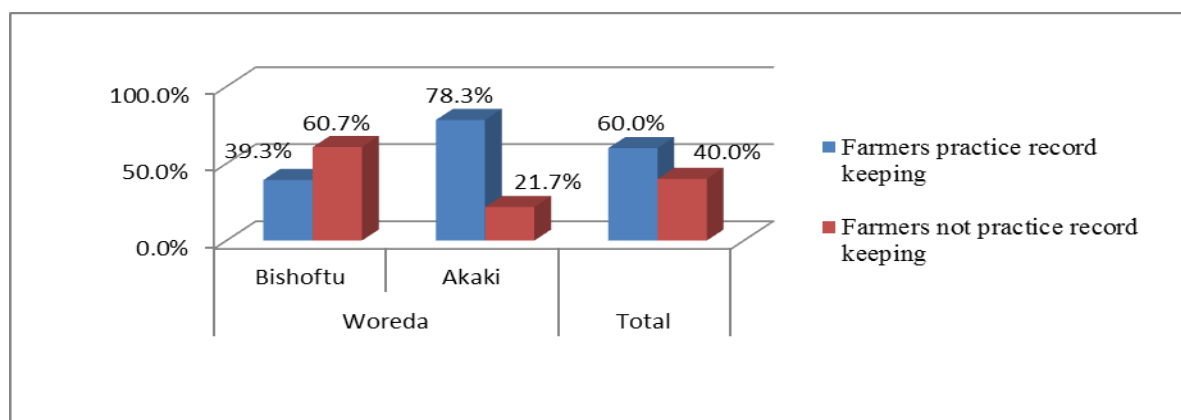


Figure 9. Percent of record keeping practices by the respondents

### 4.3. Constraints of Dairy Cattle Production

The main dairy production constraints as perceived by farmers included high cost of dairy cattle feed, shortage of high yielding dairy cattle, diseases, poor veterinary services and inadequate water supply (Table 17). Each respondents involved in the study was requested to prioritize the constraints of dairy husbandry practice. Lack of dairy cattle feed supply was mentioned as the most important constraint. Inadequate water supply was the second most important constraint in both areas. Improved dairy cattle procurement, prevalence diseases and space limitation for dairying and high cost of animal feeds reported as constraints in both areas.

Table 17. Major dairy production constraints in Bishoftu and Akaki areas (% reported)

Constraints	Town		Overall (N=130)
	Bishoftu (N=61)	Akaki (N=69)	
Inadequate water supply	24.6	17.4	20.8
Lack of grazing land	3.3	-	1.5
High cost of animal feeds	-	7.2	3.8
Shortage of quality feed supply	32.8	69.6	52.3
Space limitation for dairying	4.9	4.3	4.6
Poor veterinary services	-	1.4	0.8
Improved dairy cattle procurement	8.2	-	3.8
Prevalence of diseases	4.9	-	2.3
AI service delivery	11.5	-	5.4
Manure handling/disposal	9.8	-	4.6

N=number of households

### 4.4. Reproductive and Production Performance of Dairy Cattle

This section describes the reproductive and production performances of dairy cattle. The performance of the crossbreed in the two towns was compared to assess their suitability in different management practices.

#### *4.4.1. Age at first service (AFS)*

The smallholder farmers reported that the mean age at first service was  $18.7 \pm 3.7$  and  $18.7 \pm 3.5$  months (range of 13 to 26 months) old for crossbred cattle reared by the farmers in Bishoftu and Akaki, respectively (Table 18). There was no significant difference ( $p < 0.05$ ) in the AFS of the crossbred cattle in the two towns. The largest age recorded in these areas could have resulted from the low level of management and poor feeding of calves and heifers at the earlier stages, which consequently had reduced growth rate and delayed puberty.

#### *4.4.2. Age at first calving (AFC)*

The minimum and maximum age at first calving (AFC) of crossbred cattle was 18 and 36 months in the study areas, respectively. The high AFC observed here may be related to environmental conditions and husbandry practices which may affect the growth. These may retard growth rate, delay puberty, reduced fertility and conception, thus, the high age at first calving of the imported breed.

#### *4.4.3. Calving interval (CI)*

The mean for CI were  $13.0 \pm 2.1$  and  $13.8 \pm 1.9$  months for crossbred cattle at Bishoftu and Akaki, respectively (Table 18). The high calving interval reported in the present study may be related to poor management practices and other environmental stresses that could affect the animals to return oestrus, heat detection, serving and conception at Bishoftu and Akaki towns.

Table 18. Reproductive performance of crossbreed dairy cattle

Parameters	Bishoftu			Akaki		
	Min.	Max.	Mean± SD	Min.	Max.	Mean±SD
AFS (in months)	12	28	18.7±3.7	14	25	18.7±3.5
AFC (in months)	18	36	27.0±3.7	18	36	26.9±5.4
CI (in months)	12	24	13.0±2.1	12	18	13.8±1.9

AFS = Age at First Service, AFC = Age at First Calving, CI = Calving Interval, SD = Standard Deviation

#### 4.4.4. Daily milk yield

The milk productions at different stage of lactation of crossbred dairy cows are presented in Table 19. The mean milk yield was 14.3±5.4 liters, 12.7±2.7liters, and 7.9±2.5 liters for the first, second and third stage of lactations, respectively with an overall average of 11.6±3.1 liters day/cow in Bishoftu. The mean milk yield was 14.5±3 liters, 10.6±2.67liters, and 7.1±2.0 liters for the beginning, mid and end lactations, respectively with an overall average of 10.8±2.4 liters per d/cow in Akaki.

#### 4.4.5. Total lactation milk yield (TLMY)

Table 19 shows that the total mean lactation milk yield (TLMY) of crossbreed dairy cows was found to be 3208.56 liters and 3031.56 liters for Bishoftu and Akaki, respectively. The lower total lactation milk yield obtained here could have been influenced by keeping low productive crossbred dairy cattle, and poor management practices.

#### 4.4.6. Lactation length

The mean lactation length of crossbreed cows in the present study was found to be 276.6±35.1and 280.7±19.3 days for Bishoftu and Akaki, respectively (Table 19).

Table 19 Productive performance of crossbreed dairy cows

Production parameters	Town	
	Bishoftu (Mean±SD)	Akaki (Mean±SD)
DMY(liter)	11.6±3.1	10.8±2.4
Beginning lactation	14.3±5.4	14.5±3
Mid lactation	12.7±2.7	10.6±2.6
End lactation	7.9±2.5	7.1±2.0
TLMY/cow (liter)	3208.56±108.81	3031.56±46.32
LL (Days)	276.6±35.1	280.7±19.3

DMY= Daily milk yield; TMY/L= Total milk yield per lactation; LL= Lactation length; SD= Standard deviation; mean value

#### 4.5. Raw Milk Physical Characteristics

The physical parameters of milk samples collected from the milk value chain points such as milk producers, milk collectors and milk processors in Bishoftu and Akaki towns are shown in table 20 and 21.

##### 4.5.1. Added water

In the value chain points, the overall mean value of added water for milk producers, milk collectors and milk processors was 2.80±3.60. The added water of milk samples collected was not significant varied ( $P>0.05$ ) among the value chain points. The average mean values of added water content in Bishoftu and Akaki was 3.58±3.91 and 1.20±2.18, respectively. The result showed that there was significant difference in adulteration rate of added water in the two towns.

##### 4.5.2. Freezing point of milk

Mean value and standard deviation of freezing point of milk from milk producers (MP), milk collection (MC) and milk processing plants (MPP) were evaluated. The freezing

point of milk samples collected was not significantly varied ( $P>0.05$ ) among the value chain points (Table 20). The mean values of freezing point of milk samples collected from Bishoftu was significantly ( $P<0.05$ ) high as shown in (Table 21).

#### *4.5.3. Density of milk*

The mean and standard deviation of the specific gravity of raw milk samples collected from milk producers MP, milk collection MC and milk processing plants MPP was  $1.028\pm 0.002$ ,  $1.028\pm 0.002$  and  $1.028\pm 0.002$  respectively. Statistically it was found that there were no significant differences ( $P > 0.05$ ) within the specific gravity of milk collected from the different milk value chain points (Table 20). The specific gravity of milk obtained from Bishoftu ( $1.028\pm 0.002$ ) was higher than the specific gravity of milk obtained from Akaki ( $1.029\pm 0.002$ ). Significant differences ( $P<0.05$ ) were observed for density between the towns as shown in table 20.

#### *4.5.4. pH*

The average pH value was  $6.66\pm 0.04$  with the raw milk sampled recording readings. The pH of all the milk samples collected from MP, MC and MPP were found to be  $6.66\pm 0.05$ ,  $6.66\pm 0.01$  and  $6.66\pm 0.01$ , respectively (Table 20). No significant variations were found for the parameter in all the milk samples in the different milk value chain points. The mean pH values of raw milk were  $6.67\pm 0.04$  for Bishoftu and  $6.64\pm 0.05$  for Akaki. The results showed significant variation ( $P<0.05$ ) in the tow towns.

### **4.6. Raw Milk Chemical Characteristics**

The results of the laboratory for chemical parameters of raw milk samples such as solid not fat (SNF), protein, lactose, fat, total solids (TS) and ash are shown in (Table 20 and Table 21).

#### *4.6.1. Fat content*

The composition of milk samples collected from different channels/value chain points is presented in Table 20. The mean value of fat content in milk samples collected from MP was  $3.60\pm0.5$  followed by MC and MPP ( $3.56\pm0.30$  and  $3.63\pm0.22$ , respectively). Statistical analysis showed that there were no significant differences ( $P>0.05$ ) within the fat content of milk collected from different value chain points. The mean value of fat content in milk collected from Bishoftu ( $3.51\pm0.54$ ) was lower than milk samples collected from Akaki ( $3.78\pm0.46$ ), even though there was not significantly different ( $P>0.05$ ) Table 21.

#### *4.6.2. Solid not fat (SNF)*

The mean values of solid not fat (SNF) content of raw milk samples collected from MP, MC and MPP are shown in the Table 20. Statistical analysis showed that there were no significant differences within the SNF content of milk collected in the different milk value chain points. The average SNF content of raw milk samples collected from Bishoftu and Akaki towns were  $7.69\pm0.42$  and  $7.98\pm0.33$ , respectively. It was found that there was significant difference within the SNF of raw milk samples collected from between the towns (Table 21).

#### *4.6.3. Total solids (TS)*

The average total solid (TS) content of raw milk samples collected from MP, MC and MPP are shown in the (Table 20). The means and standard deviation of TS content of raw milk collected from MP, MC and MPP were  $11.43\pm0.79$ ,  $11.12\pm0.83$  and  $11.44\pm0.59$ , respectively (Table 20). Statistical analysis showed that there were no significant differences within the TS content of milk collected from the milk value chain points. The mean values of total solids in milk collected from Bishoftu ( $11.20\pm0.80$ ) was significantly ( $P<0.05$ ) lower than milk samples collected from Akaki town ( $11.76\pm0.60$ ) (Table 21).

#### *4.6.4. Ash content*

The average ash contents of raw milk samples collected from MP, MC and MPP were  $0.63\pm 0.05$ ,  $0.59\pm 0.04$  and  $0.60\pm 0.00$  respectively as shown in table 19. Statistically it was found that there were no significant differences within the ash of different types of raw milk samples collected from the different value chain points. The average ash content in milk samples collected from Bishoftu town ( $0.62\pm 0.06$ ) and Akaki ( $0.62\pm 0.04$ ) was similar. Statistically it was found that there were not significant differences ( $P>0.05$ ) within the ash content of different types of raw milk samples collected from Bishoftu and Akaki towns (Table 21).

#### *4.6.5. Protein content*

The average protein contents of raw milk samples collected from MP, MC and MPP were  $3.28\pm 0.14$ ,  $3.19\pm 0.20$  and  $3.28\pm 0.15$  respectively. Statistical analysis showed there were no significant difference ( $P>0.05$ ) in protein percentage among the three value chain points. The mean protein content obtained in Bishoftu was ( $3.23\pm 0.16$ ) and the mean protein content obtained from Akaki town was ( $3.34\pm 0.12$ ). There was significant difference ( $P < 0.05$ ) between the two locations.

#### *4.6.6. Lactose*

The average lactose contents of raw milk samples collected from MP, MC and MPP were  $3.95\pm 0.23$ ,  $3.82\pm 0.34$  and  $3.94\pm 0.28$ , respectively (Table 20). Statistical analysis showed that there was no significant difference ( $p>0.05$ ) in the value chain points. Although no significant variations ( $P>0.05$ ) were obtained between the two locations, the mean lactose content of milk collected from Bishoftu ( $3.87\pm 0.26$ ) was lower than that of milk samples collected from Akaki ( $4.04\pm 0.20$ ).

Table 20. Physico-chemical parameters of raw milk collected from value chain points

Parameters (%)	Milk value chain points			P-value	Overall
	MP (N=40)	MC (N=8)	MPP (N=4)		
pH	6.66±0.05	6.66±0.01	6.66±0.01	0.98	6.66±0.04
Freezing point	-0.55±0.02	-0.53±0.04	-0.55±0.03	0.25	-0.55±0.03
Density	1.028±0.002	1.028±0.002	1.028±0.002	0.41	1.028±0.002
Added water	2.43±2.98	4.76±5.85	2.61±3.58	0.25	2.80±3.60
Fat	3.60±0.58	3.56±0.30	3.63±0.22	0.97	3.60±0.53
Protein	3.28±0.14	3.19±0.20	3.28±0.15	0.27	3.27±0.15
SNF	7.83±0.38	7.56±0.55	7.81±0.42	0.26	7.78±0.41
Total solid	11.43±0.79	11.12±0.83	11.44±0.59	0.60	11.38±0.78
Lactose	3.95±0.23	3.82±0.34	3.94±0.28	0.43	3.93±0.25
Ash	0.63±0.05	0.59±0.04	0.60±0.00	0.13	0.62±0.05

MP =Milk collectors, MC= Milk Producers, MPP =Milk processing plants, N=number of samples, SNF= solid not fat, Mean value with different superscript letters for each milk quality parameters in the rows are significantly different (p<0.05)

Table 21. Physico-chemical properties of raw milk samples

Parameters (%)	Town		P-value
	Bishoftu	Akaki	
pH	6.67±0.04 <sup>a</sup>	6.64±0.05 <sup>b</sup>	0.03
Freezing point °C	-0.54±0.03 <sup>a</sup>	-0.56±0.02 <sup>b</sup>	0.04
Density	1.028±0.002 <sup>a</sup>	1.029±0.002 <sup>b</sup>	0.04
Added water	3.58±3.91 <sup>a</sup>	1.20±2.18 <sup>b</sup>	0.02
Fat	3.51±0.54	3.78±0.46	0.08
Protein	3.23±0.16 <sup>a</sup>	3.34±0.12 <sup>b</sup>	0.02
SNF %	7.69±0.42 <sup>a</sup>	7.98±0.33 <sup>b</sup>	0.02
Total solid	11.20±0.80 <sup>a</sup>	11.76±0.60 <sup>b</sup>	0.01
Lactose	3.87±0.26 <sup>a</sup>	4.04±0.20 <sup>a</sup>	0.06
Ash	0.62±0.06 <sup>a</sup>	0.62±0.04 <sup>b</sup>	0.04

Mean value with different superscript letters for each milk quality parameters in the rows are significantly different (p<0.05)

#### **4.7. Correlation Between Physico-Chemical Properties of Raw Milk**

A correlation between different physico-chemical properties of raw milk in the study towns are presented in (Table 22). Acidity was negatively and significantly correlated with pH, freezing point and add water ( $P < 0.01$ ). Moreover, acidity was positively and significantly correlated with lactose, protein, SNF, total solid and density at ( $P < 0.01$ ) and fat at ( $P < 0.05$ ). However, there was no correlation between ash and acidity. Milk protein was positively and significantly correlated with fat, SNF, ash, lactose and total solid of milk ( $P < 0.01$ ) and significantly correlated with each other ( $P < 0.05$ ). Milk protein was negatively and significantly correlated with pH ( $p < 0.05$ ), added water, freezing point at ( $p < 0.005$ ) and positively significantly correlated with density at ( $p < 0.01$ ).

Table 22. Correlation among physico-chemical properties of raw milk

	Acidity	PH	Freezing point	Density	Add water	FAT%	Protein	SNF	Total solid	Lactose
Acidity	1									
PH	-.610**	1								
Freezing point °C	-.578**	.260 <sup>NS</sup>	1							
Density	.541**	-.266 <sup>NS</sup>	-.943**	1						
Add water	-.568**	.229 <sup>NS</sup>	.945**	-.861**	1					
FAT	.315*	-.206 <sup>NS</sup>	-.349*	.159 <sup>NS</sup>	-.394**	1				
Protein	.606**	-.314*	-.987**	.938**	-.934**	.400**	1			
SNF	.600**	-.308*	-.988**	.947**	-.933**	.365**	.999**	1		
Total solid	.531**	-.303*	-.761**	.611**	-.762**	.869**	.801**	.778*	1	
Lactose	.571**	-.224 <sup>NS</sup>	-.954**	.934**	-.913**	.280*	.958**	.963*	.701**	1
ASH	.151 <sup>NS</sup>	-.095 <sup>NS</sup>	-.436**	.325*	-.426**	.550**	.457**	.442*	.606**	.296*

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\* . Correlation is significant at the 0.01 level (2-tailed). NS= have not significant difference correlation

## **4.8. Microbial and Associated Quality of Cow's Raw Milk**

### *4.8.1. Total bacterial count*

The average values of total bacteria count/ml of raw milk samples collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were  $7.01 \pm 1.02 \log_{10}$  cfu/ml,  $7.50 \pm 0.51 \log_{10}$  cfu/ml, and  $8.16 \pm 0.68 \log_{10}$  cfu/ml, respectively (Table 23). Statistically there was a significant difference ( $P < 0.05$ ) in total bacteria count/ml of raw milk collected from the three different value chain points. The overall mean of TBC obtained from raw milk in the present study is  $7.17 \pm 0.98 \log_{10}$  cfu/ml.

