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STUDY ON DAIRY CATTLE PRODUCTION SYSTEMS, MILK QUALITY AND MAJOR DISEASE PROBLEMS IN DEBRE BERHAN MILKSHED, CENTRAL HIGHLANDS OF ETHIOPIA

PhD Dissertation

By

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Department of Animal Production Studies

PhD Program in Animal Production

June, 2020

Bishoftu, Ethiopia

STUDY ON DAIRY CATTLE PRODUCTION SYSTEMS, MILK QUALITY AND MAJOR DISEASE PROBLEMS IN DEBRE BERHAN MILKSHED, CENTRAL HIGHLANDS OF ETHIOPIA

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

By

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Bishoftu, Ethiopia

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College of Veterinary Medicine and Agriculture

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As members of the Examining Board of the final PhD open defense, we certify that we have read and evaluated the Dissertation prepared by Mr. **Admasu Lakew Kidane** Entitled: "**Study on Dairy Cattle Production Systems, Milk Quality and Major Disease Problems in Debre Berhan Milkshed, Central Highlands of Ethiopia**", and recommend that it be accepted as fulfilling the dissertation requirement for the degree of Philosophy in Animal Production.

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DEDICATION

This Dissertation is dedicated to my late mother Asegedech Argaw and my late father Lakew Kidane who selflessly endured for the success of their children and others.

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 Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University Library to be made available to borrowers under the rules of the Library. I solemnly declare that this dissertation is not submitted to any other academic institution anywhere for the award of an academic degree, diploma or certificate.

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BIOGRAPHICAL SKETCH

The author was born in Debre Brehan town of North Showa Administrative Zone of the Amhara Regional State in May 1985. He attended his elementary and junior secondary educations at Model Kutir 2 Elementary and Atse Zerayakobe Junior Secondary School, and his high school education at, Haile Mariam Mamo Comprehensive and Preparatory School. After successful completion of preparatory education, he joined the then Hawassa University College of Agriculture in 2006 and graduated with BSc Degree in Animal and Range Sciences in 2008. Right after graduation, he was assigned by the Ministry of Education to Mekelle University as a Graduate Assistant and served for one year. He joined again the School of Graduate Studies of Hawassa University in 2010 and obtained an MSc Degree in Animal and Range Sciences (specialization in Animal Production) in 2012. Again, he returned to Mekelle University as a Lecturer and taught several Animal Science courses until September 2014. He moved to Debre Berhan University in September 2014 and served for a year as a Lecturer. In 2015 he joined the School of Graduate Studies of the College of Veterinary Medicine and Agriculture of Addis Ababa University to pursue his PhD. study in Animal Production. He is married and a father of two sons.

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ABBREVIATIONS

AI	Artificial Insemination
ANOVA	Analysis of Variances
APHA	American Public Health Association
CFT	Complement Fixation Test
Cfu	Colony-forming units
CM	Clinical Mastitis
CMT	California Mastitis Test
CNS	Coagulase Negative Staphylococci
CPS	Coagulase Positive Staphylococci
CSA	Central Statistical Authority of the Federal Democratic Republic of Ethiopia
DDA	Dairy Development Authority
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
HHs	Households
IMI	Intermammary Infection
kg	Kilogram
km	Kilometer
MCC	Milk collection center
MoA	Ministry of Agriculture
MP	Milk producer
MPP	Milk Processing Plant
NAIC	National Artificial Insemination Center
NMC	National Mastitis Council

LIST OF ABBREVIATIONS (CONTINUED)

NRC	National Research Council
OIE	Office International des Epizooties
RBPT	Rose Bengal Plate Test
RFM	Retained Fetal Membrane
SAS	Statistical Analysis System
SCC	Somatic Cell Count
SE	Standard errors
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
USD	United States Dollar
VRBA	Violet Red Bile Agar

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STUDY ON DAIRY CATTLE PRODUCTION SYSTEMS, MILK QUALITY AND MAJOR DISEASE PROBLEMS IN DEBRE BERHAN MILKSHED, CENTRAL HIGHLANDS OF ETHIOPIA

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ABSTRACT

A cross-sectional study was conducted with the major objectives of characterizing dairy cattle production systems, analyses of the quality of raw milk and major disease problems in Debre Berhan milkshed in central highlands of Ethiopia. The survey was conducted in three selected study sites of Debre Berhan milk shed. A total of 175 randomly selected household were involved in the study. Data from the household survey were collected using pre-tested fully structured questionnaire, through observation and focused group discussion. The result showed that crossbred dairy cows were preferably kept by the producers than local dairy cows. The main reason producers involved in dairying was income generation either from milk sale or animal sales followed by dairy farmers kept dairy cattle as a means of assets. Among the many constraints raised by dairy producers, shortage of land was the major one which has limiting effect both on keeping dairy animals and production of dairy feed. The others included feed shortage, high feed price, poor nutritional quality of available feeds and prevalence of production related diseases. Indoor feeding and artificial insemination were mostly used feeding and breeding practices, respectively. The majority (95.4%) of respondents used to wash their hands before milking of which 78.3% had access to tap water to clean hands, milk utensils and the udder of cows. About 77.1% of the respondent's cleaned milk utensils immediately after use with cold water and detergent while 16.6% of dairy farmers cleaned the equipment prior to use but not immediately after use. The total bacterial count of cow milk produced in the urban and peri-urban were 7.11±0.86 log_{10} cfu /ml and 7.17±0.61 log_{10} cfu/ml, respectively. The somatic cell count in the urban and peri-urban milk production system was 6.17±0.54 log_{10} cfu/ml and 5.42±0.43log_{10} cfu/ml respectively. Higher (SCC/ml) was found in urban (6.17) areas of the study compared to the peri-urban areas (5.42). Microbial load of dry season milk was significantly ($p<0.05$) higher than wet season milk. Significantly higher total bacterial count (TBC) and coliform count (CC) was found for milk obtained from processing plant than milk collection center and dairy farmers. The total bacterial count (TBC) collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were 7.14±0.74 log_{10}cfu/ml, 7.43±1.11 log_{10}cfu/ml, and 7.84±0.54 log_{10}cfu/ml respectively. The SCC collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were 5.68 log10 somatic cell/ml, 5.39 log10 somatic cell/ml and 5.87 log10 somatic cell/ml, respectively. Major health problems