### *4.8.2. Coliform count (CC)*

The average values of coliform counts/ml of raw milk samples collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were  $5.66 \pm 1.71 \log_{10}$  cfu/ml,  $6.81 \pm 0.81 \log_{10}$  cfu/ml and  $6.75 \pm 0.96 \log_{10}$  cfu/ml, respectively (Table 23). Statistical analysis showed that there was no significant difference within the coliform counts/ml from different raw milk sample sources and it was observed that the coliform counts/ml of milk samples were high. This may be due to poor hygienic milking, improper cleaning of dairy utensils and unhygienic handling during marketing of milk.

### *4.8.3. Somatic cell count (SCC)*

Results for somatic cell count (SCC) are summarized in Table 23. The SCC collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were  $4.90 \pm 2.04 \log_{10}$  somatic cell/ml,  $5.64 \pm 0.57 \log_{10}$  somatic cell/ml and  $5.71 \pm 0.55 \log_{10}$  somatic cell/ml, respectively. Analysis showed that there was no significant difference ( $p > 0.05$ ) in the different milk value chain points and between the two towns. The overall mean of SCC in the two areas was  $5.07 \pm 1.83 \log_{10}$  somatic cell/ml.

#### 4.8.4. Titratable acidity

Mean value and standard deviation of acidity in raw milk samples collected from MP, MC and MPP were  $0.176\pm 0.02$ ,  $0.175\pm 0.01$  and  $0.175\pm 0.01$ , respectively (Table 23). The analysis showed that there was significant differences ( $P < 0.05$ ) within the acidity percentage of milk collected from different value chain points. The mean acidity percent of milk samples collected from Bishoftu town and Akaki town was similar. There was no significance variation ( $P > 0.05$ ) showed between the two towns (Table 24).

Table 23. Microbial counts and acidity of raw cows' milk in the value chain points

Variables	Milk value chain points			Overall
	MP (N=40)	MC (N=8)	MPP (N=4)	
TBC (log <sub>10</sub> cfu/ml)	7.01±1.02 <sup>a</sup>	7.50±0.51 <sup>b</sup>	8.16±0.68 <sup>c</sup>	7.17±0.98
CC (log <sub>10</sub> cfu/ml)	5.66±1.71 <sup>a</sup>	6.81±0.81 <sup>a</sup>	6.75±0.96 <sup>a</sup>	5.92±1.62
SCC (log <sub>10</sub> sc/ml)	4.90±2.04 <sup>a</sup>	5.64±0.57 <sup>a</sup>	5.71±0.55 <sup>a</sup>	5.07±1.83
Acidity%	0.178±0.017 <sup>a</sup>	0.183±0.013 <sup>b</sup>	0.175±0.013 <sup>c</sup>	0.179±0.016

MP=milk producers, MC=milk collectors, MPP=milk processing plants, N = number of samples taken; cfu = colony-forming units; Means with different superscript letters in rows are significantly different, ( $P < 0.05$ ); TBC=Total Bacterial count; CC =Coliform count.

Table 24. Microbial counts and acidity of raw milk (mean ± SD)

Milk sources	N	Variables (Log <sub>10</sub> )			TA%	
		TBC (cfu/ml)	CC (cfu/ml)	SCC (sc/ml)		
Bishoftu	Milk producers	23	6.78±1.13	5.48±1.90	4.88±2.14	0.17±0.02
	Milk collectors	5	7.40±0.55	6.80±0.45	5.79±0.54	0.18±0.02
	Milk processors	3	8.67±0.58	6.33±1.15	5.52±0.46	0.19±0.02
	Total	31	7.06±1.15	5.77±1.75	5.09±1.89	0.18±0.02
Akaki	Milk producers	17	7.24±1.03	5.53±1.37	4.92±1.95	0.18±0.02
	Milk collectors	3	7.33±0.58	6.33±1.15	5.39±0.65	0.18±0.01
	Milk processors	1	7.00±0.00	7.00±0.00	6.31±0.00	0.16±0.00
	Total	21	7.24±0.90	5.71±1.35	5.05±1.79	0.18±0.02

N=Number of source of samples; TBC=Total bacterial count; CC= Coliform count; TA= Titratable acidity; SD=Standard deviation, cfu= colony-forming units; SCC= Somatic cell count

#### **4.9. Analysis of Milk Value Chain and Marketing**

The current survey revealed the existence of different types of milk market outlet options/channels in the study areas. The formal system delivers raw milk to milk collectors and milk processors. Channel 3 and channel 4 showed the formal milk value chain. In the informal system, milk passes from producers to consumers directly or it may pass through two or more retailers. Milk outlet channels of the formal and informal value chain is carried through different channels in the study areas. Five channels of distribution of milk by smallholder farmers have been identified which are explained as follows:

Channel 1: Producers → Individual consumers

Channel 2: Producers → Retailers (Local hotels, restaurants, cafes) → Consumers

Channel 3: Producers → Collection centers → processing plants → Consumers

Channel 4: Producers → Milk processing plants → Consumers

Channel 5: Producers → Sale at retail shops (sell dairy products only) → Consumers

#### **4.10. Milk Value Chain Actors**

The value chain actors identified include input suppliers, producers, milk collectors, processors, distributors and consumers (Figure 10). Description of the roles of the value chain actors is given below.

##### *4.10.1. Dairy inputs/services providers*

Debre-Zeit research center, Oromia cooperative bank, district cooperative development office and Addis Ababa University college of Veterinary Medicine and Agriculture, district livestock development offices, National Artificial Insemination Center (NAIC) veterinary clinics, private feed processing plants and Private AI service provide the inputs required for the functioning of the subsequent chains. The services include: feeds, veterinary service, AI/breeding service and credit service, among others.

#### *4.10.1.1. Feed suppliers*

Farmers indicated that they purchase concentrate feeds and associated ingredients from either local processing units or small retailers in Bishoftu and Akaki towns and crop residues and native grass hays from neighboring rural kebeles and enclosures from government institutions.

#### *4.10.1.2. Veterinary services*

Discussions with FGDs with veterinarians, development agents (DAs), livestock experts and farmers at both towns revealed, among others: external parasites, foot and mouth disease, mastitis, abortion and liver fluke were the critical dairy cattle health problems. The private service providers the government's agricultural extension system based at district level also providing veterinary services to the smallholder milk producers. However, this service was rated to be inadequate in terms of drugs, financial, material and knowledge capabilities.

#### *4.10.1.3. Artificial insemination*

This study revealed two categories of AI service providers to exist in the system (government and private service providers). While AI service is delivered by the government National Artificial Insemination Center (NAIC), Private AI service providers are located in towns and provide the service directly to the producers on a demand basis in addition natural service is provided by bulls owned by individual farmers in the towns who charge little or nothing. The proportion of farmers' currently getting AI services in Bishoftu and Akaki was similar. Close to 97% farmers indicated to have access to AI in both areas with a service charge of close to 39 and 26 ETB per conception in Bishoftu and Akaki, respectively.

#### *4.10.1.4. Training and extension services*

The study indicated that 90.2% of the respondents from Bishoftu and 46.4% from Akaki were involved in various agricultural extension services. According to development agents, provision of extension services was based on the needs of farmers and the training was indicated to provide in collaboration with governmental and nongovernmental organizations. Only 88.5% in Bishoftu and 42% in Akaki of the dairy cattle owners reported that had given training on general aspects of farm management, proper milking, milk handling, milk marketing, processing, record keeping, heat detection feeding and dairy health management which is organized by Bureau of Agriculture and Rural Development (BoARD), microenterprises and urban agriculture development desk (Table 4).

#### *4.10.1.5. Market information*

The study indicated that around 56% of producers get market information from extension agents, other farmers, stakeholders and association. Around 44% of farmers indicated to have no market information and sale their product directly to retailers (hotels, shops café etc.) collectors, processors and individual consumers (Table 4).

#### *4.10.2. Milk producers*

The study indicated that farmers deliver their milk to collection centers (48.5%), to hotels restaurants and cafes (13.1%), processing plants (12.3%), retail shops or kiosks (11.5%), neighborhood customers (12.3%) and very small numbers of farmers (2.3%) consume as raw milk and process into butter and other milk derivatives for household consumption (Figure 10). Based on direct observation, it was found that plastic buckets were commonly used to collect the milk before transferring into bulk tanks.

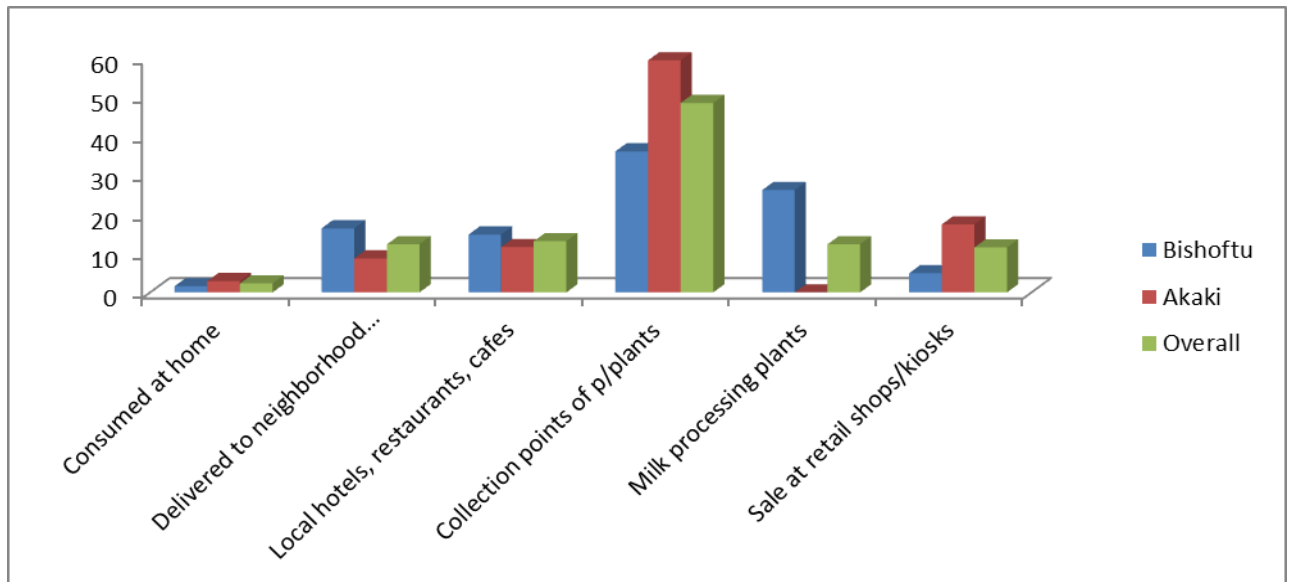


Figure 10. Distribution and utilization of raw milk by the farmers

#### 4.9.2.1. Allocation pattern of milk

The mean daily milk yields were around 15 and 13 liters/household in wet and dry season, respectively. Average milk production per household per day was 14 litres. The bulk of farm produced milk is delivered usually twice a day to milk collection center or processing plants. Dairy producers sell varying amounts of milk depending on socioeconomic characteristics. The amount of milk disaggregated in the towns was to consume at home, provide to calves, milk wasted and for selling (Table 25).

Table 25. Allocation of milk quantities (in litre) at different seasons (per day/HH)

Raw milk	Bishoftu( N=61)	Akaki (N=69)	Overall (N=130)
	Mean± SD	Mean± SD	Mean± SD
<b>Wet season</b>			
Total milk yield	15.21± 7.5	15±3.7	15.1±5.7
Home consumption	1.48±1.8	1.2±0.6	1.3±1.3
Milk wastage	0.1±0.2	-	-
Milk given to calf	1.54±1	1.6±1.1	1.6±1.1
Milk sold/delivered	12±7.3	12.3±2.9	12.2±5.4
<b>Dry season</b>			
Total milk yield	14.2±7.1	12.3±3.5	13.2±5.5
Home consumption	1.2±1.3	0.9±0.7	1.0±1.0
Milk given to calf	1.7±1.1	1.7±1.0	1.7±1.1
milk sold/delivered	11.3±7	9.8±2.8	10.5±5.2

#### 4.10.3. Milk collection and transportation

Milk collection centers are owned by cooperatives and processing plants. Farmers are usually paid two weeks after milk has been delivered. Most of the smallholder dairy farmers deliver their milk themselves to the collection centers or processing plants on foot. Some farmers use different transportation means such as motor vehicles, bicycles and carts with different types of milk containers such as aluminum containers and plastic containers (Table 26). Based on field observation quality checks (color, added water and odder) were done using observation, lactometer and alcohol tests. The plastic containers were unhygienic as they are more difficult to clean than the more expensive aluminum cans.

About 44.3% of the respondents lived at distances less than 1km from the respective milk collection centers, 29.5% at 1-5 km and 26.2% travel greater than 5km in Bishoftu. About 49.3% farmers traveled less than 1km and 50.7% traveled 1-5km for Akaki. Thus the longer the distance from the milk collection center the lower the number of smallholder dairy farmers delivering their milk.

Table 26. The distance and mode of transportation to deliver the milk (%)

Distances to milk delivered	Town	
	Bishoftu (N=61)	Akaki (N=69)
Less than 1 km	44.3	49.3
1-5 km	29.5	50.7
>5 km	26.2	-
<b>Means of milk deliveries</b>		
Motor vehicles	23.0	4.3
Bicycles	-	5.8
On foot	60.6	89.9
Cart	16.4	-

#### 4.10.4. Milk processing

There are 4 companies processing milk in Bishoftu. The processing capacity of existing plants is over 45000 litres/day but only 35% of that capacity is currently processed. The main products of the plants are standardize pasteurized milk (skim), ultra-heat treated (UHT) milk, raw milk (full cream and skimmed), yoghurt, butter and ghee, cheese and cream. Fresh milk sold in the urban centers is the main product. The plants processed various types of milk products are shown in Table 27.

Other necessary inputs in processing operations include packaging materials, different ingredients, laboratory equipment and chemicals. One of the main reasons pointed out by the owners for poor capacity utilization of the plants is due to low milk deliveries from the farmers. This is caused by low producer prices paid to the farmers, which lead to side marketing and milk being retained for household consumption.

Table 27. The dairy processing plants currently produce/sell dairy products

<b>Dairy Products</b>	<b>Plant</b>	<b>Plant B</b>	<b>Plant C</b>	<b>Plant D</b>	<b>Packaging material</b>
Pasteurized Milk (full cream)		√	√		
Pasteurized Milk (skim)				√	
Extended shelf-life milk		√			
UHT milk	√			√	
Raw Milk (full cream)		√	√	√	
Raw Milk (skim)					
Cream			√		
Table Butter			√		
Cooking Butter	√	√	√	√	
Local cheese		√	√	√	
Yogurt	√				Plastic cup
Gouda Cheese		√	√		
Flavoured yogurt	√	√	√		Plastic cup and sticker

#### 4.10.5. Consumers

Consumption of milk and milk products started at farm and farmers consumed limited quantity of milk in different forms. This showed that in addition to creating access to food through increased cash income, milk directly contributed to the food security at the household level. In the study areas, milk from the smallholders reached the final consumers passing through different channels (Fig. 11).

#### 4.10.6. Enabling environment

The existence of conducive policy frame work in the development of agricultural sector in general and the dairy sector in particular have significant roles to play in enabling the performance of a commodity value chain. The milk value chains describe many policies, regulations, guidelines, and programs that affect the dairy sector. Dairy value chain operates in an enabling environment, which is improving, but is not yet effective in facilitating a competitive value chain that allows actors to seek and expand opportunities. There are a number of policy and regulatory issues that directly impact the dairy businesses in the study areas. These business enabling environment include access to

finance, commercial registration and business licenses, access to land, grades and standards, animal health regulatory issues and access to some basic infrastructure (Fig. 11).

#### **4.11. Map of Inputs and Products Flow in Dairy Value Chain**

A schematic diagram/map representing raw milk value chain at Bishoftu and Akaki towns was figured based on information gathered during the field study (Figure 11). At both towns, the main value chain divisions identified were: input supply, production, collection, processing and consumption. The main actors along the value chain include input suppliers, producers, collectors, processors and consumers. Under the input supply division, inputs like feed, breeding and AI services and animal health services, technology and information services inputs were found to be important. Moreover, enabling environments contain infrastructures, policies and regulations (livestock development), investment policies, quality control, standards, social and cultural norms and institutions have significant roles to play in enabling the performance of dairy commodity of value chain.