*encountered were mastitis, black leg and foot and mouth disease. A total of 510 lactating cows were examined clinically. California Mastitis Test (CMT) was used to detect clinical and subclinical mastitis. The overall prevalence of mastitis at cow and quarter level was 72.2% and 55.95%, respectively. Among mastitis cases, 54.9% was subclinical and 17.3% was clinical mastitis. Similarly, among the total (2040) quarters investigated, 55 quarters (2.65%) were blind. In clinical mastitis, age, breed, previous history of mastitis, milk yield, herd size and teat lesion had shown statistically significant association with the prevalence of mastitis (P<0.05). The most repeatedly isolated pathogens from mastitis positive cases was Staphylococcus species (*57.3*%).The study indicated that the overall cow level occurrence of lameness was found to be 9.2%. The risk factors for the prevalence of lameness at the animal level were production systems, length of cow track in meter, floor type and hoof trimming practices. The average daily milk yield/cow was found to be significantly decline by 1.77 liters with the case of lameness. A total of 744 blood samples were collected* both *from male and female of non-vaccinated, crossbred, Jersey and local breeds of dairy cattle. The seroprevalence of bovine brucellosis was 11 (1.5%) by RBPT and 1.21 %. by CFT. The risk of having brucellosis in those herds experiencing abortion was 22.97 times higher (OR =22.97, CI = 2.72-193.73) than those without abortion. It could be concluded that dairy production was commonly practiced and was good source of income in the study area. However, land and feed shortage and the price of feed were among the constraints severely affecting dairying. Milk collected from all value points did not meet the minimum quality standard hence continuous awareness creation should be practiced. Among the major dairy cattle diseases, mastitis was a serious problem in dairy farms in the study areas. Therefore, hygienic milking practice, frequent screening for mastitis and special handling of chronically infected and older cows with repeated mastitis records, cow therapy and awareness creation to dairy farm should be practiced to reduce the risk of mastitis. Similarly, the study showed that lameness is an economically important dairy cattle problem. Consequently, prevention and treatment of lameness in cows at all stages of lactation should be part of dairy farm management practice. Finally, isolation of aborted and new entry animals, movement control between different herds and creation of public awareness by educating people are forwarded to reduce disease transmission within animals and from animals to humans.*

Keywords*: Crossbred dairy cattle; Debre Berhan; Ethiopia; Management practices; Mastitis; Milk quality; Socio-economic characteristic; urban and peri-urban dairy production*

1. INTRODUCTION

Ethiopia has over 59.5 million heads cattle of which 54.68% are female. Among the female cattle population, dairy-cows (milk production) are estimated around 7.16 million and milking-cows (cows raised for some other purposes other than milk production; for example traction, meat, etc.) are about 11.83 million heads (CSA, 2018). Dairy cows are mainly found in the Ethiopian highlands, which inhabit the central part of the country (Fazzini *et al*., 2015). Now a days, Ethiopia already has a shortage of dairy products and imports dairy products from other countries (Azage *et al*., 2013). Moreover, in order to increase milk production per animal, it is increasing the productivity of animals, because the existing milk production per cow often is relatively low with fairly some potential for improvement. This low production of milk requests for improving the productivity of dairy cattle, such as by improving animal health and specifically udder and reproductive health(Sefinew, 2018).

In the early 1950s, modern dairying was started, when the country received the first Holstein Friesian (HF) cows from the United Nations Relief and Rehabilitation Administration. With the introduction of these cattle in Holleta and the former Shola dairy farms in Addis Ababa, commercial liquid milk production started in Ethiopia (Ketema, 1998). The government encouraged dairy production through the introduction of these high-yielding dairy cattle and by promoting cross-breeding HF cows with indigenous Zebu cattle. This crossbreeding was introduced in 1967 and is nowadays widely practiced (Gebremedhin *et al*., 2009). Ethiopia is benefiting from the dairy in that it has led to poverty alleviation and increased economic growth, with an average contribution both total national (GDP) and (AGDP) of 12-16% and 45% respectively (CSA,2018). Moreover, the dairy sector pay to improve the nutritional status and income gain of the people by providing milk, cheese, butter and commodities, such as live animals, hides, and skins for home use and export; and avert risks in times of crop failures (CSA, 2018). The milk production is likely to continue to grow over the upcoming years. Due to an increasing human population and a growing income of the majority of these people, higher demand and therefore increased commercial potential for dairy products is to be expected (Sefinew, 2018). In

Ethiopia, considering the potential for smallholder income and employment generation, the growth of the dairy sector can contribute significantly to poverty alleviation and nutrition (Mohamed *et al*., 2004).

In Ethiopia, about 83% of milk obtained from cows and remaining 17% comes from camels and goats (USAID, 2010). Recent report indicated that, Ethiopia produces approximately 3.07 billion liters per year from 16 million milking cows with average of 1.318 liters per cow per day over a lactation period of 180 days (Mulugojjam and Aleme, 2015).Similarly the average consumption of milk per household per year estimated to be 19 kg/year, which is 181 liters below the recommended 200 liters (DDA, 2011). This is much lower than African and world per capita average of 40 kg/year and 105 kg/year, respectively (AGP, 2013). This is due to inadequate and low-quality feed resources, poor nutrition, genotype, and health care management, poor marketing system, insufficient training, and extension services, the productivity of dairy cattle and consumption of their products is generally low (Azage *et al*., 2013).