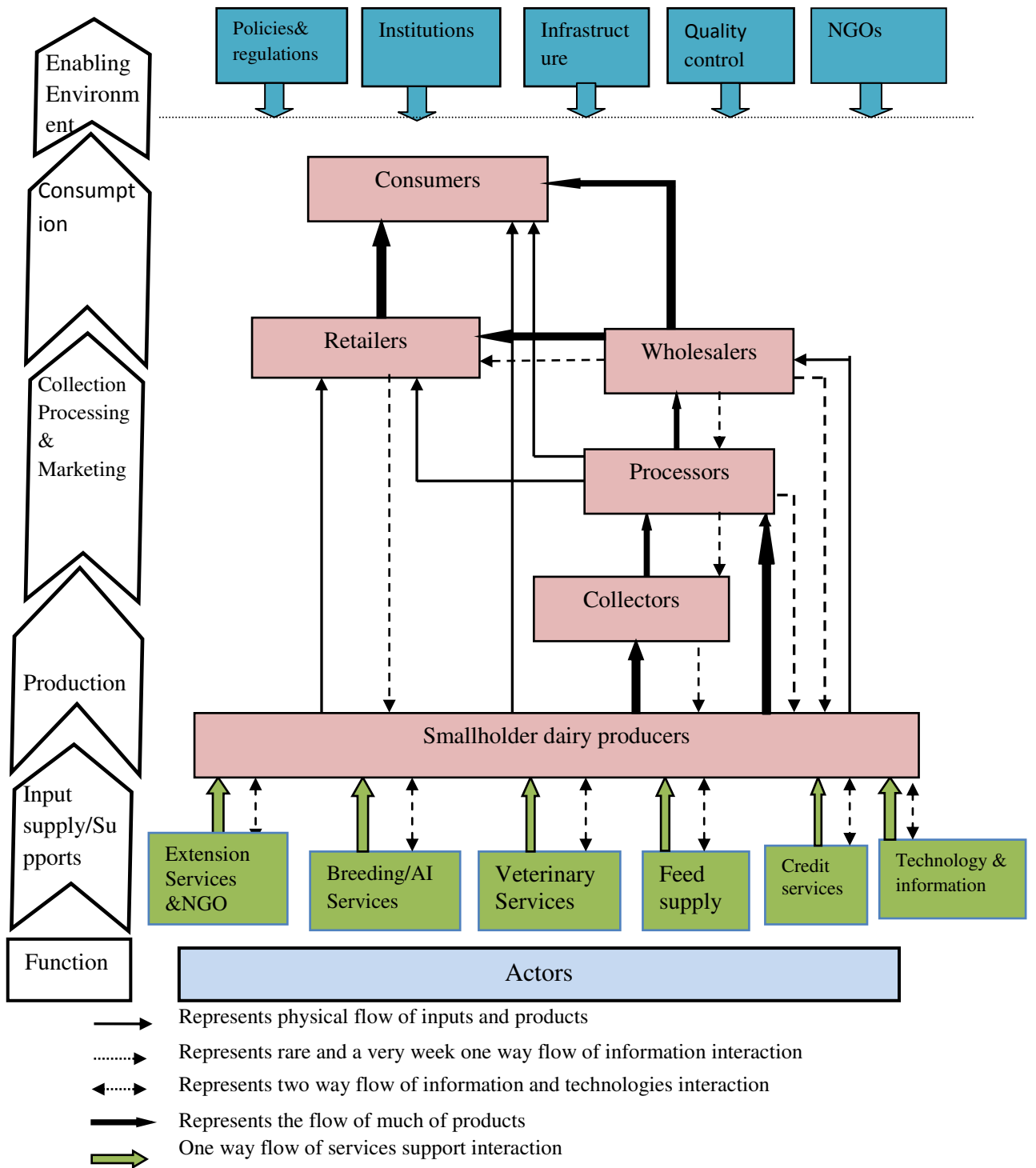


Figure 11. A schematic diagram describing dairy value chain in study areas  
 Source: Author's illustration based on field information

#### 4.12. Raw Milk Marketing and Value Chain Constraints

There are many constraints encountered by the milk producers in marketing of milk through five different channels of distribution (Table 28). The respondents were asked to prioritize the constraints of dairy value chain in Bishoftu and Akaki. They indicated that low milk price, lack of access to adequate markets and lack of access to credit was the main obstacle hindering them from channeling their milk to costumers, processors either through milk collection centers or selling direct to processing plants. In addition, data from key informant interview showed that the absence of policy instrument that governs market route is serious milk marketing problem.

Table 28. Smallholders milk marketing constraints (% of respondents)

Main constraints	Town		Overall (N=130)
	Bishoftu (N=61)	Akaki N(=69)	
Distance to collection centers	11.5	-	5.4
Lack of access to adequate markets	21.3	24.6	23.1
In adequacy of labor to transport	6.6	2.9	4.6
Spoilage of milk during transportation	11.5	4.3	7.7
Inadequate market information	1.6	2.9	2.3
Inadequate infrastructural development	3.3	5.8	4.6
Lack of access to credit	6.6	11.6	9.2
Low price of milk	37.7	47.8	43.1

## 5. DISCUSSION

### 5.1. Household Characteristics

In the current study it was observed that 66.9% of interviewed stallholders keeping dairy cattle were male while 33.1% of them were female which is similar to the findings reported by Mustefa (2012) for Sululta and Welmera but different from the findings reported by Diriba (2014) in Bako and Nekemte peri-urban areas. It does not mean that more men are involved in dairy activities than women. It suggests a possibility of both men and women controlling most household resources and hence both play crucial role in household income generation. Results showed that the majority of the respondents were married 84.6%. This implies that dairy production activities are dominated by married people and the reason could be that they kept crossbred dairy cows for the purpose of supporting their family members using income generated by selling dairy products. This finding also concur with the finding of Lucas (2013) who reported that, majority of the married farmers engage in milk marketing activities in order to generate cash income to meet various household needs or requirement as well as expanding their household income base.

The mean ( $45.37 \pm 9.69$  years) age of household heads found across the two towns was comparable to the  $46.02 \pm 0.75$  years reported by Hailu *et al.* (2011) but less than to the  $47.6 \pm 1.7$  years reported by Wondatir (2010). In the present study, most of the respondents' age ranged between 41-50 years, who is working in dairy farms with probable family responsibilities. This finding was contrary with that of Dawit (2010) where it was reported that the age of 15 and 65 years is being for active and productive group. This implies that a great proportion of the respondents were adult people who have involve in dairy production activities. Age can be an indicator of experience, extent of wealth accumulation and capacity of decision making which affect how one works and his/her productivity. The proportion of farmers, business men, and government employees took the leading with regard to ownership of dairying in the study areas as a

whole. Retired person and others are also involved in dairy production though they were in small proportion.

Educational level of all interviewed smallholder framers were 29% could write and read and 16% of them illiterate (could not write and read) 13% elementary school completed and 14% secondary and above. Illiteracy obviously has negative impact on transfer of improved technologies to the communities, as anticipated by Mulugeta (2005) and Quddus (2013) reported that adoption of dairy technology is positively or negatively associated with the level of farmer's education. It could be said that dairy smallholder farmers with higher education level were more likely to accept training on dairy management, feed properly and protect animals from disease which resulted producing larger volume of quality daily milk yield. Education is an important factor which if lacking can negatively impact on future improved dairy production and productivity.

The overall mean family size per household in study areas was  $5.49 \pm 1.8$  which is similar with findings of Assaminew (2014) in Holleta area and greater than the national average 4.6 persons per family (CSA, 2011). However, the average family size of the respondents was less than the result 7.4, 7.5 and 7.1 persons/household reported by Zewdie (2010), in Debre-brhan, Jima and Sebeta, respectively. In this study, smallholder dairy farmers owned land at an average of  $0.71 \pm 1.08$  hectares per household which is less than 1.14 hectares reported by Sintayehu *et al.* (2008) for smallholder dairy production in Shashemene–Dilla area. Results of the study showed that the milk covers the major source of income 39.1% and 41% to the smallholder farmers in Bishoftu and Akaki, respectively. They are also involved in cropping, livestock rearing, employments and others as complementing additional income generating activities to supplement their household requirements. Kibru *et al.* (2015) reported similar result on dairy husbandry practice, dairy activities implies that dairy farmers can earn additional income from other sources, outside the dairy farming activities income, increases the farmers' financial capacity and increases the probability of investing on improved dairy husbandry practices.

The dominant source of labour for dairy farming activities across the towns is family labour while the contribution of hired labour is minimal. This is similar with the finding of Embaye (2010) who reported that family members are the only source of labor for any dairying activities in Atsi-Wemberta and Alamata. In the current study milking, milk processing, sale of milk products and barn cleaning are mainly the jobs of women in Bishoftu and Akaki. This is different from the findings of Azage *et al.* (2013) and Asaminew (2007) who reported that milking activities of dairy cow was the job of men. However, the present finding is in agreement with those reported by Gebrekidan *et al.* (2012), Samuel (2005), and Njarui *et al.* (2012) who found that milking activity of dairy cows is mainly a job of women. The smallholder farmers kept crossbred dairy cattle for the purposes of supporting their family members. This is concord with the finding of Gebrekidan *et al.* (2012) in pre-urban and urban areas. The smallholders farmers kept different livestock species and the overall average number of livestock per smallholder was 7.28 cattle, 1.70 sheep, 0.26 goats, 4.02 chicken, 0.92 donkey and 0.06 horse with a high proportion of cattle. Similar result for cattle (7.1) in highlands and central rift valley was reported by Zewdie (2010). Keeping of different livestock species by farmers may be used for the diversification of farmers' incomes.

The mean herd structure of crossbred dairy cattle (pregnant, lactating, dry cows, heifers and female calves) owned by smallholder farmers in Akaki were higher than the crossbred reared by smallholder farmers in Bishoftu town. This result is supported by Asrat *et al.* (2013) high population, increasing urbanization and improvement in the life standard, high demand for dairy products, proximity of the area to the capital city, have a better access for concentrated feed, animal health services and high demand for fresh milk which might be an incentive to the farmers to have relatively high number of lactating cows.

## **5.2. Dairy Cattle Husbandry Practices**

### *5.2.1. Breeding system*

Results showed that 50.8% and 46.4% of the interviewed dairy cattle farmers used artificial insemination (AI) in Bishoftu and Akaki, respectively. About 47.8% and 42.6% of the respondents use both AI and bull services in Bishoftu and Akaki, respectively. The finding in the current study is supported by Mulisa *et al.* (2011) who reported more (46.4 percent) smallholder dairy farmers using AI service compared to 20.3% of them who use using natural service. This study is comparable with the report of Alemshet (2014) who found AI being used by the majority of the farmers at Adigrat, where there is a good access for AI services. The higher users of AI may be due to the accessibility of AI service and rearing bull is costly and on the other hand the farmers want to upgrade their dairy cattle via introduction of exotic blood.

Possible problems causes of AI failure reported by the respondents were heat detection problem, distance to AI centre, absence of AI technician and AI technician inefficiency. Gizaw *et al.* (2016), Tsegay *et al.* (2015), Zerihun *et al.* (2013) and Nuraddis *et al.* (2014) reported similar findings as the current research for the major cause of AI failure. Insemination charges were also varied based on the areas. The farmers were charged from 26.2- 39.3 Birr per insemination.

### *5.2.2. Dairy cattle housing and milk hygienic practices*

The majority of farmers in Bishoftu and Akaki reported that they fellow the housing system permanent enclosure with roofed kraal. The general dairy cattle housing and hygiene conditions of the current study is in line with research finds reported by (Hunduma, 2013; Mulisa *et al.*, 2011, Zemenu *et al.* 2014) in pre-urban and urban of the country. Moreover, this is in line with observations made in several urban and per-urban dairy units of East Africa (Gillah *et al.*, 2012). In the present study, majority of the interviewed milk producer farmers used plastic made milk containers during milking and

transportation to milk collection centers and processing plants. They also washed their milk containers with hot water and soap and kept either hanging them, on rafts and on the ground. This is supported by Kurwijila (2006) hygienic practices leads to the destruction of harmful bacteria contributed to the good quality of the milk. Karuga (2009) recommended aluminum milk containers better than plastic containers because they don't have adhesive properties and therefore easy to clean.

### *5.2.3. Milking and calf rearing management*

All of the respondents reported that cows are milked twice a day. Similar findings were also reported by Asaminew and Eyassu (2009), Amistu *et al.* (2015) and Sintayehu *et al.* (2008) that farmers milked their herds twice using hand milking. About 68.8% of the respondents used bucket feeding, 24.2% use partial suckling and 7% used both methods in calf management practices. The overall mean weaning age for calves in the present study is lower than that reported by Kibru *et al.* (2015) those  $8.36 \pm 0.217$  months. Farmers sold them cheaply or culled them from stock as soon as possible because keeping male calves are not economical.

### *5.2.4. Dairy cattle disease prevalence and health care services*

The high incidence of lumpy skin disease observed in Bishoftu is in agreement with findings of Belay (2012) who reported lumpy skin disease was identified as the major diseases affecting dairy cattle in Jimma town. The dairy cattle diseases noted in this work also agree with report of Abreham *et al.*, (2010). The widespread inefficiency of the existing veterinary service delivery systems observed in this study also matches with earlier observations in which the scenario was described as non-participatory and implemented by experts of low technical capacity and operating under critical shortage of budget and facilities (Gebremedhin *et al.*, 2007). As it was explained by stallholder farmers, districts animal health staff and development agents during focus group discussion, the increased disease incidence in the study areas was associated among

others with lack of adequate and quality drugs in government veterinary clinics and expensive drugs in the private owned vet clinics.

#### *5.2.5. Feed resources and feeding strategies*

Maintaining access to adequate quantity and quality of feed resource is crucial for milk production in dairy farming. Most of the respondents commonly feed their cattle; natural pasture/hay, crop residues/straw and fodder trees/forages and industry byproducts such as wheat bran, wheat middling and noug seed cake mixtures. This is similar with findings of Sintayehu *et al.* (2008), Yisehak *et al.* (2013), Yigrem *et al.* (2008) and Ike *et al.* (2005) in different areas of the country. This finding is also in line with the report of Asaminew (2007) and Seyoum *et al.* (2007) who indicated that the major basal feed resources for cattle in Bahir Dar and Mecha districts and the highlands of Ethiopia, respectively. Stall (intensive) feeding and combinations of feeding systems were mainly the characteristics of the study areas. About 74.6% of the respondents used stall (intensive) feeding and 25.4% practice a combination of feeding system. This shows that there is shortage of land in around the towns for the production of forages. It was observed, about (60%) of the respondents use purchased feeds. Even though they give feeding priority for dairy cow (64.6%), the survey revealed that householders were not applying specific feeding plans. The major source of water was obtained from pipe line. This is similar with the reports of Gebrekidan *et al.* (2012) (61.25%) and Asrat (2013) (91.6%). The distance and availability of water affects the farmers to provide their cows with water ad libitum. According to Radostits (2001), inadequate water supply results in reduced dry matter intake and decreased milk production of dairy cows and a consequential loss of body weight.

#### *5.2.6. Record keeping practices*

Recording system in dairy farms is a basis for proper dairy husbandry practices, considered as a tool of effective management and help to make important decisions at all

times. According to the present study, majority of the households (60%) kept records relating milk sales because they want to be sure they are getting a correct payment at the end of the half month and AI services whereas (40%) of the households didn't kept any records. This is in line the finding of Tadele and Nibret (2014) who reported only 18.2% of the famers had kept record of their cows and most of the (81.8%) had no any record keeping practice about their cows in and Around Maksegnit Town. But lack of record keeping is likely to prevent farmers from recognizing cattle disease, reduced cattle productivity and may represent an important barrier to changing the husbandry practices in their farms (Vasseur *et al.*, 2012). Simple recording tools can be developed and the farmers can be trained in utilization of this information to make decision for better dairy cattle management and thereby optimize the utilization of the available resources in the study areas.

### **5.3. Constraints of Dairy Cattle Production**

Almost all of the participants were claiming feed shortage and high price of feed resource as the major challenge in the areas. Similarly, different research works Agza *et al.* (2013) and Teshager *et al.* (2013 in different parts of Oromia were implicated that milk production in Ethiopia is highly hindered by one or more of the above mentioned factors that affect dairy production. Moreover, different researchers identified similar constraints in smallholder dairy production in different pre-urban and urban areas of Ethiopia (Fayo, 2006; Zemenu *et al.*, 2014; Haile *et al.*, 2012; SNV, 2008; Solomon, 2006). According to Ketema (2014) disease, scarcity of improved breed, lack of space and water shortage was identified as major constraints of dairy production. Moreover, Sitayehu *et al.* (2008) identified lack of land for sustainable dairy development, problems related to waste disposal (for urban producers), discouraging seasonal marketing systems, shortage of supply of genetically superior dairy animals, poor animal health services, poor extension services (especially to urban producers), knowledge gap regarding improved dairying and labour problems for urban producers.

### **5.4. Reproductive and Production Performance of Dairy Cattle**

The age at first service revealed in this study is shorter than the mean of  $24.30 \pm 8.01$  months reported by Belay *et al.* (2012) in Jima town and 27.5 months of AFS crossbred dairy cows reported by Zewdie (2010), in the highlands and central rift valley of Ethiopia. The largest age recorded in these areas could be due to the low level of management and poor feeding of calves and heifers at the earlier stages, which consequently had reduced growth rate and delayed puberty.

In the current result, the average age at first calving (AFC) is lower than average age at first calving of  $31.9 \pm 0.22$  months, which is reported by Yifat *et al.* (2009) for crossbred in Zway. Moreover; the mean result of the age at first calving was lower than that of Hunduma (2012) in Assela, Kumar and Tkui (2014a), in Mekelle, and Nibret (2012) in Gonder who reported  $34.8 \pm 4$ ,  $36.4 \pm 1.7$  and 32.4 months, respectively for crossbred cows. The prolonged AFC of cows in the present study may be related to environmental conditions and husbandry practices which may affect on the cattle growth. Hence, there should be concerted efforts to improve the feeding and nutrient profile of feeds offered to the cattle, housing, disease prevention and management especially during harsh climatic conditions in order to improve on age at first calving. With good feeding, it is expected that heifers would exhibit fast growth and attain higher weights at relatively younger ages. Younger age at first calving is beneficial in that it can potentially lead to an earlier return on investment.

The calving interval is the period between two consecutive parturitions, and ideally should be 12 to 13 months. Calving interval (CI) is one of the major components of reproductive performance that influences livestock production system. The mean for CI were  $13.0 \pm 2.1$  and  $13.8 \pm 1.9$  months for crossbred cattle at Bishoftu and Akaki, respectively. The current results are in concordance to the previous findings of Hunduma (2012), with  $372.8 \pm 5.9$  days (12.4 months) in Assela town. However, the mean calving interval observed in this study is shorter than 17.8 months who reported by Emebet and Zeleke (2007), in Dire-Dawa and in line with 13.6 months reported by Yifat *et al.* (2009) in Zway for crossbred dairy cows. The high calving interval reported here may be related

to poor management practices and other environmental stress that could affect the animals return to oestrus, heat detection, serving and conception at Bishoftu and Akaki towns. Moreover, poor nutrition that leads to poor body condition prevents cows from showing oestrus during lactation.