Milk is a cash crop in the milk shed areas that enables families to buy other foodstuffs and significantly contributing to household food security (Abebe *et al.,* 2012*)*. Even if, in urban and peri-urban areas of Ethiopia, milk is commonly practiced with almost no quality control at all levels (Bekele and Bayileyegn, 2000). According to Hossain *et al*. (2010), milk is free from harmful toxic substances, free from sediment and extraneous substances of good flavor with normal composition. Microbial contamination of milk may be obtained from infected lactating cow, milk market chain, milkers during milking, unclean milking equipment, water suppliers used in cleaning procedure, improper handling and poor storage (Kurwijila, 2006). According to Zelalem (2012), it is therefore essential to produce the best quality raw milk in the dairy farm in order to manufacture milk products of acceptable quality. The production of milk of good hygienic quality is desirable from the consumer's health point of view (Zelalem, 2012).

Mostly, the chemical composition, particularly milk fat content is used as a quality test (Zelalem, 2012). Similarly, the higher the solids content the better its nutritional value and

more of a milk product can be made (Pandey and Voskuil, 2011). According to FAO (2004), one of the main quality determining criteria applied to milk payment to producers in many countries are priced according to fat and solids-non-fat composition. Therefore, information on the microbial and chemical composition of milk was essential to understand the quality of marketed milk supply. Previous research works mainly focused on microbial quality of fluid milk and very few studies were reported in both microbial and chemical composition at smallholder milk producers and dairy cooperatives (Abebe, 2018). Therefore, assessing the quality of raw milk in terms of its microbial and chemical compositions from different milk value chain points is crucial.

Currently, the dairy sector has remained hindered by multi-faceted, production and reproduction-related constraints such as genotype, feed resources, and feeding systems, health, access to services and inputs, low adoption of improved technologies, marketing, and absence of clear policy support to the sector (FAO, 2018). In the face of all the aforementioned challenges, the government has a huge plan (livestock research plan, growth, and transformation program) to improve the dairy sector to achieve the growing demand for dairy products resulting from increasing human population especially in urban areas and rising consumer income and to benefit from the sector in terms of import substitution and export. Consequently, in order to secure the demand and supply, as a result, it is necessary analyzing how the existing smallholder dairy cattle production systems are working in order to plan to alleviate both challenges related to the production and reproduction of dairy cattle in the country (FAO, 2018). The low productivity of dairy cattle because of different production and reproductive diseases, affects the producer lifestyle. Some production diseases such as mastitis and lameness causing economic loss to the dairy industry. Now a days, mastitis is one of the major diseases in the dairy sector worldwide. According to Tesfaye *et al*. (2010), mastitis is the major disease that affects the dairy sector since the introduction of Holstein-Friesian blood in Ethiopian cattle. According to Halasa *et al* (2007) reported that; milk production losses, diagnostic costs, treatment costs , discarded milk, increased risk of other diseases, culling of dairy animals and occasionally deaths are among the factors which contribute to the economic impacts of mastitis. Therefore, systematic and early detection of sub-clinical mastitis is, therefore,

essential for investigations to establish its prevalence and recommended correction measures (kurjogi *et al*., 2014). Therefore, further information on the significant mastitis factors', main pathogens and their transmission routes, and risk causes for poor udder health, is essential. Therefore, sympathetic what encourages dairy farmers to essentially put on existing facts to control mastitis is also crucial to effectively improve the mastitis condition. Similarly, lameness is one of the greatest constraints to productivity, health and welfare of dairy cattle. It is a clinical manifestation of a vast spectrum of diseases specified in a total of 43 causes (Blowey *et al*., 2004) and more than 80 potential hazards (Bell *et al*., 2008). Hazards to claw health and cow mobility can take many different forms. Inappropriate cow environment such as housing type and flooring quality can put claw health at risk (Haskell *et al*., 2006). Regularly claw trimming activities (Espejo *et al*., 2007) and over-crowding (Leonard *et al*., 1996) are also considered to have an impact on claw health. Evidence for loss of productivity due to lameness through premature culling, treatment costs and milk loss is important to encourage the unwilling farmer to consider changing the environment. Even though lameness is one of the importance constraints in the dairy sector, there is no studies conducted in the current study areas. Thus, conducting the prevalence and major risk factors of lameness is fundamental.

Recent studies indicated that the reproductive performance of dairy cattle is one of the key component of dairy production and the goal of reproductive management in dairy cattle, which is to have cows become pregnant in an efficient means and at a profitable interval after calving (Plazier *et al*., 2002). Accordingly, high reproductive efficiency is necessary for a successful dairy operation and requires a calving interval that maximizes milk production within the herd (Ferguson and Galligan, 2000). However, the reproductive performance of dairy cows affected directly by infectious diseases. *Brucellosis* is one of the infectious diseases that is highly characterized primarily by causing an abortion in late pregnancy, retained placenta, endometritis, and infertility in subsequent pregnancies in cattle. Several studies indicated that poor reproductive performance is a major cause of involuntary culling and therefore reduces the opportunity for voluntary culling and has a negative influence on the subsequent productivity of a dairy herd (Hossein-Zadeh, 2013). Seleem *et al*. (2010), reported that brucellosis is considered as the most important and

widespread zoonotic disease with economic and public health impacts, particularly for human and animal populations. Previous studies were also limited in their scope as they were concentrated only on a few parts of the country (Yohaness, 2017; Abeje, 2018; Edao *et al*., 2018), which hardly represent the whole country in general and Debre Berhan milk shed central highlands of Ethiopia in particular. Even though the study area is one of the major milk producing area and rich in crossbreed dairy cattle resources very little has been done to characterize, identify and document the existing crossbreed dairy cattle production systems, milk quality analyses and the prevalence of major production and reproductive disease problems. Therefore, this study was conducted to characterize dairy cattle production systems, milk production and hygienic practices, identifying the list of purpose of keeping cross bred dairy cattle, determine the prevalence of major health problems in Debre Berhan milk shed, North Shewa zone of Amhara Regional State of Ethiopia.