The mean milk yield was  $14.3\pm 5.4$  litter,  $12.7\pm 2.7$ litter, and  $7.9\pm 2.5$  litters for the beginning, middle and end lactations, respectively with an overall average of  $11.6\pm 3.1$  litters per day/cows in Bishoftu. The mean milk yield was  $14.5\pm 3$  litter,  $10.6\pm 2.67$ litter, and  $7.1\pm 2.0$  litters for the beginning, mid and end lactations, respectively with an overall average of  $10.8\pm 2.4$  litters per day/cows in Akaki. This result is comparable with the average milk yield of crossbreed cows  $9.40\pm 2.33$ litre/cow per day (Gebrekidan *et al.*, 2012; Alemayehu *et al.*, 2012). The milk production was significantly decreased in end than beginning and middle of lactation. The result of the current study is greater than Addis *et al.* (2015) who was reported  $7.012\pm 2.73$ ,  $5.55\pm 2.83$  and  $3.50\pm 1.64$  litters for the first, second and third stages of lactation, respectively with an overall average yield of  $5.35\pm 1.23$  liters per day. However, the current result is slightly greater than Adebabay (2009) who reported 10.96, 9.12 and 5.04 litters for first, second and third stages of lactation respectively.

The total mean lactation milk yields (TLMY) of crossbreed dairy cow was found to be  $3208.56\pm 108.81$  liters and  $3031.56\pm 46.32$  litres, respectively. The mean lactation milk yield found in the study areas, were lower than 3025,  $5807.83\pm 78$ liter litters reported by Dennis (2010) in Kenya, and Naceur *et al.* (2012) in Tunisia, respectively. The lower value obtained here could have been influenced by environment and poor management practices. Lactation length refers to the time of period from when a cow starts to secrete milk after parturition to the time of drying off. A lactation period of 305 days is recommended to take advantage of 60 days dry period. The mean $\pm$ SD lactation length of cross breed cows in the present study was found to be  $276.6\pm 35.1$ days,  $280.7\pm 19.3$  days, respectively. The effect of study areas on lactation length was not significant ( $P>0.05$ ). The lactation length of the present study is shorter than with the finding of Mulugeta and Belayneh (2013) who reported that the lactation period for crossbreed dairy cows was 333.9 days in North Showa and with the findings of Ketema (2014), who reported the

average lactation period of crossbreed cow was 303 days in Kersa Woreda. Zewdie (2010) reported that the average lactation period of crossbreed dairy cows in Debre-Birhan, Jima and Sebeta were  $291.0\pm 21.2$ ,  $288.5\pm 21.2$ , and  $300.0\pm 21.2$  days, respectively. Level of management achievable in Ethiopia is unfavorable to crossbred dairy cows (Aynalem *et al.*, 2009).

### **5.5. Raw Milk Physical Characteristics**

The overall mean of added water was similar with finding of Tsedey and Asrat (2015) and higher than the results of Dehinet *et al.* (2013). It has been noticed that addition of water to normal whole milk was assumed to increase the quantity of milk (Bhatti, 2010). However, the addition of water to milk not only reduces the nutritional value of milk but also contaminated water may also pose a health risk (Pitty, 2011) and if contaminated, it poses a health risk to consumers (Kandpal *et al.*, 2012). The management practices, particularly the remains of the rinse water in the milk container prior to milking and addition of the wash water to the tank after the milking might have contributed to the presence of added water in milk (Wangdi *et al.*, 2016). The freezing point of milk in current result was comparable with the average milk freezing points reported by Abdul and Monem (2012) of  $(-0.531\pm 0.02^{\circ}\text{C})$  and Ciprovica (2013)  $(-0.53\pm 0.01)$  from raw milk collected. This finding also concurs with studies carried out by Kinyua (2012) who reported  $-0.541^{\circ}\text{C}$  in Limuru and Eldoret, Kenya. The freezing point of milk could be affected during cooling, or addition of wash water to the tank in most cases.

The specific gravity of raw milk was slightly similar to that reports of Teklemichael *et al.* (2015), Zelalem (2012) and Wangdi *et al.* (2016). The pH value of this study is in line with the normal pH of fresh cow milk (FAO, 1999). The pH value found in the current study was comparable with the findings reported by Teklemichael *et al.* (2015). A pH value found in the sampled raw milk is in agreement with the findings of Imran *et al.* (2008).

## 5.6. Raw Milk Chemical Characteristics

The current result of fat content is less than the report of Teshome *et al.* (2014) who found  $(4.28\pm 0.05)$  fat from raw cow's milk produced and marketed in Shashemene town, Southern Ethiopia, and Kunda *et al.* (2015) who reported 3.9% raw milk produced by smallholder dairy farmers in Lusaka Province of Zambia and also Alganesh (2016) who found 3.76% fat content from raw milk collected in peri-urban areas of Ejere, Walmera, Selale and Debre Birhan districts of the central highlands of Ethiopia. The lower fat content of milk may be due to cows of that farm were high milk producing crossbreeds cows which reduces the fat content of the milk samples or water may be added with milk or partly skimming the milk or due to the feed they offered. According to the Ethiopian standard agency, the minimum fat percent for whole milk should not be less than 3.5 percent (ESA, 2009). Consequently, the average fat content  $(3.60\pm 0.53)$  observed from the three values chain points milk samples obtained fulfilled the recommended standards.

The current result of the laboratory analysis of SNF content of raw milk was in agreement with Estifanos *et al.* (2015), who report the average SNF  $(7.98\pm 0.98)$  of raw cow milk. But different with the findings of Dehinnet *et al.* (2013) who reported that the average SNF  $(8.44\pm 0.72)$  of raw milk from selected areas of Amhara and Oromia National Regional States, Fikrineh *et al.* (2012) found the average SNF percentage of raw milk of Adama town to be  $9.05\pm 0.16$  and Debebe (2010) also reported the minimum  $(8.3\pm 0.36)$  and maximum  $(8.7\pm 0.36)$  SNF content of raw cow's milk obtained from street-vendors and milk producers in and around Addis Ababa, respectively. The minimum standard for SNF content of whole cow milk is 8.25% (FDA, 2010). The average SNF content for the current study is below the recommended standards. The low SNF content of the samples from the study areas could have been attributed to a variety of factors including the feed, genetics, season of the year, stage of lactation and disease (Harris and Wattiaux, 2012).

The total solids (TS) content of raw milk collected from MP, MC and MPP was slightly comparable with the finding of Teshome *et al.* (2014) who found total solid content in milk from Shashemene town  $(12.87\pm 0.11)$  and also Mirzadeh *et al.* (2010) reported total

solids content in some dairy farms in Iran ( $12.57\pm 0.69\%$ ). According to European Union established standards for total solids content of cow milk not to be less than 12.5% (FAO, 2007). Therefore, the current result of the average total solid content ( $11.38\%$ ) found from the current study is below the recommended standards. The lower TS content of found from current study may be due to addition of water with milk and removal of fat content. The overall mean of ash content ( $0.62\pm 0.05$ ) found in the current study is slightly similar with the findings of Imran *et al.* (2008) and Estifanos *et al.* (2015) who observed that the means of ash in cow's raw milk collected from different locations were  $0.64\pm 0.07$  and  $0.68\pm 0.16$ , respectively. But different from the finding of Teshome *et al.* (2014) who reported the ash content ( $0.78\pm 0.00$ ) for the raw cow's milk collected from produced and marketed in Shashemene town, Southern Ethiopia.

The current finding of protein content ( $3.27\pm 0.15$ ) was similar with reports of Debebe (2010) ( $3.2\pm 0.22$ ), Mirzadeh (2010) ( $3.2\pm 0.22\%$ ) and Belay and Janssens (2014) ( $3.21\pm 0.06$ ). But slightly, it is lower than from the research result of ( $3.94\pm 0.07$ ) Gurmessa *et al.* (2015) who reported for the raw cow's milk in Yabello District, Borana Zone. Dehinnet *et al.* (2013) found that the mean value of protein content in milk collected from selected areas of Amhara and Oromia National Regional States ( $3.12\pm 0.32\%$ ) which is lower than that of the current study. But, Teklemichael *et al.* (2012) reported slightly higher result than protein contents ( $3.42\%$ ) for milk collected from dairy farms in Dire Dawa town and Fikrineh *et al.* (2012) reported higher protein content ( $3.46 \pm 0.04$ ) for milk samples collected from households rearing local and crossbred cows in Mid-Rift Valley of Ethiopia compared to the present study. According to Ethiopian standards Agency, the minimum percent protein content of whole milk should be 3.2 percent (ESA, 2009). Hence, the average protein content for the current study is similar with the recommended standard of the nation.

Lactose content found in the current study is less than the findings of Belay and Janssens (2014) who reported the lactose content ( $4.34\pm 0.13$ ) of raw milk samples collected from different urban dairy farms located in Jimma town and Soomro *et al.* (2014) who reported cow's raw milk ( $4.56\pm 0.21$ ). According to European Union quality standards for

unprocessed whole milk, lactose content should not be less than 4.2% (Tamime, 2009). Therefore, the current average lactose content ( $3.93 \pm 0.25$ ) found for the raw milk samples was below the recommended standards. This might be due to the action of lactose hydrolyzing enzymes produced by microorganisms as result of storage temperature variation. In general the composition of milk can vary depending on breed of the animals, management practices such as feeding management, and environmental factors influenced the milk composition (Pandey and Voskuil, 2011).

### **5.7. Microbial and Acidity Analysis**

The total bacteria count obtained from the current research result is slightly similar with research conducted in the country by Tsedey and Asrat (2015) ( $7.03 \pm 0.07 \log_{10}$  cfu/ml) and Fikrineh *et al.* (2012) ( $7.08 \log$  cfu/ml). This value is lower than the total bacteria count reported by Zelalem (2010) ( $9.10 \log$  cfu/ml), Abebe *et al.* (2012) ( $9.82 \log$  cfu/ml) and Asaminew and Eyassu (2011) ( $7.58 \log$  cfu/ml) and this is generally high as compared to the acceptable level of  $1 \times 10^5$  ( $5.0 \log_{10}$  cfu/ml) bacteria per ml of raw milk (Lore *et al.*, 2005).

In all cases, the increase in bacterial load was statistically significant. This indicates a general trend of decreasing quality from farms to milk processors, which clearly raises food safety concerns about contamination by pathogenic organisms and suitability of raw milk consumption in the milk value chain points of Bishoftu and Akaki. This might be due to the contamination originating from the udder surface, in farm level, lack of cooling technology and transport, uncleaned milk containers, quality of water used for cleaning milking utensils and the time lapse from production to marketing. This is also supported by Hossain *et al.* (2011) the most frequent causes of high bacterial load are poor cleaning of the milking system, milking dirty udders, maintaining an unclean milking and housing environment, and failure to rapidly cool milk to less than  $4^{\circ}\text{C}$  after milking.

The current result of coliform counts/ml is higher than the findings of Tesfay *et al.* (2013) ( $4.13 \pm 0.76 \log_{10}$  cfu/ml), Asaminew and Eyassu (2011) ( $4.49 \pm 0.11 \log_{10}$  cfu/ml) and

Fikrineh *et al.* (2012) who found coliform count (CC) of  $4.35 \pm 0.06 \log_{10}$  cfu/ml for raw cow's milk. But lower than from the result of Zelalem and Faye (2006) who reported higher coliform count of 6.57cfu/ml. The presence of high numbers of coliforms in milk indicates that the milk has been contaminated with fecal materials and this could be attributed to insufficient pre-milking udder preparation, poor hand washing practice of milker and use of poor quality and non-boiled water for cleaning of milking utensil. This is supported by Grillet *et al.* (2007) higher coliform counts result may be due to the contamination of the milk either from dirty equipment or from milking cows with environmental coliform mastitis. Moreover; bulk milk coliform bacteria are used as indicator of hygienic condition during handling.

Finding of the somatic cell from this study are in agreement with other studies carried out by Mustofa (2012) and Kunda *et al.* (2015). Findings by Stulova *et al.* (2010) and Dehinenet *et al.* (2013) showed higher counts compared to those found in the present study. The current mean of SCC was showed slightly above the recommended limit of USA, EU and Sweden for the accepted value of  $< 7.5 \times 10^5$ ,  $4 \times 10^5$  and  $< 4.99 \times 10^3$  sc/ml respectively (IFCN, 206; Murphy, 2008). This might be due to lack of knowledge on dairy cattle management and use of unclean milking equipment could be the factors which contributed to the high somatic cell per ml in the study areas.

The acidity content obtained in the current study is slightly higher than the result reported by Teklemichael *et al.* (2015) ( $0.165 \pm 0.022$ ). However, this result disagrees with the findings of Asaminew and Eyassu (2011) who found the acidity content of the milk to be ( $0.28 \pm 0.01$ ) and Zelalem and Faye (2006) (0.27) lactic acid. The current finding is above the range reported by O'Connor (1994) who stated that the normal fresh milk has an apparent acidity of 0.14 to 0.16% as lactic acid. In general, the high percent lactic acid of milk observed in the present study may be due to microbial activities or enzymatic reaction, time required from milking up the processing plants and longer storage of the milk before delivered.

## **5.8. Analysis of Milk Value Chain and Marketing**

The present survey revealed the existence of different value chains; formal and informal value chain and types of milk market outlets channeled by different actors identified include input suppliers, producers, milk collectors, processors and consumer.

### *5.8.1. Input/services providers*

The current study result and the findings of Anteneh (2008) and Girma (2012) have similarity who reported that governmental organization and private sector play a vital role in provision of different inputs. They also categorized the service delivery system of the study area into different main types such as animal feed suppliers, animal health providers, AI and improved bull service providers and financial service providers. This is supported by Martin (2007) the range of services that can add value and strength to a value chain include input supply, market information and product development support, consulting, transportation and logistics, quality assurance, skills, extensions and training, veterinary services, as well as credit and other financial services allow the value chain to grow and enhance its competitiveness.

Provision of extension services is based on the needs of farmers and the training was indicated to provide in collaboration with governmental and nongovernmental organizations. Similar finding reported by Tegegne *et al.* (2010) the role of the NGO has to be promoted and supported in different forms to ensure proper dairy input supply system. Only 88.5% in Bishoftu and 42% in Akaki of the dairy cattle owners reported that they had got training on general aspects of farm management, proper milking, milk handling, milk marketing, processing, record keeping, heat detection feeding and dairy health management which were organized by BoARD, microenterprises and urban agriculture development desk. The study indicated that more than half of (56%) of milk producers get market information from extension agents, other farmers, stakeholders and association. This is supported by FAO, (2015) report that getting information on quality

requirements and selling price encourages farmers to apply good practices for better products, which benefit not only farmers but the whole marketing chains.

### *5.8.2. Milk producers*

With regard to milk yield, mean of milk yield per day of smallholders in wet and dry season was 15.1 and 13.2 liters, respectively. This result is consistent with the finding of Woldemichael (2008). As the survey result indicated in Bishoftu and Akaki, majority of milk producers were selling/delivered the fluid milk to formal milk collectors/processing plants. This is in line with the findings of Assaminew (2014) who reported raw milk was the main output from dairy cattle and sold to collectors for processing, hotels, cafeterias and directly to consumers in Holeta, Amsitu *et al.* (2015) who reported majority of the participants brought their milk to the collection center and private dairy processing plants and Njauri *et al.* (2010) who reported dairy products distributed directly to the market and sold their products across the counter within their premises. This is inconsistent with the findings of Dennis (2010) who also found out that direct milk marketing to consumers is the most popular channel of fresh milk marketing. The bulk of farm produced milk is delivered usually twice a day (morning and afternoon) to milk collection center or processing plants.

### *5.8.3. Milk collection and transportation*

The smallholder dairy farmers deliver their milk themselves to the collection centers or processing plants on foot and some farmers use different transportation means such as motor vehicles, bicycles and carts. This is in line with Kedija *et al.* (2008) and Amistu *et al.* (2015) who reported majority of participants were market milk travelling on foot by holding milk in Meiso districts and in different critical points of Oromia special zone, respectively. This is comparable with Revoredo- Giha *et al.*, (2013) who reported on the milk delivered by the farmers usually by bicycle or by foot) is bulked at the collection centers, and collected by the dairy processors on a (usually) daily basis.

Plastic containers were the most common milk containers used by the milk producers. This is in line with Hyera (2015) who reported that plastic containers were commonly used for collection, storage and transportation of milk and can be easily scratched and are difficult to clean thus provide hiding places for bacteria and this is in line with FAO (2011) that reported occasionally plastic cans, are used for bulking milk from individual suppliers and delivering it to processors' collection, bulking and cooling centers, from where it is transported in cans or by refrigerated tanks to the main processing plants. About 44.3% of the respondents lived at distances less than 1km from the respective milk collection centers and processing plants in Bishoftu and 50.7% traveled 1-5km in Akaki. This is similar finding of Woldemichael (2008) who reported that (50%) of the respondents in Yirgalem traveled less than 1km and this is consistent with findings by Dries and Swinnen (2004) where the proximity to milk collection centers or processing plants facilitated the preservation of selling or deliver of milk. Thus the longer the distance from the milk collection center the lower the number of smallholder dairy farmers delivering their milk. This is supported by Sumuni (2013) remoteness and poor infrastructures constitute the largest bottlenecks to collection and marketing of milk in Tanzania. Thus the milk produced was mostly consumed locally and quite often a significant amount was left for the calves. This could be lack of cooling facilities and inadequate infrastructures for milk transportation to the processing.