Specific objectives:

1. To characterize dairy cattle production systems ,
2. To analyse raw milk quality at selected segments of the value chain;
3. To determine the prevalence, risk factors and their association with bovine mastitis;
4. To assess the prevalence and major risk factors of lameness in dairy cows in the study area;
5. To determine the seroprevalence, risk factors and their association with Brucella seropositivity in the study areas.

2. REVIEW OF THE LITERATURE

2.1. Dairy Production Systems in Ethiopia

According to Azage *et al*. (2013), dairy production is unique of the sectors of the livestock production system predominant in Ethiopia. Based on weather, feed source and feeding system, land holdings, herd type and herd size, the objective of keeping animals and combination with crop production as a criterion, three major (urban, peri-urban and rural) dairy production systems were known in Ethiopia (Zelalem *et al*.,2011).

2.1.1. Urban production system

This production system is included of medium to large-sized dairy farms that are accomplished of keeping improved dairy herds (Azage *et al.,* 2013). Reports by Nigussie (2006) indicate a number of smallholder and commercial dairy farms are emerging mainly in and around the capital, Addis Ababa and most regional towns and weredas. agro-industrial by-products and purchased roughage are the main feed resources found in the country(Belete *et al*., 2010). Fekede *et al.* (2013) also stated that urban dairy production is fairly intensive and mainly based on indoor-feeding using purchased roughages and concentrates.

2.1.2. Peri-urban production system

The peri-urban dairy production system includes commercial to smallholder dairy farmers which are found in the proximity of major cities (Addis Ababa) and other regional towns that own improved dairy stock (Sintayehu *et al*., 2008). Dairy processors and most milk collecting cooperatives are located in this system. Milk producers are commercially oriented and respond to improved best practices, technology, input supply, and marketing services, if available, especially when a milk market is secured (Makoni *et al*., 2013). The main feed resources are agro-industrial by-products, purchased roughage and crop residue and pasture land. The primary objective of milk production is also generating additional cash income (Belete *et al*., 2010). Based on the number of animals overcome and the

position of farmstead structure and facilities available on-farm, classified the peri-urban dairy farms into the small scale and medium-sized peri-urban dairy farms subsystems (Diriba *et al.,* 2014). In a peri-urban dairy production system, crop and livestock production are closely integrated and agricultural activities other than milk production form additional sources of income (Fekede *et al.*, 2013).

2.1.3. Rural production system

The rural dairy production system mainly uses indigenous breeds and includes pastoralists and mixed crop-livestock producers (Mohamed *et al*., 2004). According to Belete *et al*. (2010), rural dairy production systems are practiced in most parts of the highlands of mixed farming systems. In this system improved concentrate feed accounts for only 0.25% (CSA, 2011). Milk production in this system is characterized by low yield and seasonal availability(Sintayehu *et al*., 2008). Kiros (2019) noted that there are two types of dairy systems in the highlands: the traditional and the market-oriented system.

2.2. Socio-economic Characteristics of Dairy Production Systems

In Ethiopia, dairy sectors have considerable economic and social importance for household and national levels. Keeping livestock is an important risk reduction strategy for vulnerable communities, as animals can act as insurance in times of need. Different authors suggested that livestock sectors have contributed to household incomes for smallholder dairy farmers (Girma *et al*., 2014; Dereje and Yoseph, 2016; Kiros *et al*., 2018a). The land is a key resource for dairy farming activity in the mixed crop-livestock system of the central highlands of Ethiopia. While land size per household and communal grazing land have been decreasing due to population growth and expansion of urbanization. According to the report of (CSA, 2016), the average land size of the national is 1.20 hectares. A study in peri-urban areas of Assela (40%) and urban areas of Sululta (45%) dairy farms was established about 6 to 10 years ago. Solomon (2014) also reported that (41.7%) of dairy farms in Mekelle city have dairy rearing experiences of 6-10 years. In Bangladesh, the majority of dairy producers had 10 to 19 years of experience in dairy farming (Quddus, 2017). A study in Shashemene –Dila and Jimma towns by Sintayehu *et al*. (2008) and Belay

and Geert (2016) shown that the farmers' main objective of keeping crossbreed dairy cattle was for generating cash income. Similar studies from different parts of the country mentioned that dairying generated the total household income of farmers (Belay and Geert, 2016; Dessalegn, 2017; Kiros *et al*.,2018a). The average landholding per household (1.4 hectares) reported by Tahir *et al*. (2018) in North Shoa Zone of central highlands of Ethiopia was lower than the national average value (1.60 hectares) reported by FAO (2008) and (2.6 ha) reported by Asaminew and Eyassu (2009) in Bahir Dar Zuria and Mecha district respectively. Tahir *et al*. (2018) further indicated that land scarcity as one of the main constraints for dairy farmers in the central highlands of Ethiopia. According to Mekete (2018) indicated that in urban and peri-urban farms comprises of (50.4%) male and (49.6%) female.

2.3. Dairy Cattle Holding

Dairy cattle ownership varies depending on the type of production system, wealth status and the overall farm production objectives (Kiros, 2019). The average cattle herd size per household for smallholder farmers were 4.7 cattle in Central highlands of Ethiopia (Abebe *et al*., 2017) and 8 cattle in Mekelle City (Negussie, 2006). According to Ayenew *et al*. (2011) stated that local cows are mainly kept on peri-urban areas of Bahir Dar and Gondar town, whereas in the other locations and farming systems higher numbers of crossbred cows/households were reported (5.4-11) from Sebeta, Bahir Dar and Hawassa areas (Ayenew *et al*., 2011; Haile *et al*., 2012 and Dereje and Yoseph, 2014).

2.4. Dairy Cattle Husbandry Practices

2.4.1. Dairy cattle feeding

In Ethiopia dairy feed resources are classified as natural pasture, crop residues like (teff, barley, wheat, faba bean, and oat (Abebe *et al*.,2017; Admasu *et al*.,2019) and improved forages, agro-industrial by-products and others such as food and vegetable refusals and a by-product of local beer production like *Atella* (Fekede *et al*., 2014). According to Ketema (2014) improved forage production is important as assistants to crop residues and natural

pastures and may be used to fill the feed gaps during periods of inadequate crop residues and natural pasture supply. Agro-industrial by-products mostly produced from the flour/oil industries are wheat bran, maize, and wheat middling, which are commonly used as energy supplements, and oilseed cakes like, cottonseed, peanut, and sesame cake are mainly used as protein supplements, are available only to farmers close to urban areas (Diriba *et al*., 2014) and currently in the central highland of the country brewery by-product mainly used as a protein supplement (Admasu *et al*., 2019). Feed-in Ethiopia is generally either not available in sufficient quantities due to fluctuating weather conditions or the available ones are of poor quality (Diriba *et al*., 2014). This results in low milk yields, high mortality of young stock, longer calving intervals and decreased live animal weights.

2.4.2. Sources of water for dairy cattle

The reports have shown in the peri-urban dairy system river followed by pipe water are the major source of water for dairy animals, however, the majority of the urban dairy farming system depends on pipe water (Asrat, 2013; Abebe *et al*., 2017; Kiros, 2019). The major water resources for livestock are wells and rivers for market-orientation in Fogera Woreda, Amhara region, Ethiopia (Belete *et al*., 2010). The report, as shown for watering frequency of dairy cattle, depends on access to water sources, the age of the animals, physiological stage of animals and season. For instance, in the urban and peri-urban system of in different parts of Ethiopia, dairy farmers water their cattle once a day and three times per day (Zewdie, 2010; Azage *et al*., 2013; Tilahun and Gebregiorgis, 2016; Bernabas *et al*., 2017; Abebe, 2018). As reported by Alemshet (2014) in Adigrat, Tigray 28.9% of respondents in urban and 15.25% of peri-urban dairy farmers watered their animal's adlibitum. According to Asfaw *et al*. (2010) and Kassahun *et al*. (2008) reported that trekking of dairy animals can decrease the watering frequency which in turn contributes to low dairy cow productivity.

2.4.3. Dairy cattle breeding

According to the report of Abebe *et al*. (2017), both AI and natural service are practiced as breeding methods. The report indicated by Solomon *et al.* (2014) majority of the farmers in the Metekel zone depends on natural mating in the absence of artificial insemination (AI) facilities. Under mixed crop-livestock production systems in Boditti town, South Ethiopia most of the farmers depend on natural breeding using native bulls, while others depend on AI (Asrat *et al*., 2013). According to Ayantu *et al*. (2012) and Dereje (2015), more farmers practiced natural, unplanned and uncontrolled mating systems and keeping of sire was not practiced by smallholder farmers rather they use for both breeding and drought power. A study in Borana zone by Dejene (2014) described that about (75- 84.2%) of farmers used natural service for breeding their animals. On the other hand, Alemselam *et al*. (2015) indicated that the common breeding methods for crossbred dairy cattle were both AI and natural mating by bull followed by AI and natural service. As reported by Dessalegn *et al*. (2016) dairy farmers used both AI and natural bull service for their dairy cattle.

2.4.4. Dairy animal health

The occurrence of several animal diseases affects dairy development programs in varying scales, depending on agro-ecological zones and management levels. According to Shapiro *et al.* (2015), Foot and Mouth Disease (FMD), Contagious Bovine Pleuropneumonia (CBPP) and brucellosis are the three most important diseases of cattle in Ethiopia. Several earlier studies in different parts of Ethiopia reported that mastitis, anthrax, FMD, mastitis, pasteurellosis, blackleg, and LSD were the leading dairy cattle health problems (Azage *et al*., 2013; Abebe *et al*. (2017). The health of dairy cows has a great impact on on-farm profit. Therefore, improved animal health care is also essential as it imposes a serious source of loss. Out of 8.96 million cattle suffering from diseases in Ethiopia, 3.45 million died and the remaining were treated and cured (CSA, 2011). In Ethiopia, the government is the major animal health service provider. There is also limited involvement of the private sector in the provision of drugs and animal health services. During this time, they cannot serve the farmers in their area (Zijlstra *et al*., 2015).

2.5. Constraints of Dairy Cattle Production Systems

Dairy development in the tropics is based on the smallholder production system, where scarcity and poor quality feed resources are the major constraints (Olaloku and Debre, 1992). Seasonal availability and costs of feeds and feeding systems could be among the major contributing factors to urban and peri-urban dairy production systems (Sintayehu *et al*., 2008). A shortage of land was reported as the most limiting factor in urban dairy production systems (Belay *et al*., 2011; Azage *et al*., 2013; Abebe *et al*., 2017). Kiros (2019) also indicated that high feed cost, land shortage, and space limitations, feed quality and availability as well as inadequate extension and veterinary services were the major dairy production system constraints in both urban and peri-urban areas of the central highlands of Ethiopia. Asrat *et al*. (2013), also land shortage, availability and costs of feeds, shortage of genetically improved dairy animals, unpromising seasonal marketing systems, poor animal health services, problems related to waste disposal, poor extension services and knowledge gap regarding improved dairying were the major dairy production system constraints in Boditti town, South Ethiopia. Terefe *et al*. (2014) explained the feed shortage was also identified as the basic constraint of dairy production in Dale and Shebedino wereda. In another study shown in Gondar town, the land shortage was the major constraint on dairy production.