#### *5.8.4. Milk processing and marketing*

The high percentage of respondent's used of formal market as their milk channel. This result is comparable with the report of Sintayehu *et al.* (2008) who reported that a majority (79.2%) of the peri-urban and urban areas farmers produced milk for sale. A comparatively larger proportion of milk produced at Bishoftu and Akaki was entirely delivered directly to the processing plants and collection centers. This is slightly similar with the findings of Chitika (2008) and Fussi (2010) who indicated formal milk value chain was described as a process involving all the channels through which farmer delivers milk directly to the milk processing plant or to a milk collection centre or to traders who buys milk from the farmer and sell it to the milk collection center or processors. Whereas

in the informal milk marketing involves the direct delivery of fresh milk by the farmer to the consumer or milk that may pass through two or more milk vendors before reaching the consumer; this is similar with the reports of Yilma *et al.*, (2011) around 95% of the milk marketed at national level was reported to be channeled through informal outlets which is characterized by direct delivery of fresh milk to immediate neighborhood consumers or catering service providers, Diriba *et al.* (2014) who reported that there is no formal milk marketing system in Nekemte and Bako milkshed in western Ethiopia and Eyassu and Doluschitz (2014) who reported that there is no formal milk marketing system in Dire Dawa, Eastern Ethiopia. Direct delivery to the nearby consumers is the informal milk outlet for producers of both towns. Most of smallholder dairy farmers who deliver their milk to collection centers and processing plants in Bishoftu and Akaki were paid every half of the months by the milk receivers/processing plants. This is lightly with Getu *et al.* (2012) who reported that payment was made either every 2 weeks or sometimes on monthly basis. The findings revealed that respondents selected their milk marketing channels according to consistency of markets not the price. This is different with finding of Steal *et al.* (2006) who reported dairy farmers sell their milk on cash or credit payment arrangements.

Most of the processing plants are concentrated near larger markets and potential sources of milk. This is concurs with finding of Besigye (2014) who reported that increasing milk processing operations are rendering this level of the value chain to be very competitive which directly impacts the efficiency of the entire dairy value chain.

The main reasons pointed out by the owners for poor capacity utilization of the milk processing plants is due to low milk deliveries from the farmers, packaging materials, different ingredients, laboratory equipment and chemicals. Similar finding is reported by Abou El-Amaiem (2014), factors such as lack of cold chains, adulteration, unhygienic on farm production, fragmented farm base and distance to dairy farmers affect processing operations. Consequently, none of the processing units is operating at optimal capacity. This is caused by low producer prices paid to the farmers, which lead to side marketing and milk being retained for household consumption.

## 5.9. Milk Value Chain Constraints

According to the group discussion, there are many constraints encountered in the various linkages and the flow of commodities and services from the dairy producers, inputs/service providers, milk collectors, transporters, processors and customers. This is similar with findings of Yilma *et al.* (2011), Eyassu and Doluschitz (2014) and (Staal *et al.*, 2006) who reported that weak linkages among the different actors in the dairy value chain are some of the important factors that contribute to the poor development of dairy sectors. Moreover, dairy processing in the country is basically limited to smallholder level and hygienic qualities of milk products are generally poor (Zelalem and Faye 2006). The spoilage problem was severe during transfer of milk from container to container and during transportation process. This concurs with Pandey and Voskuil (2011) who reported spoilage as the major reason for milk postharvest loss. This is also supported by Addis *et al.* (2011) who reported that plastic containers are poor conductor of heat and hence may hinder effective sanitization by heat and based on makeup and design they are difficult to sanitize especially in the inner corners and bottom. Similar observations were also reported by Bukuku (2013) who reported that plastic containers increased microbial count in milk.

Milk price, quality standards, and inadequate and uncoordinated dairy market information systems limit dairy development. This is similar with finding of Ayele *et al.* (2003) who reported the structure and performance of dairy production and its products including dairy products marketing both for domestic consumption and for export is generally perceived poor in Ethiopia due to underdeveloped and lack of market-oriented production, lack of adequate information on livestock resources, inadequate permanent trade routes, lack or non-provision of transport, ineffectiveness and inadequate infrastructural and institutional set-ups and illegal trade. This result is similar with the finding of SNV (2008) that reported on the major constraints of the dairy sector are lack of inadequate dairy services, lack of marketing outlets, and poor roads and transportation systems in three East African countries viz., Ethiopia, Kenya and Uganda. Tariq *et al.*, (2008) reported on the milk marketing and value chain includes; traditional production

and marketing channels, milk production practices, unorganized farmer community, seasonal fluctuation, financial aspects of dairying, role of middlemen, infrastructure, price fixation and role of government agencies in Pakistan and Rajendran and Mohanty (2004), reported on the constraints in milk marketing lack of an assured year-round remunerative producer price for milk; an inadequate basic infrastructure for provision of production inputs and services; an inadequate basic infrastructure for procurement, transportation, processing and marketing of milk; and lack of professional management.

## **6. CONCLUSIONS AND RECOMMENDATIONS**

This section concludes the major findings of the study. Finally, appropriate recommendations within the scope of the work reported are given.

### **6.1. Conclusions**

Smallholder dairy production is a viable business and could play a significant role in employment and income sources, as well as in enhancing household nutrition and food security. It can be concluded from this study that crossbred dairy cattle kept by smallholder farmers in Bishoftu and Akaki towns contributes to the household welfare in terms of income generation. The reproduction and production performances (AFS, AFC, CI, LL and LMY) of crossbred dairy cattle are below the standard expected. Unimproved management system was among the factors affecting the standard expected reproductive and production performance of crossbred cattle in the study areas.

Despite, there are various impediments limiting milk production in the towns, feed availability in quantity and quality was the most important constraints followed by shortage of land and inadequate water supply. The other main constraints of dairy production were unimproved husbandry practices (proper feeding, housing, AI services/breeding, watering and health care) and inadequate extension services. Moreover, lumpy skin disease, black leg; foot and mouth disease, anthrax and mastitis were the most prevalent diseases occurred and considered to be the major obstacle to the viability of smallholder dairying in study areas.

The practices and conditions under which smallholders and their dairy chains operate make it difficult to deliver high-quality milk to dairy plants. Majority of physicochemical properties of milk samples obtained from the milk producers, milk collectors and milk processors were within the standards except, the density of the milk, SNF, total solid and ash of the milk samples obtained from the milk value chain points.

On the other hand, high level of microbial loads brought about by unhygienic distributions of raw milk by the smallholder dairy farmers also reduces the standard of milk. The outcome of this study showed that, all the microbial qualities were poor, as judged from the high values of total bacterial count (TBC), coliform count (CC) and somatic cell count (SCC) which were significantly higher than the recommended values of the international standards safety for human consumption. These microbial loads may be due to unhygienic condition during milking and milk handling during transportation, use of plastic containers and improper cooling system. In general, the result of this study indicated that urgent measures are needed to quality and safe milk production at dairy stallholder's community level through promotion of good hygienic practices and adequate sanitary measures at all stages from production to consumption. Commonly, physicochemical and microbial qualities of raw milk are important from the consumers' health point of view as well as for further processing of milk and milk products. These findings will also evoke awareness in governmental companies as well as publics to be assembled to monitor the standard regulation of milk compositions in every dairy farm

The input suppliers are those agents who supply inputs such as feed, veterinary services and AI services, training and technological packages. The milk produced by the stallholders in Bishoftu and Akaki marketed through different marketing channels that were being identified during the survey. The most milk value chain type for raw milk was formal value chain. Dairy producers delivered the milk to collectors and milk processing plants then to consumers.

There are many problems encountered by the milk producers in marketing of milk through the different channels of milk distribution. Low milk price, offered by processors, lack of access to inadequate markets, inadequate infrastructural development, inadequate market information and spoilage of milk during transportation were the main obstacle hindering them from channeling their milk to costumers, processors either through milk collection centers or selling directs to processing plants. In addition, the absence of policy instrument that governs market route is serious milk marketing problem. The high total bacteria counts of coliforms counts and the high levels of somatic cell in milk are

indicative of a potentially hazardous product which is likely to be posing a serious health risk to the consumers.

## 6.2. Recommendations

From the study findings, it is recommended that

- In an attempt to develop dairy management system of Ethiopia, needs to move out from the traditional subsistence mentality to market-oriented approach.
- Non Governmental Organizations, feed supplying companies be supposed to initiating dairy industries by doing on forage development, genetic improvement, milk quality control and solving market by acting in value chain of milk production.
- Animal health was another major hindrance to dairy farming. Disease control programs should include regular reminder training for livestock and veterinary officers as well as provision of means of mobility and facilitate access to basic veterinary medicines to these staff.
- More training for farmers on dairy cattle husbandry should be conducted regularly so as to improve dairy cattle performance.
- The findings of this study highlight the need to implement improved hygiene practices and to apply effective monitoring throughout the production to delivery chains.
- Training is also needed for all persons who deal with milk production, marketing and processing to ensure the safety and quality of milk.
- Further research and extension is needed to characterize critical quality points and hazards in order to ensure that good quality dairy products are produced and consumed.
- Further projects should also consider constructing more milk collection centers and processing plants near smallholder dairy farmers in order to sustain the dairy development sectors. All actors along the milk value chain should be organized and regularly trained to increase their awareness on management of animals, general milk handling, milk hygiene and commercialization of milk.

- The poor milk quality observed in the present study requires further investigation of the status of the farms, milk handling, and transportation delivery of milk from the farm up to consumers.
- To keep the quality of milk from deteriorating and reduce product losses proper and fast transport and equipped with cooling facilities and establish strategically positioned milk collection centers near to potential areas to increase the quantity of milk they handle.
- In addition, introducing quality consciousness to milk producers, collecting centers, processors and distributors and consumers and milk sampling and testing kits have to be introduced to effectively controlling of milk quality.
- It is recommended that the government, NGOs and other development partners should improve or modernize the existing government veterinary clinics/extension services so that they provide more services and put strategies that will help more dairy farmers to access services.
- The results presented in this research are based on a two-years survey. However, reproductive and production performance of dairy cattle breeds, husbandry practices, milk handling and quality management aspects and milk value chain and market prices related output and services of smallholder dairying in any given areas may vary over time due to different factors. Thus, it is necessary to conduct research in multidisciplinary to reach to a conclusive dairy husbandry practices, value chain and quality analysis estimates.

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## 8. APPENDIX

### Appendix 1: Questionnaire

1. Zone \_\_\_\_\_ District/Town \_\_\_\_\_ kebele \_\_\_\_\_
2. Name of enumerator \_\_\_\_\_
3. Date \_\_\_\_\_ Starting time \_\_\_\_\_ Ending time \_\_\_\_\_

#### I. Producer (households') characteristics

1. Gender of household head

- 1) Male.....
- 2) Female.....

1. Age of household head (yrs) \_\_\_\_\_

2. Marital status:

- 1) Married.....     2) Single.....
- 3) Divorced.....     4) Widowed.....

3. Total *numbers of household members* including household head

No.	Age Category (in years)	No. of members in the household		
		Male	Female	Total
1	< 6 years old			
2	6-9 years old			
3	10-15 years old			
4	15-60 years old			
5	> 60 years old			

4. Educational status of the household

1. Illiterate.....     4. 9-12 grades.....
2. Reading and writing     5. Diploma holder.....
3. 1-4 grades.....     6. Degree holder.....
5. 5-8 grades.....     7. Others, specify \_\_\_\_\_

6. Major occupation of household head:

- 1) Government employee.....
- 2) Retired government employee.....

- 3) Daily laborer.....
- 4) Trader.....
- 5) Other, specify \_\_\_\_\_
7. Did you have prior knowledge of dairy farming? 1) Yes....  2) No ...
8. If yes, from where? .....
9. How did you start dairy farm?
- 1) Encouraged by parents/relatives/friends...
- 2) Introduced by Govt./NGO.
- 3) Self-motivated.....
- 4) Inherited.....
- 5) Other, please specify \_\_\_\_\_
10. Why did you start dairy farm? (Tick up to 2 options)
- 1) To increase income .....
- 2) To increase food security
- 3) To diversify of income..
- 4) Other, please specify \_\_\_\_\_
11. For how many years have you been doing dairy farming \_\_\_\_\_
- 1) <3.....  2) 3-5.....  3) >5.....
12. How did you get the (dairy) cattle when you first set up your dairy farm?
- 1) Credit by government..
- 2) Pass on credit by NG...
- 3) Purchased myself .....
- 4) Given by relatives.
- 5) Donated .....
- 6) Other, please specify \_\_\_\_\_
13. Land holding/ farm size )

S. No.	Category	Land ownership in hectare			
		Own	Rent	Other	Total
1	Crops land				
2	Grazing land				
3	Forest				
4	Fallow land				
5	Homestead				
6	Total size				
7	Other than communal				

14. What is your source of income?

(Tick first column as appropriate, rank level of source of income in the second column (1-5))

S.N	Income sources of the family	Tick	Rank (max. 5) of your sources of household income in ascending order as follows:  (1 = most important to 5 = least important)
1	Dairy farming		
2	Other livestock / Beef fattening/ rearing		
3	Crop (Agriculture) (maize, barley, teff wheat)		
4	Home industries		
5	Government employment		
6	Private sector employment		
7	Daily labour		
8	Trade / Shopkeeper		
9	Forest products		

\*Includes the value of non-cash outputs or products e.g. manure,

15. Livestock holding

(Tick first column as appropriate, rank the most important species in the second column)

S. No.	Category	Number	Most important species (rank up to 3: 1,2,3)
1	Cattle		
2	Sheep		
3	Goat		
4	Chicken		
5	Pigs		
6	Donkeys		
7	Others (specify.		

16. Dairy cattle breed composition

S. No.	Cattle herd structure		Breed
			Crossbred (>50% blood level)
1	Pregnant cows (n)		
2	Lactating cows (n)		
3	Dry cows (n)		
4	Heifers (n)		
5	Bull (n)		
6	Oxen (n)		
7	Calves (n)	Male	
		Female	
<b>Total</b>			

n= Number

17. Division of labour among milk producing HH members

S. No.	Activities	Men	women	Children	Hired
1	Herding				
2	Milking				
3	Milk processing				
4	Barn cleaning				
5	Sale of dairy products				
6	Sale of animals				
7	Stall feeding				

18. Primary purposes for keeping cattle

(Tick first column as appropriate, rank that brings more income in the second column 1, 2 & 3)

S. No.	Purpose of keeping dairy cattle	(tick)	Rank that brings more income
1	Produce milk for home		
2	Milk for sale and home		
3	Produce milk for sale		
4	For milk and meat		
5	Manure		
6	For asset		
7	For sale of calves/heifer		
8	Growing males for ploughing		
9	Others if any		

19. Have you been provided with extension services? 1) Yes...  2) No .

20. Have you ever taken any dairy training related to improve your husbandry practice?

1) Yes .....  2) No.....

21. If yes, specify the type of training and the organization responsible for the training

S. N	Types of training	Duration	Organization
1	Proper milking and clean milk		
2	Record keeping		
3	Milk marketing		
4	Dairy health		
5	General farm management		
6	Pasture establishment		
7	Dairy cattle feeding		
8	Heat detection		
	Others		

22. Has the training been helpful in gaining knowledge and skills to solve your practical problems related to dairy production and marketing? 1) Yes.....  2) No...

If no why? \_\_\_\_\_

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## 2. Reproductive and production performance of dairy cattle

Production and reproductive performance of dairy cattle in the study areas

S. No.	Performance/Parameters	Crossbred (>50% blood level)
1	Age at first service (month)	
2	Age at first calving (month)	
3	Calving interval (month)	
4	Days open (month)	
5	Average milk yield /day/cow (in liters)	early lactation
		mid lactation
		late lactation
	Lactation length (days)	
	Dry period (days)	
6	Calf weaning age (month)	
7	Culling age of breeding female	
8	Cow's lifetime of calves production (n)	

## 3. Dairy cattle husbandry practices

### A. Breed and breeding system

1. Which type of exotic breed is available in your farm?

1) Friesian.....  2) Jersey.....  3) both.....

2. Which type of local breed is available in your farm?

1) \_\_\_\_\_

2) \_\_\_\_\_

3) \_\_\_\_\_

3. What is your breeding system?

- 1) Natural breeding.....
  - 2) Artificial insemination .....
  - 3) Both .....
4. If your breeding system is natural, what are its mechanisms?
- 1) We select the best type of bull and we bred our cattle.....
  - 2) Have not any selection activity; simply we used uncontrolled breeding.
  - 3) Others \_\_\_\_\_
5. Do you have an experience of selection the best cattle type for breeding purpose?
- 1) Yes.....
  - 2) No .....
6. If yes what are your parameters used to select the best cattle for breeding purpose?
- 1) Color coat.....
  - 2) Behavior of the animals.
  - 3) Body conformation.....
  - 4) Milk production potential...
  - 5) Drought power potential.....
  - 6) Others \_\_\_\_\_
7. How did you get your crossbred cow?
- 1) Purchased from neighbors
  - 2) Purchased cow from any ....
  - 3) Purchased from market.....
  - 4) Through A.I. ....
  - 5) Supplied by the MOA.....
  - 6) Other, specify \_\_\_\_\_
8. When did you start having cross bred cows?
- 1) One years ago.....
  - 2) Two years ago.....
  - 3) Six months ago.....
  - 4) >3years ago.....
  - 5) Others, specify \_\_\_\_\_
9. Why did you start with cross breed cows/heifers?
- 1) Better milk production.....
  - 2) Higher growth rate.....
  - 3) Higher weaning weight.....
  - 4) Better body conformation.....
10. Why you only stick with local cows?
- 1) Better disease resistance quality...
  - 2) Better resistance on heat stress.....
  - 3) Better milk fat content .....
  - 4) I don't get cross breed heifers.....

- 5) Better body conformation.....
- 6) Because they need less mgt.....
- 7) They can fit for drought purpose.....
- 8) I don't know other means .....
11. Do you have experience/system of detecting estrous?  
 1) Yes.....  2) No.....
12. If yes, how do you detect estrous period?  
 1) Herdsman information...  3) Follows up during morning & night..   
 2) Using teaser bull.....  4) Other, specify\_\_\_\_\_
13. Do you have an experience of using AI? 1) Yes...  2) No.....
14. If yes, why did you use it?  
 1) I do have access to AI service.....   
 2) It is simpler than raising a bull.....   
 3) It is more economical than a bull service...   
 4) I do not have a bull.....   
 5) Others\_\_\_\_\_
15. If AI, who delivers the service? \_\_\_\_\_
16. How much do you pay for the service? \_\_\_\_\_birr
17. Do you think the existing insemination fee is fair?  
 1) Yes.....  2) No.....
18. Distance from insemination centre \_\_\_\_\_  
 1) <1Km ....  2) 2-4Km .....  3) 5-7Km...  4) >7Km....
19. If it is on payment basis, how much do you pay for the service? \_\_\_\_\_birr
20. Have you faced failure of artificial insemination?  
 1) Yes.....  2) No.....
21. If yes how many times?  
 1) One...  2) Two...  3) Three...  4) More than four.....
22. What do you think the reason for the failure?  
 1) Heat detection problem.   
 2) AI technician inefficiency..   
 3) Distance of AI centre.....

4) Absence of AI technician

5) Disease problem.....

6) Other, specify\_\_\_\_\_

Please rank them as 1<sup>st</sup> \_\_\_\_\_ 2<sup>nd</sup> \_\_\_\_\_ 3<sup>rd</sup> \_\_\_\_\_ 4<sup>th</sup> \_\_\_\_\_

23. What alternative do have taken when AI service interrupted? -----

1) Privet exotic bull .....

4) Using exotic bull at communal.

2) Home bred exotic bull.....

5) Extending the mating time .....

3) Using own local bull ...

6) Other, Specify\_\_\_\_\_

24. If no, why did not use it?

1) I have no access to AI service .....

2) The efficiency of AI service is not good.....

3) I do not want to use AI services because of cultural reasons .....

4) I have a bull, which I can also use for other purposes.....

5) Others \_\_\_\_\_

Please rank them as 1<sup>st</sup> .\_\_\_\_\_ 2<sup>nd</sup> .\_\_\_\_\_ 3<sup>rd</sup> .\_\_\_\_\_ 4<sup>th</sup> .\_\_\_\_\_

25. If natural mating, from where do you acquire the bull and what is the breed type?

1) Own local breed bull.....

2) Own cross bred bull .....

3) Neighboring farmer's local breed bull.....

4) Neighboring farmer's cross bred bull.....

5) Community owned cross bred bull.....

26. If you are only sticking on local cattle, what was the source of your bull?

1) Own source.....

2) From neighbors.....

3) From everywhere source.....

4) Others \_\_\_\_\_

27. Mode of natural mating service delivery:

1) Free of charge.....

2) Little charge.....

38. Replacement females

1) Rise on own farm.....

- 2) Buy.....
- 3) Rise own and buy.....
- 4) Other, specify\_\_\_\_\_
30. Constraints related to dairy breeding\_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
31. Opportunities related to dairy breeding\_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
32. Do you have any suggestions on how to increase the effectiveness of the services you use, please explain?\_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

**Housing**

33. What type of shelter/house do you provide?
- 1) Roofless kraal.....
- 2) Roofed kraal.....
- 3) I tethered at the yard .....
- 4) I keep with the people residence campus.....
- 5) Others (specify)\_\_\_\_\_
34. What type of housing system do you use?
- 1) Permanent enclosure/house.....
- 2) Semi-permanent (temporary) .....
- 3) Open barn (only fence).....
- 4) I tethered at the yard .....
- 5) I keep with the people residence campus.....
- 6) Others (specify)\_\_\_\_\_
35. What material do you use for the wall and roof of the cow shed?
- 1) Wood + Iron sheet.....                       3) Wood + plastic.....
- 2) Bricks + Iron sheet.....                       4) Wood + homestead.....

- 5) Other, specify\_\_\_\_\_
36. What material do you use for the floor of the cow shed?
- 1) Earthen floor.....                       3) Stones.....   
 2) Concrete.....                                       4) Other (Specify)\_\_\_\_\_
37. Does your cow's shade have bedding? (1)Yes....  (2) No.....
- If yes, what type of bedding?.....
- 1) Straw.....                       4) Grass.....   
 2) Wood shavings.....                       5) Other (Specify)\_\_\_\_\_
- 3) Soil.....
38. How often do you clean/ remove manure from the shed?.....
- 1) Every day.....                       4) >Two times/week.....   
 2) One time/week.....                       5) Other (specify)\_\_\_\_\_
- 3) Two times per a week.....
39. Do you clean/wash the animal itself? 1) Yes.....  2) No.....

**C. Milking management and hygiene information**

40. How many times do you milk your cow per day?
- 1) Morning only.....                       3) Three times/ day.....   
 2) Morning and evening....                       4) Other, Specify\_\_\_\_\_
41. Do you wash your hands before milking? (1)Yes.....  (2) No.....
- If you wash, what do you use?
- 1) Water alone.....  2) Water + soap/disinfectant.....  3) other (specify) \_
42. If you wash your hands, do you dry them before milking? 1) Yes.  2) No.
- If yes, what do you use?
- 1) Newsprint.....                       3) Re-usable cloth.....   
 2) Disposable paper towels....                       4) Other, specify \_\_\_\_\_
43. Do you wash your cow's udder during milking? 1) Yes.....  (2) No...
- If yes, when do you wash it?
- 1) Washing udder before milking only.....   
 2) Washing udder after milking only.....   
 3) Washing udder both before and after milking.....   
 4) No hygienic practice.....

44. If you clean the udder, what do you use;  
 1) Udder cloth.  2) Disposable towel  3) Massage with bare hand.
45. If your answer is udder cloth, do you use a separate one for each cow?  
 1) Yes.....  2) No.....
46. If you use the udder cloth, how often do you wash it?  
 1) Daily.....  2) Weekly...  3) Never.....
47. How do you wash the udder cloth?  
 1) With warm water.....  3) With cold unboiled water....   
 2) With warm boiled water.....  4) With cold boiled water.....
48. Do you use teat dipping after milking to prevent mastitis? 1) Yes...  2) No
49. What type of a container do you use to deliver the milk?  
 1) Plastic....  2) Stainless steel can .  3) Other, specify\_\_\_\_\_
50. How often do you wash the container?  
 1) Before every use.....   
 2) After every use.....   
 3) Before and after every use .....
51. How do you clean the container?  
 1) With cold water alone.....  4) With hot water and soap...   
 2) With hot water alone.....  5) With detergent and water.....   
 3) With cold water and soap...  6) Others (specify)\_\_\_\_\_
52. What is source of water for farm activities?  
 1) Piped/ tap.....  4) Roof catchment (rain water)....   
 2) River/ stream.....  5) Private ground pump/well.....   
 3) Community ground pump.....  6) Other (specify)\_\_\_\_\_
53. How do you store the milk containers after cleaning?  
 1) On rafts.....  3) On the ground.....   
 2) Hanging them.....  4) Other (specify).....
54. Did any of your cows have mastitis? 1) Yes.....  2) No.....
55. How do you treat for mastitis?\_\_\_\_\_

**D. Calf rearing practice**

54. Which method do you use for pre-weaning calf milk feeding?

No.	Breeds	Bucket feeding (1)
		Partial suckling (2)
		Both (3)
1	Local	
2	Cross breed	
3	Exotic	

55. If it is a bucket feeding, how many liters and for how long are given?

- 1) Morning milk \_\_\_\_\_ liters, for \_\_\_\_\_ days
- 2) Evening milk \_\_\_\_\_ liters, for \_\_\_\_\_ days

56. At what age do you normally wean your calf?

No.	Breeds	Age in months	
		Female	Male
1	Local		
2	Cross breed		
3	Exotic		

57. What type of feed is given to the calf immediately after weaning?

- 1) We give them concentrates.....
- 2) Simply leave to graze in the field.....
- 3) We don't differentiate with the old one.....
- 4) We don't care them.....
- 5) Others \_\_\_\_\_

58. When do you start giving hay/concentrate to your calf?

- 1) After 3 month.....
- 2) After 6 Month .....
- 3) After 1 Year .....
- 4) Other (specify) \_\_\_\_\_

59. If you are giving concentrate and hay to your calf how much you give per day? \_\_ kg

60. After weaning, what do you do with male calves?

No.	Breeds	1. Sell	2.Fatten them	3.Sell as sire
1	Local			
2	Cross breed			
3	Exotic			

61. What type of housing do you use for your calves? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**E. Feed resources and feeding strategies**

62. What is the feeding system in your dairy farm?

- 1) Free grazing (fulltime) .....
- 2) Stall feeding.....
- 3) Stall feeding with limited grazing .....

63. What are the major feed resources in the area? (Rank 1 - 7 in order of importance)

Season	Natural pasture	Crop residues/straw	Hay	Fodder trees/forag	Crop after math	Industrial by product
<b>Dry Season</b>						
<b>Wet Season</b>						

64. What is the major source of feed for your dairy cattle?

- 1) Own farm produced.....
- 2) Purchased.....
- 3) Both farm produced and purchase.....

65. Do you have priority for your animal to feed available feed at hand?

- 4) 1) Yes.....  2) No.....

66. What other supplements do you provide the dairy cow?

- 1) Salt licks .....  2) Mineral licks .....

- 3) Concentrates .....                       5) No supplements provide..   
 4) Mixture of above .....

67. How often do you feed concentrate to dairy cattle?

- 1) Never .....                       4) Thrice day.....   
 2) Once a day .....                       5) Occasionally.....   
 3) Twice a day.....                       6) Others \_\_\_\_\_

68. Did you have feed shortage problem for your dairy animals? 1. Yes....     2.  
 No....

69. What strategies you adopt during season of feed scarcity? (Tick more than one)

- 1) Preserve feed during high abundance.....   
 2) Feed less to all animals.....   
 3) Feed less to some animals.....   
 4) Purchase concentrates .....   
 5) Reduce herd size .....   
 6) Purchase fodder from other farmers.....   
 7) Purchase fodder from markets.....   
 8) Feed forages not normally used.....

70. Do you have experience of growing improved forages?

- 1) Yes.....     2) No.....

71. If no, why not to grow?

- 1) Land problem.....                       3) Luck of awareness.....   
 2) Seed problem.....                       4) Others.....

72. Please rank your knowledge on dairy feed and feeding

- 1) Very good...  2) Good ...  3) Fair ...  4) Needs to be improved...

**F. Water provision**

70. What is the source of water for dairy cattle?

No.	Source	Wet Season	Dry season
1.	River		
2.	Borehole		
3.	Pipe water		
4.	Pond		
5.	Spring water		
6	Other source		

73. What is your main water related problem?

- 1) Scarcity.....
- 2) Parasites such as leaches ..
- 3) Unhygienic/impurity.....
- 4) Other, specify \_\_\_\_\_

74. How far the water points from your home?

No.	Distance	Wet Season	Dry season
1.	watered at home		
2.	< 1 km		
3.	1-5 km		
4.	6-10 km		
5.	> 10 km		

75. What is the frequency of watering your animals?

**Frequency (code):**

1 = Once in a day 2 = Twice in a day 3 = Three times in a day 4 = other (specify)

Cattle breeds	Frequency	
	Dry season	Wet season
Local		
Cross breed		
Exotic breeds		

## G. Disease and Veterinary services

76. What are the major diseases occur in your dairy farm?

S.N	Diseases prevalence	Tick (√)	Rank them according to their importance (1, 2, 3, 4,
1	Black leg		
2	Anthrax		
3	External parasites		
4	Liver fluke		
5	Foot and mouth disease		
6	Abortion		
7	Lumpy skin disease		
8			
9			
10			

77. Who provides dairy veterinary services/ treatment to your animals in case of sickness?

1) Government actors .....  2) Private actors .....

78. Distance to veterinary services

1) <1km.....  3) 6-10km.....   
 2) 1-5km.....  4) >10km.....

79. Constraints of public veterinary services \_\_\_\_\_

80. Constraints of private veterinary services \_\_\_\_\_

81. Are you satisfied with veterinary services you use? 1) Yes...  2) No .....

82. Do you have any suggestions on how to increase the effectiveness and opportunities associated with veterinary services of you use, please explain? \_\_\_\_\_

## H. Record keeping practices

83. Do you practice record keeping on your farm? 1) Yes.....  2) No.....

If yes, select the type of information you record in the table below

S.N	Type of record	Tick (√)
1	Individual cow records	
2	Breeding/fertility/reproduction records	
3	Milk production records	
4	Milk sales records	
5	Farm costs	
6	Other, please specify _____	

**4. Constraints of dairy cattle production**

1. What are the major dairy production constraints you have been faced?

S. N	Production constraints	Tick (√)	Rank them 1-10
1	Lack of grazing land		
2	Inadequate water supply		
3	Inadequate feed supply		
4	High cost of animal feeds		
5	Poor quality of animal feeds		
6	Space limitation for dairying		
7	Improved dairy cattle procurement		
8	Poor veterinary services		
9	Lack of AI/breeding service		
10	Prevalence of diseases		
11	Manure handling/disposal		

2. What are your suggestions on improving dairy production activities? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**5. Milk products outlets and value chain**

**Milk producers/farmers**

1. When do you sell your fluid milk and other milk product(s)?

1) Dry season.....  2) Wet season.....  3) Year round....

2. Where do you sell your fluid milk and other milk product(s)? \_\_\_\_\_

3. To whom do you sell your fluid milk and other milk product(s)?

1) Consumed at home.....

2) Delivery to neighborhood individual customers.....

3) Local hotels, restaurants, cafes .....

4) Collection points of processing.....

5) Milk processing firms.....

6) Sale at retail shops/kiosks.....

4. Disaggregated milk quantities

Category	Average litres per day	
	Wet season	Dry season
Total milk production		
Home consumption		
Milk wastage		
Milk given to calves		
Milk sold		
Other, please		

5. If you consume the milk at home in what form of do you use?

- |   |   |
|---|---|
| 1) Fresh whole milk..... <input type="checkbox"/>         | 5) Nitir kibe (Ghee) ..... <input type="checkbox"/> |
| 2) Ergo (naturally fermented). <input type="checkbox"/>   | 6) Ayib (cottage cheese). <input type="checkbox"/>  |
| 3) Butter..... <input type="checkbox"/>                   | 7) Aguat (whey) ..... <input type="checkbox"/>      |
| 4) Arera (defatted sour milk) .. <input type="checkbox"/> |   |

6. How often do you deliver milk to the center?

- 1) Twice a day...  2) Once a Day ...  3) Once every other day.....

7. Price of milk

- Price of milk/liter at farm gate? \_\_\_\_\_
- Price of milk at retail shops? \_\_\_\_\_
- What is the unit price per unit of other milk products? \_\_\_\_\_

8. Do you have market information on price details of your dairy products?

- 1) Yes.....  2) No.....

9. Do you ever have difficulties selling your milk? Yes.....  No.....

If yes, what are the difficulties?

- |   |  |
|---|--|
| 1) Poor quality of milk..... <input type="checkbox"/> | 4) Lack of transportation ..... <input type="checkbox"/> |
| 2) No market ..... <input type="checkbox"/>           | 5) Other, please specify_____                            |
| 3) Low price..... <input type="checkbox"/>            |  |

10. How do you transport milk to market place/retailing shops?

- |  |   |
|--|---|
| 1) Bicycles ..... <input type="checkbox"/>       | 4) Cart ..... <input type="checkbox"/>            |
| 2) Motor vehicles ..... <input type="checkbox"/> | 5) Situated on site..... <input type="checkbox"/> |
| 3) Go by foot..... <input type="checkbox"/>      |   |

11. If you sell far from the farm, how far is your place to deliver the milk?

- 1) Less than 1 km .....                       4) 10-20 km .....   
 2) 1-5 km .....                                       5) Over 20 km.....   
 3) 5-10 km .....

12. Has your milk been rejected by the collection center /buyers in the last one month?

- 1) Yes.....     2) No.....

If yes, why was it rejected?.....

- 1) Abnormal colour.....                       4) Dirtiness.....   
 2) Failed alcohol test.....                       5) Adulteration.....   
 3) Abnormal smell.....                       6) Other (Specify).....

13. Do you do any milk test before delivering milk to the collection centre?

- 1) Yes.....                       2) No.....

14. If yes, which are these tests?

- 1) Alcohol test .....                                       4) Organoleptic test.....   
 2) Clot on boiling test...                                       5) Lactometer test.....   
 3) Microbial test.....

15. Is there quality based payment? Yes .....  No .....

16. What are the constraints/challenges you are facing in milk marketing?

S. No	Marketing constraints	Tick (√)	Rank 1, 2, & 3.....
1	Distance of collection centers form my home		
2	Lack of access to adequate markets		
3	In adequacy of labor to transport		
4	Spoilage of milk during transportation		
5	Inadequate market information		
6	Inadequate infrastructural development		
7	Lack of access to credit		
8	Low market price of milk		
9	Low quality of milk		

16. Do you have an access to the following dairy inputs/ services supplies and which organization (s) provide you with these technology (**Innovational**)

No.	Dairy inputs/services supplies	Mark(√)	Frequency of getting the services			Organization/Institution provided you
			Whenever needed	Sometimes	Never	
1	Milk marketing ( Buying & Selling)					
2	AI/Bull services					
3	Feed supply					
5	Veterinary Services					
6	Improved breeds /heifers supply					
7	Credit services					
8	Extension advisory services					
9	Training and education services					
10	Machinery Equipment and packaging					

## Appendix 2. Checklist for general information of smallholders' dairy farms

### Milk Producers:

- 1) Average of cows per farm
- 2) Feeding and feed sources
- 3) Major crops
- 4) Breeds commonly used
- 5) Is there AI used? (breeding methods)
- 6) Types of dairy production commonly produced
- 7) Statistics: Number of farms, number of dairy farmers
- 8) Water sources for cattle
- 9) Housing systems for cattle
- 10) Animal healthcare
- 11) Milking and handling systems
- 12) Manure management
- 13) Average production level?
- 14) Are the farmers getting training, yes, from which organizations?

**Marketing:**

1. Which produce is home consumed and which is sold? (Volume and prices)
2. Sold were? To whom? What basis?
4. Are there seasonal influences or influences in fasting days?
5. What are the different market channels?