2.6. Milk Handling, Marketing, and Consumption

2.6.1. Milk handling practices

Milk handling is essential at each stage; at the farm, cooling center during transport and at the processing plants (Pandey and Voskuil, 2011; Abebe, 2018). FSA (2006) indicated that cleaning of the udder before milking is important to remove both visible dirt and bacteria from the outer surface of the udder. Aysheshim *et al*. (2015) also indicated that milk producers should follow hygienic practices during milking and handling, before delivery to consumers or processors. According to Blowey and Edmondson (2010), poor milking practices, dirty udders or teats, damaged teats, and poor operator hygiene can all lead to increased contamination of raw milk. 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, 2014). This could be due to the cross-contamination of milk during transportation, lack of sanitation of storage container and lack of temperature control (Amistu *et al*., 2015).

2.6.2. Milk marketing systems in Ethiopia

Liquid milk is marketed through both formal and informal channels (Wouters and van der Lee, 2010). There are basically two marketing systems in the central highlands of Ethiopia: formal and informal. In the formal market chain, milk is marketed through registered marketing channels, processed in established processing plants and put on the market in packed products (Zelalem, 2012; Abebe, 2018). In this market system, milk is collected at collection centers that belong to cooperatives or private collectors and subjected to preliminary milk quality tests upon delivery and finally transported to processing plants (van der Valk and Tessema, 2010; Saba, 2015). According to Zelalem (2012) indicated that milk market system has encouraged the producers to improve the hygiene conditions, storage, and transportation of the milk in order to avoid rejection of the product upon delivery to the collection centers. While informal milk market contains direct delivery of milk and milk products by producers to consumers (van der Valk and Tessema, 2010; Abebe, 2018). Additionally, Girma and Verschurr (2014) reported 35% of the respondents were sold their milk following both informal and formal channels and 25% of the respondent's farmers were sold their milk through formal marketing channels. The hygienic condition of milk and milk products channeled through this system is poor.

2.6.3. Milk consumption pattern in Ethiopia

Ethiopians consume less dairy products than some other African countries and far less than the world consumption. According to Azage (2018), the country produces about 4 billion liters of milk per year. The national average per capita consumption of milk was 20kg/year as compared to 44 kg/year for the African countries and 87kgs/year for the world per capita consumption recommended by FAO (2009). From the same source, it has been learned that 22 billion liters of milk are required each year to bridge the demand and supply gap in the country. Taking the current production rate (i.e., 4 billion), there's an annual shortage of about 18 billion liters. In peri-urban areas of Shashemene–Dilla milk-shed, about 25% of dairy households used milk for home consumption, while in the urban dairy production system, only 14.2% used milk for family consumption (Azage *et al*., 2013). So far, it has been frequently reported that per capita milk consumption oscillates between 16 and 19 liters (Effa *et al*., 2016). Given the low levels of per capita dairy product consumption and consumer's willingness to increase dairy consumption (95%), the prospect for market-oriented dairy production in Ethiopia is promising. To this end, consumers, industry, and governments need up-to-date information on how milk and dairy products can contribute to human nutrition and how dairying and dairy-industry development can best contribute to increasing food security and alleviating poverty (FAO, 2013).

2.7. Milk Quality and Safety in Ethiopia

2.7.1. Chemical composition of raw milk

A very important aspect of raw milk quality is its composition. The following are the typical ranges of milk constituents of water (87.5–89.5), milk solids (10.5–12.5), fat (3.0–6.6), lactose (4.8), protein (2.6–4.4) and minerals (1.0%) (Moran, 2009). The main measures used to describe milk composition are the concentrations of milk solids (total solids), milk fat and milk protein. Since lactose and mineral contents are very stable (Moran, 2009). Fat and protein content are expected to respond to farming conditions and technology, such as breed and individual genotypes of herds, quality and quantity of feed, intervals/stage of milking and health status, cow age, lactation period, climate and

seasonality (Morgan, 2009). There were various reports concerning milk composition (fat and protein) in different parts of the country were within the ranges of 3.6 to 6.02 % of fat and 2.49 to 3.51 % of protein respectively (Negash *et al*., 2012; Sefinew *et al*., 2013; Teshome *et al.*, 2015; Alganesh, 2016; Genzebu *et al.,* 2016).

2.7.2. Microbial quality of raw milk

Milk is one of the vital nutritious food for human and young mammals, but inappropriate handling contaminates it with microorganisms and reduces it unsafe for human consumption and/or unfit for further processing (Ali and Abdelgadir, 2011). Raw or poorly processed and/or handled milk can lead to food-borne illness in humans (FAO, 2013). As reported by Richard (2002), the total bacterial count is a good indicator of the manner of milk handling from the time of milking to consumption. Earlier research conducted in Ethiopia revealed that the microbial count of milk is generally above the acceptable limits of 5 logs CFU/ml. According to Biruk *et al*. (2009) documented that the higher total bacterial counts in raw milk are an indication of a diseased udder, unsanitary handling of milk, or unfavorable storage temperatures. For instance, the Total Bacterial Counts (TBC) reported for raw milk in different parts of the country were within the ranges of 5.85 to 9.28 log CFU/ml (Asaminew and Eyassu, 2011; Zelalem *et al*., 2011; Abebe *et al*., 2012; Hiwot, 2013; Solomon *et al*.,2013; Gurmessa, 2014; Saba, 2015; Tesfay *et al*., 2013; Dehinenet *et al*., 2015). High Coliform Counts (CC) in raw cow milk sampled from different parts of the country that ranged from 4.03 to 7.6 log CFU/ml was also reported by many previous works (Abebe *et al*., 2012; Asaminew and Eyassu, 2011; Asrat *et al*., 2012; Haile *et al*.,2012; Gurmessa, 2014; Saba, 2015). Since it is not practical to produce milk free of coliforms even at a high level of hygienic conditions their presence in raw milk to a certain extent may be tolerated. However, if present over 2 logs CFU/ml of raw milk, it means that the milk was produced under unsanitary conditions and/or from the cow with mastitis infection (Walstra *et al*., 2006). The presence of large numbers of coliforms is an indication that the product may potentially carry serious pathogenic coliforms that are hazardous to the consumers health (Godefay and Molla, 2000). Hence, coliform bacteria in raw milk and milk products are often an indicator of fecal contamination.Furthermore,

the occurrence of pathogenic microorganisms in milk products could be hazardous for consumers particularly for countries like Ethiopia which commonly consume raw milk (Zelalem and Faye, 2006).