## Study of Reproductive and Production Performance of Crossbreed Dairy Cattle under Smallholders Management System in Bishoftu and Akaki Towns

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**Abstract:** The objective was to assess the reproductive and productive performance of crossbreed dairy cattle under smallholder farmers' level in Bishoftu and Akaki districts of Ethiopia. The districts were purposively selected based on their potentiality of crossbreed dairy cattle population. A cross-sectional survey and structured questionnaire were used to collect data from 130 households. The data were analyzed using the Statistical Package for the Social Sciences to study the magnitude and direction of variation in months age at first services (AFS), age at first calving (AFC), calving interval (CI), lactation milk yield (LMY) and lactation length (LL) due to management factors. Results revealed that calving interval (CI) was only significantly ( $p < 0.001$ ) found different between the districts. The mean of AFS, AFC, CI, DMY, TLMY and LL were estimated to be (18.7±3.7 and 18.7±3.5 months), (26.9±5.4 and 27.0±3.7 months), (13.0±2.1 and 13.8±1.9 months), (11.6±3.1 and 10.8±2.4 liters per day/cows), (3208.56±108.81 and 3031.56±46.32 litres) and (276.6±35.1 and 280.7±19.3 days), respectively in Bishoftu and Akaki Towns. Poor management was the most probable factors affected the standard expected reproductive and production performance of crossbreed cattle in the study areas. Efficient heat detection and timely insemination, better health management, genetic improvement of crossbreeding, supplementing of good quality feed resources are required for optimal reproduction and production performance.

**Key words:** Crossbreed • Dairy cattle • District • Productive • Reproductive

### INTRODUCTION

Livestock production plays an important role to human health and poverty alleviation in Ethiopia. The cattle production gives multi-purpose role where cattle provide milk, meat, fertilizer, fuel, draft power and also as a means of economic uplift from the sale of milk and milk products. The sector contributes 15 to 17% of gross domestic product (GDP) and 35 to 49% of agricultural GDP and 37 to 87% of the household incomes [1].

Ethiopia has the largest livestock production in Africa. CSA [2] stated that the total cattle population of the country in 2013 was estimated to be about 55.03 million. Out of this total cattle population, the female cattle constitute about 55.38% and the remaining 44.62% were

male cattle. The large cattle population; favorable climate for improved, high yielding cattle breeds; and relatively animal disease free environment make Ethiopia to hold a substantial potential for dairy development [3]. Despite of the existing dairy scenario with a potential for its subsequent development, productivity of crossbreed dairy cattle in general is low thereby impeding its direct contribution towards national economy.

Like most developing countries, Ethiopia's increasing human population, urbanization trends and rising household incomes are leading to a substantial increase in the demand for livestock products, particularly milk and meat. In order to meet the growing demand for milk in Ethiopia, milk production has to grow at least at a rate of 4% per annum [4]. Ethiopia has given the priority on the development of dairying at farmer's level to increase the

supply of milk from smallholder dairy farms. Reproductive performance is one of the major factors, other than milk production, that affects productivity and profitability of a dairy herd. The reproductive and production performance of the herd or animal is a key indicator of sustainability of a dairy farming system. The important parameters that determine cattle reproductive and productive efficiency are age at first service, age at first calving, birth weight, total milk yield, average milk yield per day, calving to first service interval and calving interval [5].

Currently, a large number of smallholder dairy farms are operating. However, information on productive and reproductive performance of crossbreed dairy cows in the study area raised under smallholding system is not well elucidated. Most of the research conducted for crossbreed dairy cows has been under controlled conditions at research centers and government-owned institutions and thus has limited application to different production systems in Africa [6]. Moreover, the area is well communicated and the farmers are responsive make the research suitable in the study areas. The present study was therefore undertaken to investigate the productive and reproductive performances of crossbreed dairy cattle in Bishoftu and Akaki under smallholder management system.

## MATERIALS AND METHODS

**Study Areas:** The study was conducted in smallholder dairy farms found in Bishoftu and Akaki Towns of Ethiopia. The two towns were selected due to their high potential for dairy production, role in the commercialization of the dairy sector due to the proximity to Addis Ababa, a huge gap between demand and supply of milk and improved technologies accessibility for research undertaking.

Bishoftu is located in 45 km along South East of Addis Ababa. The area is located at 9°N latitude and 40°E longitude at altitude of 1850 m.a.s.l with annual rain fall of 866 mm of which 84% is in the long rainy season from June to September [8]. The annual average temperature ranges from 12.3 to 27.7°C with an overall average of 18.7°C. The soil and climate are similar to those in many highland areas in Ethiopia. Cattle, small ruminant, poultry and equines are the major livestock species kept with fast growing smallholder dairy production [7].

Akaki district is located 25km away from Addis Ababa at 9°-10°24' North latitude and 37°56'-40° 35' East longitude with an altitude range of 1500-3100 m.a.s.l.

Its annual temperature ranges from 15°C-27°C. The mean annual rainfall of the district is 800-900mm and the short rain occurs during February, March and April and the long rain extends from June up to August (Unpublished data of 2010/11). The report also shows that all of the domestic animals raised in the District, cattle population takes the first rank with 91,040, followed by 39,055 goats, 39,048 sheep, 22,676 donkeys, 6,136 horses and 2,015 mules.

**Sampling and Data Collection Method** **Sampling Method:** Bishoftu and Akaki were selected based on their crossbred dairy cattle population, ease of access, feeds and feeding systems and other characteristics of herd management. Smallholder farmers were selected from the list using a stratified random sampling procedure based on the information of city agricultural desk. Sample size was determined using the formula given by Arsham [9] for survey studies:

$$N=0.25/SE^2$$

Where, N = sample size

SE= Standard error of the population.

Accordingly, a total of 130 (61 from Bishoftu and 69 from Akaki) smallholder farmers were selected at 4.38% standard error by random sampling method.

**Data Collection Method:** Structured questionnaire was prepared and used to collect information from crossbreed dairy cow owners under smallholder condition in one visit interview and reproductive performance of their crossbreed dairy cows were studied. The questionnaires were checked for clarity of the questions prior the interview. Prior the interview, respondents were briefed to the objective of the study. Following that, the actual questions and questionnaires were presented. Accordingly, information about the reproductive and production performance of crossbreed dairy cattle >50% blood levels (age at first calving, age at first service, calving interval and calf crops, daily milk yield, total lactation yield and lactation length) were collected.

**Data Analysis:** The data were entered and organized in the excel spread sheet and then they were analyzed using descriptive statistics (SPSS, version 20). Descriptive statistics was used to display the result such as mean and standard deviation. ANOVA comparison was performed using significance at  $p<0.05$ .

## RESULTS AND DISCUSSION

### Reproductive and Production Performance of Dairy Cattle:

This section describes the reproductive and production performances of dairy cattle. The performance of the breed in the two districts was compared to assess their suitability in different management practices. Reproductive traits considered were age at first calving, calving interval, calf crops and number of service per conception while the production performance included were daily milk yield, total lactation yield, lactation length and dry period.

### Reproductive Performance of Dairy Cattle

**Age at First Service:** Age at first service (AFS) is the age at which heifers attain body condition and sexual maturity for accepting service for the first time. The respondents reported that the mean age at first serviced were  $18.7 \pm 3.7$  and  $18.7 \pm 3.5$  months (range of 13 to 26 months) old for crossbred cattle reared by the farmers in Bishoftu and Akaki, respectively (Table 1). There were not significant differences ( $p < 0.05$ ) in age at first services (AFS) of the crossbred in the two districts. The mean estimated AFS observed in this study was shorter than findings of Belay *et al.* [10] where the AFS crossbred dairy cows were  $24.30 \pm 8.01$  in Jima Town and 27.5 months of AFS crossbred dairy cows reported by Zewdie [11] in the highlands and central rift valley of Ethiopia. The largest age recorded in these areas could have resulted from the low level of management and poor feeding of calves and heifers at the earlier stages, which consequently had reduced growth rate and delayed puberty.

**Age at First Calving:** Age at first calving is the age at which heifers calve for the first time. The means  $\pm$  SD (minimum 18 months and maximum 36 months) of age at first calving (AFC) were  $26.9 \pm 5.4$  and  $27.0 \pm 3.7$  months for crossbred cattle in Bishoftu and Akaki, respectively (Table 1). Age at first calving did not differ significantly between the two districts ( $P < 0.05$ ). In the present study

the average age at first calving is lower than AFC of  $31.9 \pm 0.22$  months, which is reported by Yifat *et al.* [12] for crossbred in Zway. Moreover; the mean result of the age at first calving in the present study was lower than that of Hunduma [13] in Assela, Kumar and Tkui [14] in Mekelle and Nibret [15] in Gonder who reported  $34.8 \pm 4$ ,  $36.4 \pm 1.7$  and 32.4 months, respectively for crossbred cows. The high age at first calving observed here may be related to environmental conditions and husbandry practices which may affect on the cattle growth. These may retard growth rate, delay puberty, reduced fertility and conception, thus, the high age at first calving of the imported breed. Hence, there should be concerted efforts to improve the feeding and nutrient profile of feeds offered to the animals, housing, disease prevention and management especially during harsh climatic conditions in order to improve on age at first calving. The other reasons determining AFC or conception in particular should also have been considered; in other case the reasons affecting AFS and AFC are completely overlapping.

**Calving Interval:** The calving interval is the period between two consecutive parturitions and ideally should be 12 to 13 months. Calving interval (CI) is one of the major components of reproductive performance that influences livestock production system. The means  $\pm$  SD (minimum 12 months and maximum 21 months) for CI were  $13.0 \pm 2.1$  and  $13.8 \pm 1.9$  months for crossbred cattle at Bishoftu and Akaki, respectively. There is a statistically significant ( $P < 0.05$ ) difference in the mean length of calving interval in the two areas. Presented results are in concordance to the previous findings of Hunduma [13], with  $372.8 \pm 5.9$  days (12.4 months) in Assela Town. However, the mean calving interval observed in this study is shorter than 17.8 months reported by Emebet and Zeleke [16] in Dire-Dawa and in line with 13.6 months reported by Yifat *et al.* [12] in Zway for crossbred dairy cows. The high calving interval reported in the present study may be related to poor management practices and

Table 1: Reproductive performance of crossbred dairy cows

Parameters	Bishoftu			Akaki			P
	Min.	Max.	Mean $\pm$ SD	Min.	Max.	Mean $\pm$ SD	
AAS (in months)	12	28	$18.7 \pm 3.7$	14	25	$18.7 \pm 3.5$	0.93
AFC (in months)	18	36	$27.0 \pm 3.7$	18	36	$26.9 \pm 5.4$	0.96
CI (in months)	12	24	$13.0 \pm 2.1$	12	18	$13.8 \pm 1.9$	0.02*

AFS = Age at First Service, AFC = Age at First Calving, CI = Calving Interval, SD = Standard Deviation \* = shows significant difference ( $p < 0.05$ )

Table 2: Productive performance of crossbreed dairy cows

Production parameters	Under three stage of lactation						P-value
	Bishoftu (Mean±SD)			(Akaki Mean±SD)			
	1 <sup>st</sup> stage	2 <sup>nd</sup> stage	3 <sup>rd</sup> stage	1 <sup>st</sup> stage	2 <sup>nd</sup> stage	3 <sup>rd</sup> stage	
DMY(liter)	14.3±5.4	12.7±2.7 <sup>b</sup> 11.6±3.1	7.9±2.5	14.5±3	10.6±2.6 <sup>b</sup> 10.8±2.4	7.1±2.0	- 0.06
TLMY/cow (liter)	3208.56±108.81			3031.56±46.32			-
LL (Days)	276.6±35.1			280.7±19.3			0.41

DMY= Daily milk yield; TLMY= Total lactation milk yield; LL= Lactation length; SD= Standard deviation; b = shows statistical significant difference (p<0.05)

other environmental stress that could affect the animals return to oestrus, heat detection, serving and conception at Bishoftu and Akaki Towns.

**Production Performance of Dairy Cattle:** Lactation yield was not measured in the survey, but based on farmers' knowledge about their production both per cow and per day.

**Daily Milk Yield:** The milk productions at different stage of lactation of crossbreed dairy cows are presented in Table 2. The mean milk yield was 14.3±5.4 liter, 12.7±2.7 liter and 7.9±2.5 liters for the first, second and third stage of lactations, respectively with an overall average of 11.6±3.1 liters per day/cows in Bishoftu. The mean milk yield was 14.5±3 liter, 10.6±2.67 liter and 7.1±2.0 liters for the first, second and third stage of lactations, respectively with an overall average of 10.8±2.4 liters per day/cows in Akaki. The milk production was significantly decreased in third than first and second stage of lactation. The milk yield of this study is greater than Addis *et al.* [17] that were reported to be 7.01±2.73, 5.55±2.83 and 3.50±1.64 liters for the first, second and third stage of lactations, respectively with an overall average yield of 5.35±1.23 liters per day. However, the result of this study is slightly greater than Adebabay [18] who reported 10.96, 9.12 and 5.04 liters for first, second and third stages of lactation respectively.

**Total Lactation Milk Yield:** Table 2 shows that the total mean lactation milk yields (TLMY) of crossbreed dairy cow was found to be 3208.56±108.81liters and 3031.56±46.32litres, respectively. The mean lactation milk yield found in these study areas, were lower than 3025, 5807 liters reported by Dennis [19] in Kenya and Naceur *et al.* [20] in Tunisia, respectively. The lower value obtained here could have been influenced by the environment and poor management practices.

**Lactation Length:** Lactation length refers to the time of period from when a cow starts to secrete milk after parturition to the time of drying off. A lactation period of 305 days is recommended to take advantage of 60 days dry period. The mean±SD lactation length of crossbreed cows in the present study was found to be 276.6±35.1days, 280.7±19.3 days, respectively (Table 2). The effect of study sites on lactation length was not significant (P>0.05). The estimated lactation length was comparable to the ideal lactation length of 305 days as defined by Foley *et al.* [21]. The lactation length of the present study is shorter than with the result of Mulugeta and Belayneh [22] where the lactation period for crossbred dairy cows were 333.9 days in North Showa and with the findings of Ketema [23] who reported the average lactation period of crossbreed cow was 303 days in Kersa Woreda. Zewdie [10] reported that the average lactation period of crossbreed dairy cows in Debre-Birhan, Jima and Sebeta were 291.0±21.2, 288.5±21.2 and 300.0±21.2 days, respectively. The result is almost similar with the present finding. Level of management achievable in Ethiopia is unfavorable to higher exotic inheritance levels than 50% Holstein Friesian inheritance [24].

## CONCLUSIONS AND RECOMMENDATIONS

The smallholder dairy productions are important, where they help to safeguard the large difference between milk demand and supply around the towns. It is concluded that the results obtained for AFS, AFC, CI, LL and LMY were below the standard expected from commercial dairy herd. Management differences (Proper feeding, housing, AI services/breeding, watering and health care) are the major constrain to decrease the productive and production performance of crossbreed cattle in the study areas. In order to improve the relatively low average daily milk yield, the extended AFC and CI and the short LL and milk production associated with these,

efficient heat detection and timely insemination, better health management, genetic improvement of crossbreeding, supplementing of good quality feed resources are necessary.

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## Physicochemical Properties of Raw Milk Collected from Different Value Chain Points in Central Ethiopia

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**Abstract:** Milk is a translucent white liquid, produced by the mammary glands of mammals with high nutritional value, providing the primary source of nutrition for young mammals before they are able to digest other types of food. This study was conducted to evaluate physical and chemical quality of cow's raw milk. Total of 52 raw milk samples were collected from milk value chain points at Bishoftu and Akaki towns and analyzed. The results showed that the overall mean and standard deviation of physical and chemical quality of milk in the study areas for PH, freezing point, density, add water, acidity, fat, protein, SNF, total solid, lactose and ash contents of milk samples were  $6.66\pm 0.04$ ,  $-0.55\pm 0.03$ ,  $1.028\pm 0.002$ ,  $2.80\pm 3.60$ ,  $0.176\pm 0.01$ ,  $3.60\pm 0.53$ ,  $3.27\pm 0.15$ ,  $7.78\pm 0.41$ ,  $11.38\pm 0.78$ ,  $3.93\pm 0.25$  and  $0.62\pm 0.05$ , respectively. The physical and chemical qualities of milk samples obtained from the study areas were significantly different ( $P<0.05$ ). The data demonstrate that milk physical and chemical properties from the value chain of Bishoftu and Akaki had slightly fulfilled to the global and Ethiopia standard.

**Key words:** Raw milk • Lactose • Chemical properties • Protein • SNF

### INTRODUCTION

Milk is a translucent white liquid, produced by the mammary glands of mammals with high nutritional value, providing the primary source of nutrition for young mammals before they are able to digest other types of food. Fresh milk considered as a complete diet because it contains the essential nutrients as lactose, fat, protein, mineral and vitamins in balanced ratio rather than the other foods [1]. Raw cow milk is composed of approximately 87.2 % water, 3.7% fat, 3.5% protein, 4.9% lactose 0.7% ash and has pH of 6.8 [2]. The smallholder dairy farming in many African countries, including Ethiopia, is important because it plays a significant role in ensuring food security and alleviation of poverty. Milk and milk products have important role in feeding the rural and urban population of Ethiopia owing to its high nutritional value. It is produced daily, sold for cash or readily pro-processed. It is a cash crop in the milk shed areas that enables families to buy other food stuffs and significantly contributing to the household food security [3].

To fulfill consumer demands, quality milk production is necessary. Quality milk means that the milk is free from harmful toxic substances, free from sediment and extraneous substances of good flavor with normal composition, adequate in keeping quality [4]. Milk if present in its natural form has high food value and supplies nutrients like good quality proteins, fat, carbohydrates, vitamins and minerals in significant amount. Besides its general need for human health, milk proteins also provide amino acids which are needed for proper growth of adults and infants [5]. Ethiopia's domestic milk production is above  $3.0\times 10^9$  litres per annum and this is produced and processed by stallholder dairy farmers in urban and rural areas mostly in traditional way and usually supplied to the consumers in raw form [6].

This production and consumption trend will compel dairy industry to produce diverse milk products to suit the consumers' preferences and taste, which could be improved and attained through milk standardization [7]. However, prior to gearing into milk standardization it has become imperative to have basic empirical information on

physicochemical components of milk produced by the farmers who own the crossbreds. At this moment such information is limited. Therefore, the aim of this study was to assess the physical and compositional quality of cow's raw milk collected from different raw milk value chain points. The research work also claimed the government body to formulate standards and enforced it to make uniform compositions quality products.

## MATERIALS AND METHODS

The study was conducted in smallholder dairy farms found in Bishoftu and Akaki Towns.

**Milk Sample Collection:** The study conducted a laboratory-based investigation aimed to assess quality of raw cow's milk collected from value chain points in Bishoftu and Akaki. 52 samples [40 milk producers (MP) who own crossbreed, 8 milk collectors (MC) and 4 milk processing plants (MPP)] were randomly selected. Before sampling the milk was thoroughly mixed and 50 ml of milk sample was collected aseptically into separate sterile bottles in the morning to be transported easily without any delay. The milk sample bottles were capped, labeled with a permanent marker and stored in an ice packed cool box and transported to the Ethiopian Meat and Dairy Industry development Institute laboratory for physical and chemical analyses on the same day.

### Laboratory Analysis of Milk

**Physical and Chemical Analysis of Raw Milk:** Ekomilk analyzer (Model: Bulteh 2000, Bulgaria) reliable, automated multi-parameter milk analyzer providing rapid test results for chemical composition of milk (fat, protein, lactose and solid not fat) and physical characteristics (milk density, freezing point and added water) of the milk samples according to manufacturer's instructions. Based on ultrasonic technology, the instrument does not require any costly chemicals, caustic substances or reagents for testing. The pH of milk samples was measured electrometrically with a pH meter (Metrohm 704 pH meter).

**Statistical Analysis:** Data obtained from laboratory milk analysis was collaborated, then entered in Microsoft EXCEL and then exported to Statistical package for social scientists (SPSS), Version 20. Results were expressed as mean and standard deviation. The significant differences between means were calculated by a one-way analysis of variance (ANOVA) statistical analysis for comparison of the parameters variation at  $P < 0.05$ .

## RESULTS AND DISCUSSION

**Raw Milk Physical Characteristics:** The physical characteristics such as specific gravity, pH, freezing point and add water are important parameters in studying the physical properties of raw milk. Table 1 and Table 2 show the various physical parameters of the different milk samples collected from the milk value chain points of Bishoftu and Akaki towns.

**Added Water:** In the study areas, an overall mean value for added water of  $2.80 \pm 3.60$  was recorded. Even though the results showed no significant variation ( $P > 0.05$ ), the mean value of added water was slightly different in the samples collected from milk collectors  $4.76 \pm 5.85$ , followed by milk collected from milk processing plants and farmers  $2.61 \pm 3.58$  and  $2.43 \pm 2.98$ , respectively. The average values of add water content in Bishoftu and Akaki were  $3.58 \pm 3.91$  and  $1.20 \pm 2.18$ , respectively. The result showed significant variation ( $p < 0.05$ ) in the different locations. Overall mean of water add in the study areas was  $2.80 \pm 3.60$ . This is similar with finding of Tseyey and Asrat [8] who reported water add content of cow's raw milk collected ( $2.83 \pm 0.99$ ) and ( $2.55 \pm 0.99$ ) in Hawasa and Yirgalem, respectively and higher than the results of ( $1.19 \pm 0.17$ ) Dehinet *et al.* [9] who reported for cow's raw milk quality under a smallholder production system in selected areas of Amhara and Oromia National Regional States, Ethiopia. It has been noticed that addition of water to normal whole milk was assumed to increase the quantity of milk [10]. However, the addition of water to milk not only reduces the nutritional value of milk but contaminated water may also pose a health risk [11]. The management practices, particularly the remains of the rinse water in the milk container prior to milking and addition of the wash water to the milk containers after the milking might have contributed to the presence of added water in milk.

**Freezing Point of Milk:** The freezing point of milk is an important indicator of the milk quality. Mean value and standard deviation of MP, MC and MPP were  $-0.55 \pm 0.02$ ,  $-0.53 \pm 0.04$  and  $-0.55 \pm 0.03$ , respectively. No significant differences ( $P > 0.05$ ) were found for freezing point of milk samples collected from different value chain points. Freezing point of milk in Bishoftu ( $-0.54 \pm 0.03$ ) and Akaki ( $-0.56 \pm 0.02$ ) was evaluated. The mean values of freezing point of milk samples collected from Bishoftu was significantly ( $P < 0.05$ ) high (Table 2). In this study, the overall mean value of freezing point was  $-0.55 \pm 0.03^\circ\text{C}$ . The findings were comparable with the average milk freezing point reported by Zagorska and Ciprovica [12] who reported ( $-0.53 \pm 0.01$ ) from raw milk collected in

Table 1: Summary of the results (mean±SD) of Physico-chemical parameters of raw milk collected from different value chain points of Bishoftu and Akaki towns, Ethiopia

Parameters	Milk value chain points			Overall
	MP (N=40)	MC (N=8)	MPP (N=4)	
PH %	6.66±0.05	6.66±0.01	6.66±0.01	6.66±0.04
Freezing point %	-0.55±0.02	-0.53±0.04	-0.55±0.03	-0.55±0.03
Density %	1.028±0.002	1.028±0.002	1.028±0.002	1.028±0.002
Add water %	2.43±2.98	4.76±5.85	2.61±3.58	2.80±3.60
Acidity	0.176±0.02	0.175±0.01	0.175±0.01	0.176±0.01
Fat%	3.60±0.58	3.56±0.30	3.63±0.22	3.60±0.53
Protein %	3.28±0.14	3.19±0.20	3.28±0.15	3.27±0.15
SNF %	7.83±0.38	7.56±0.55	7.81±0.42	7.78±0.41
Total solid %	11.43±0.79	11.12±0.83	11.44±0.59	11.38±0.78
Lactose %	3.95±0.23	3.82±0.34	3.94±0.28	3.93±0.25
Ash%	0.63±0.05	0.59±0.04	0.60±0.00	0.62±0.05

MP =Milk collectors, MC= Milk Producers, MPP =Milk processing plants, N=number of samples, SNF=solid not fat

Table 2: Physico-Chemical properties of raw milk samples collected from Bishoftu and Akaki Towns, Ethiopia

Parameters	Bishoftu (N=35)	Akaki (N=17)	P-value
PH %	6.67±0.04	6.64±0.05	**
Freezing point %	-0.54±0.03	-0.56±0.02	**
Density %	1.028±0.002	1.029±0.002	**
Add water %	3.58±3.91	1.20±2.18	**
Acidity	0.173±0.014	0.182±0.015	**
Fat%	3.51±0.54	3.78±0.46	NS
Protein %	3.23±0.16	3.34±0.12	**
SNF %	7.69±0.42	7.98±0.33	**
Total solid %	11.20±0.80	11.76±0.60	**
Lactose %	3.87±0.26	4.04±0.20	NS
Ash%	0.62±0.06	0.62±0.04	**

\*\* = showed significant difference, NS= no significant difference N=number of samples

Lativa. The freezing point of milk could be affected by the freezing point of milk during cooling, or addition of wash water to the tank in most cases.

**Specific Gravity:** The mean and standard deviation of the specific gravity of raw milk samples collected from MP, MC and MPP were 1.028±0.002, 1.028±0.002 and 1.028±0.002 respectively (Table 1). Statistically it was found that there were no significant differences ( $P < 0.05$ ) within the specific gravity of milk collected from the different milk value chain points. It was observed that specific gravity of milk obtained from Bishoftu (1.028±0.002) was higher than the specific gravity of milk obtained from Akaki (1.029±0.002). Significant differences ( $P < 0.05$ ) were observed for density between the Towns. The specific gravity of the current result of raw milk was slightly similar to that reported by Teklemichael *et al.* [13] in Dire Dawa town, Zelalem [14] who reported the specific gravity of milk samples tested was 1.028 and 1.029 for

Holetta and Selale areas, respectively and Mahmood and Usman [15] who reported density of cow's raw milk (1.029± 0.0011.028) kg/liter was observed for the milk produced in Gujrat, Pakistan.

**PH Content:** PH is the parameter that determines the sample acidity and alkalinity. The average pH value was 6.66±0.04 with the areas sampled recording readings. The pH of all the milk samples collected from MP, MC and MPP were found to be 6.66±0.05, 6.66±0.01 and 6.66±0.01, respectively (Table 1). No significant variations were found for the parameter in all the milk samples in the different milk value chain points. The mean pH values of raw milk were 6.67±0.04 for Bishoftu and 6.64±0.05 for Akaki. The results showed significant variation ( $P < 0.05$ ) in the two towns. This is in line with the normal pH of fresh cow milk ranges from pH 6.6-6.8 reported by FAO [16]. The pH value found in the current study was comparable with the findings in obtained from dairy farms in Dire Dawa town (6.627±0.135) [13]. PH values found in the sampled raw milk are in agreement with the findings of (6.76±0.51) Imran *et al.* [17] from various milk samples marketed in Pakistan and Enb *et al.* [18] who reported the pH value of (6.60±1.10) raw milk and heavy metals behavior during processing of milk in Egypt.

**Raw Milk Chemical Parameters:** The results of the experiment for chemical parameters of raw milk samples such as solids not fat (SNF), protein, lactose, fat, total solids (TS) and ash are shown in the Table 1 and Table 2.

**Fat Content:** The composition of milk samples collected from different channels is presented in Table 2. The mean value of fat content in milk samples collected from MP was 3.60±0.5 followed by MC and MPP (3.56±0.30 and

3.63±0.22, respectively). Statistical analysis showed that there were no significant differences ( $P>0.05$ ) within the fat content of milk collected from different value chain points. The mean value of fat content in milk collected from Bishoftu (3.51±0.54) was lower than milk samples collected from Akaki (3.78±0.46), even though there was not significantly different ( $P>0.05$ ). The overall mean of the fat content was 3.60±0.53. The result of fat content of this experiment is slightly similar with the finding of Jemila and Acheneff [19] who reported the fat content of (3.70±0.89) raw milk produced in mid lactation of bred cross Holstein Friesian cows, North-western Ethiopia. But less than with reports of Teshome *et al.* [20] who found 4.28±0.05 fat from raw cow's milk produced and marketed in Shashemene town, Southern Ethiopia and Alganesh [21] who found 3.76 fat content from raw milk collected in peri-urban areas of Ejere, Walmera, Selale and Debre Birhan Districts of the central highlands of Ethiopia. The lower fat content of milk may be due to cows of that farm were high milk producing crossbreeds cows which reduces the fat content of the milk samples or water may be added with milk or partly skimming the milk or due to the fed more green forages. According to the Ethiopian standard agency, the minimum fat percent for whole milk should not be less than 3.5 percent [22]. Consequently, the average fat content (3.60±0.53) observed from the three values chain points milk samples were fulfilled the recommended standards.

**Solid Not Fat (SNF):** The average SNF content of raw milk samples collected from MP, MC and MPP are shown in the Table 2. The means and the standard deviation of SNF content of milk collected from MP, MC and MPP were 7.83±0.38, 7.56±0.55 and 7.78±0.41, respectively (Table 1). Statistical analysis showed that there were no significant differences within the SNF content of milk collected in the different milk value chain points. The average SNF content of raw milk samples collected from Bishoftu and Akaki towns were 7.69±0.42 and 7.98±0.33, respectively (Table 2). Statistically it was found that there were significantly different within the SNF of different types of raw milk samples collected from different Towns (Table 2). The results of this experimental analysis of SNF content of raw milk are in agreement with Estifanos *et al.* [23] who report the average SNF (7.98±0.98) of raw cow milk collected across the value chain in Harar milk shed. But different with the findings of Dehinnet *et al.* [9] who reported that the average SNF (8.44±0.72) of raw milk from selected areas of Amhara and Oromia National Regional States, Fikrineh *et al.* [24] found the average SNF

percentage of raw milk of Adama town was 9.05±0.16 and with Debebe [25] who also reported the minimum (8.3±0.36) and maximum (8.7±0.36) SNF content of raw cow's milk obtained from street-vendors and milk producers in and around Addis Ababa, respectively. The standard for SNF content of whole cow milk is a minimum of 8.25% [26]. The average SNF content for the current study is below the recommended standards.

**Total Solids (TS):** The average total solid (TS) content of raw milk samples collected from MP, MC and MPP are shown in the (Table 1). The means and standard deviation of Total solids (TS) content of raw milk collected from MP, MC and MPP were 11.43±0.79, 11.12±0.83 and 11.44±0.59, respectively. Statistical analysis showed that there were no significant differences within the TS content of milk collected from the milk value chain points. The mean values of total solids in milk collected from Bishoftu (11.20±0.80) was significantly ( $P<0.05$ ) lower than milk samples collected from Akaki (11.76±0.60) (Table 2). The average TS of raw milk samples collected from the value chain was 11.38±0.78. This result is slightly comparable with the result of Teshome *et al.* [20] who found total solid in milk from Shashemene town (12.87±0.11) and also Mirzadeh *et al.* [27] reported total solids content in some dairy farms in Iran (12.57±0.69%). According to European Union established standards for total solids content of cow milk not to be less than 12.5% [28]. Therefore, the current result of the average total solid content (11.38 %) found from study areas were below the recommended standards. The lower TS content of collected raw milk samples may be due to addition of water with milk, lower fat content and this might also be due to the farmers' maintained high producing dairy cattle or high blood level crossbreed.

**Ash Content:** The average ash contents of raw milk samples collected from MP, MC and MPP were 0.63±0.05, 0.59±0.04 and 0.60±0.00 respectively (Table 1). Statistically it was found that there were no significant differences within the ash of different types of raw milk samples collected from different raw milk value chain points. The average ash content in milk samples collected from Bishoftu town (0.62±0.06) and Akaki (0.62±0.04) was similar. But statistically it was found that there were significant differences ( $P<0.05$ ) within the ash content of different types of raw milk samples collected from the two locations (Table 2). The overall mean of ash content (0.62±0.05) found in the raw milk during this study is slightly similar with the findings of Imran *et al.* [17] and

Estifanos *et al.* [23] who observed that the means of ash in cow's raw milk collected from different locations were  $0.64\pm 0.07$  and  $0.68\pm 0.16$ , respectively. But different from the finding of Teshome *et al.* [20] who reported ( $0.78\pm 0.00$ ) for the raw cow's milk collected from produced and marketed in Shashemene town, Southern Ethiopia.

**Protein Content:** The average protein contents of raw milk samples collected from MP, MC and MPP were  $3.28\pm 0.14$ ,  $3.19\pm 0.20$  and  $3.28\pm 0.15$  respectively (Table 1). Statistical analysis showed that there was no significant difference ( $p>0.05$ ) within the protein% of samples. The mean protein% in milk samples collected from Bishoftu ( $3.23\pm 0.16$ ) was slightly similar with Akaki town ( $3.34\pm 0.12$ ), although there was significant difference ( $P<0.05$ ) between the two locations. The overall mean of the protein content was ( $3.27\pm 0.15$ ). This result is similar with reports of Debebe [25] who found protein content of milk  $3.2\pm 0.22$  from the milk producers in and around Addis Ababa City and Belay and Janssens [29] who reported the protein content ( $3.21\pm 0.06$ ) of raw milk samples collected from different urban dairy farms located in Jimma town. But it is slightly lower than Gurmessa *et al.* [30] who reported ( $3.94\pm 0.07$ ) for the raw cow's milk in Yabello District, Borana Zone. Dehinent *et al.* [9] found that the mean value of protein content in milk collected from selected areas of Amhara and Oromia National Regional States ( $3.12\pm 0.32\%$ ) which is lower than that of the current study. But, Teklemichael *et al.* [13] reported slightly higher result than protein contents ( $3.42\%$ ) for milk collected from dairy farms in Dire Dawa town and Fikrineh *et al.* [24] reported higher protein content ( $3.46\pm 0.04$ ) for milk samples collected from households rearing local and crossbred cows in Mid-Rift Valley of Ethiopia compared to the present study. According to Ethiopian standards Agency, the minimum percent protein content of whole milk should be 3.2 percent [22]. Hence, the average protein content for the current study is similar with the recommended standard of the nation.

**Lactose:** The average lactose contents of raw milk samples collected from MP, MC and MPP were  $3.95\pm 0.23$ ,  $3.82\pm 0.34$  and  $3.94\pm 0.28$ , respectively (Table 1). Statistical analysis showed that there was no significant difference ( $p>0.05$ ) within the lactose content of different raw milk samples. The lactose of milk collected from Bishoftu ( $3.87\pm 0.26$ ) was lower than that of milk samples collected from Akaki ( $4.04\pm 0.20$ ), although no significant variations ( $P>0.05$ ) were obtained between the two locations. Lactose content found in raw milk during this research work is less than the findings of Belay and

Janssens [29] who reported the lactose content ( $4.34\pm 0.13$ ) of raw milk samples collected from different urban dairy farms located in Jimma town and Jemila and Achenef [19] who reported cow's raw milk ( $4.68\pm 0.41$ ) in bred cross Holstein Friesian cows, North-western Ethiopia. According to European Union quality standards for unprocessed whole milk, lactose content should not be less than 4.2% [28]. Therefore, the current average lactose content ( $3.93\pm 0.25$ ) found for the raw milk samples was below the recommended standards. The composition of milk can vary depending on breed of the animals and management practices influenced the milk composition [31].

## CONCLUSIONS

This research was conducted in Bishoftu and Akaki towns with the aim of assessing the physical and chemical quality of raw milk collected from different value chain points. Generally, it can be concluded that the quality of cow's raw milk collected in both towns was similar and slightly fulfilled to the acceptable global and Ethiopia standards. This finding may be helpful for the concerned bodies to monitor the quality of the raw milk products in the marketing of the country. Farmers, milk collectors and processors need training in physical and chemical quality aspects of raw milk. Further investigations are carried out to examine other milk components in the milk value chain points in the study areas.

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