2.8. Mastitis in Dairy Cows

Mastitis is defined as an inflammatory reaction of the mammary gland and the most widespread and costly disease in dairy cattle occurring throughout the world. It is of particular concern for farmers in developing countries like Ethiopia (Abebe *et al*., 2016). Costs due to mastitis include reduced milk production, condemnation of milk due to antibiotic residues, veterinary costs, culling of chronically infected cows and occasional deaths (Seegers *et al*., 2003). Mastitis is caused by a wide spectrum of pathogens and, epidemiologically categorized contagious and environmental mastitis (Cervinkova *et al*., 2013). Contagious pathogens are those for which udders of infected cows serve as the major reservoir. They spread from cow to cow, primarily during milking, and tend to result in chronic sub-clinical infections with flare-ups of clinical episodes. Contagious pathogens include *Staphylococcus aureus, Streptococcus agalactiae, and Mycoplasma spp.* And *Corynebacterium Bovis* (Radostits *et al.*, 2006).On the other hand, environmental mastitis can be defined broadly as those intra-mammary infections caused by pathogens whose primary reservoir is the environment in which the cow lives (Smith *et al.,* 1985). Environmental pathogens include *E. coli*, *Klebsiella spp*., *Strept. dysgalactiae* and *S uberis* and the majority of infections caused by these pathogens are clinical and of short duration (Harmon, 1994). Mastitis can also be classified as either clinical or subclinical. Clinical mastitis is characterized by sudden onset, alterations of milk composition and appearance, decreased milk production, and the presence of the cardinal signs of inflammation in infected mammary quarters. It is readily apparent and easily detected. In contrast, no visible signs are seen either on the udder or in the milk in case of sub-clinical mastitis, but the milk production decreases and the somatic cell count increases (Abebe *et al*., 2016). It is more common and has a serious impact on older lactating animals than in first lactation heifers (Khan and Khan, 2006).

2.8.1. Prevalence of bovine mastitis in Ethiopia

In Ethiopia, different studies conducted that bovine mastitis is one of the most frequently encountered diseases of dairy cows. The cow-level mastitis prevalence estimate falls within the range of 23.2 and 81.1% for the country (Abera *et al*., 2010; Girma *et al*., 2012; Belayneh *et al*., 2013; Lidet *et al*.,2013; Zeryehun *et al*., 2013; Duguma *et al*., 2014; Zenebe *et al*., 2014; Sarba & Tola, 2017; Yilma *et al.*, 2017). According to Gizat (2004), the variation of mastitis prevalence could result from differences in environment and management practices. The financial loss involved as a result of permanent loss of production in individual cows, discarded milk following antibiotic therapy, early culling of cows, veterinary costs, drug costs, increased labor, death of peracute cases and replacement costs (Sisay *et al*., 2012). Economic losses from clinical and subclinical mastitis in Addis Ababa milk shed were reported to be approximately 270 Ethiopian birrs (ETB) per lactation (Sisay *et al*., 2012). These figures possibly underestimate the potential benefits of a mastitis control program as they do not include other direct and indirect costs (Tesfaye *et al*., 2010).

2.9. Diagnosis of Mastitis

The following methods are used for the diagnosis of both clinical and subclinical cases. Most new mastitis infections occur during the first10days and last 2weeks of the dry period, with most of the resulting cases of clinical mastitis appearing immediately after calving.

2.9.1. California mastitis test (CMT)

The California Mastitis Test, (CMT) is one such test utilized widely to determine the disease status of lactating animals, as it is a simple, inexpensive and rapid screening test (Shitandi and Kihumbu, 2004). CMT was developed to test milk from individual quarters but also been used on composite and bulk milk samples. The CMT involves mixing and swirling equal parts of bromocresol violet reagent and milk in a plastic paddle with a compartment for each quarter (Quinn *et al*., 1999). The test results are interpreted

subjectively as either a negative, trace, 1+, 2+ or 3+ inflammatory response based on the viscosity of the gel formed by mixing the reagent with milk (ICAR, 2011).

2.9.2. Culturing method

The microbiological examination of both individual cow and bulk tank culture are elements of mastitis control. Culturing can be used in a targeted fashion for specific control programs such as segregation plans for contagious mastitis or for surveillance to detect the presence of the new or emerging pathogen. Culturing is also used to evaluate treatment efficacy and to establish susceptibility patterns to aid in the development of rational treatment strategies (Larsen, 2000).

2.10. Mastitis and Associated Risk Factors

There are a number of factors that influence the occurrence of mastitis and fewer studies that have investigated cow-level factors associated with the development of Clinical mastitis were carried out. The risk of developing Clinical mastitis is greatest in early lactation and increases with parity and level of milk production (Berry and Meaney, 2005). Mastitis risk factors depend on exposure to the microbes, Immune system and environment or management factors (Suriyasathaporn *et al*., 2000). Host factors include breed, the anatomy of the teat canal, sphincter tone and presence of teat lesion. Other findings reported by Sisay *et al*. (2012), age, parity, stage of lactation and hygienic conditions were found to be important risk factors associated with the occurrence of mastitis. Among the risk factors stage of lactation, parity and presence of teat lesions have been shown a statistically significant difference in the prevalence of mastitis (Rediet *et al*., 2013). The most important risk factor affecting the prevalence of subclinical mastitis in cows were the stage of lactation, parity number, floor type, and breed and teat lesion. The highest prevalence was observed in cows with advanced age groups, Holstein Friesian breed, multiple parity, poor body condition score, high milk producers, early lactation stage and cows having teat lesion (ICAR, 2011; Yilma *et al*., 2017).

2.10.1. Age and parity of the cow

Sharma *et al.* (2007) conducted a study on lactating cows of different age, parities, and stage of lactation belonging to different organized or un-organized dairy farms. Older cows (>10 years) are at more risk (44.6%), particularly for subclinical mastitis (38.6%) than younger cows (23.6%) in which clinical mastitis was predominant. Cows with many calves (>7) have about 13-times greater risk (62.9%) of developing an udder infection than those with fewer (3) calves (11.3%). The prevalence of infected quarters increases with age, peaking at 7 years (Radostits *et al*., 2006). Older cows, especially after four lactations were submitted to more lactation, increasing the risk for mastitis and udder tissue damage (Mahajan *et al*., 2011).

2.10.2. Breed and milk yield of the cow

The risk of mastitis varies from breed to breed. High yielding cows are generally considered to be more susceptible to intermammary infection e.g. Holstein Frisian (HF), Jersey or HF and Jersey crossbred dairy cows are more susceptible to mastitis than Zebu breeds of cows (Compton *et al*., 2007). It might be due to more resistance to disease and they are low milk producers than crossbred cows. Different studies addressed that Holstein and Jersey's cows are at higher risk for subclinical mastitis than Holstein Friesian-local zebu cross cows (G/Michael *et al*., 2013; Yilma *et al*., 2017). Reports by Islam *et al*. (2011) and Siddiquee *et al*. (2013) indicated that the highest prevalence of mastitis in cows with milk production of more than 15 liters was 61.5% and 45.8% in 7 -15 liters and lowest in <7 liters (41.4%). This is due to the reason that higher milk production has affected the capacity of the immune system of dairy cows to combat infections, and the associated bacteria have adapted to changes in their hosts and environment (Tripura *et al*., 2014).

2.10.3. Stage of lactation

The incidence of mastitis is reported to be higher immediately after parturition, early lactation and during the dry period, especially the first 2-3 weeks due probably to increased oxidative stress and reduced antioxidant defense mechanisms during early lactation (Sharma *et al*., 2011). Reports by G/Michael *et al*. (2013) also indicated that the prevalence of subclinical mastitis was higher in the late stage of lactation than early. On the other hand, authors like; Kayesh *et al*. (2014) and Mureithi and Njuguna (2016) reported a higher prevalence of subclinical mastitis during the mid of lactation. The occurrence of high prevalence during the earlier lactation stage may be due to the absence of dry cow therapy and birth-related influences (Quinn *et al*., 2005). The amount of milk ejected is also higher during earlier lactation periods and this causes increased in patency of the teats and decreased local defense factors. Similarly, the mammary gland is more susceptible to new infection during early lactation and late dry period, which may be due to the absence of udder washing and teat dipping, which may, in turn, increase the number of potential pathogens on the skin of the teat (Islam *et al*., 2011).

2.10.4. Mammary regression

There are significant functional changes in the udder during the early and late lactation and dry period, which affect the cow's susceptibility to infections. Lactating cows under stress show premature mammary regression. Such a condition compromises udder's natural defense mechanisms (Capuco *et al*., 2003) leading to invasion of the teat canals by potential pathogens. The same condition prevails during the healing process of lesions because the resistance to causal agents remains less effective.

2.10.5. Milking hygiene and procedures

Predisposing factors such as poor management and hygiene, teat injuries and faulty milking machines are known to hasten the entry of infectious agents and the course of the disease (Islam *et al*., 2010, Islam *et al*., 2011). According to Hagos (2015) reviewed that milking hygiene reduces the pathogenic organisms from inhabiting the immediate environment or

skin of the animals and minimizing their spread during the milking process. Therefore, the prevalence of mastitis in cows is more at unorganized dairy farms as compared to organized dairy farms. Udder hygiene significantly associated with the risk of environmental pathogen intramammary infection in cows and milking procedures (Compton *et al*., 2007).

2.11. Lameness in Dairy Cows

Lameness can be defined as abnormal behavior (for example reduced velocity and altered stride, curved back and lowered head or nodding movement of the head) as a way to reduce the pain (Nordlund *et al.,*2004). It is a major challenge facing the dairy industry, with negative impacts on milk production, fertility, and longevity of animals (Mahendran and Bell, 2015). It may be associated with feeding and nutrition, housing conditions, environmental factors, management practices, or a combination of any or all of these (Hristov *et al*., 2011). However, it is among the most neglected and least studied dairy problems in Ethiopia (Sulayeman and Fromsa, 2012). On the other hand, it results in milk yield reduction, reduced feed intake, weight loss, reduced fertility and premature culling of affected animals, as a result, accounts for tremendous economic loss (Refaai *et al*., 2013). In addition, reproductive efficiency was significantly lower in cows becoming lame compared to non-lame cows (Somers *et al*., 2015). Additionally, lameness increases added costs of treatment, culling, and replacement, thus making the losses to be very high for dairy farmers. In fact, losses incurred by lameness are so high that it ranks next to mastitis and reproductive problems (Singh *et al*., 2015).

In Ethiopia, there are limited studies on the occurrence of lameness and associated risk factors, which are mainly concentrated on a few parts of the country. The study carried out by Sulayeman and Fromsa (2012) in Hawassa town showed the overall lameness prevalence of 3.5%. Furthermore, a study by Abunna *et al*. (2017) indicated that the overall animal level occurrence of lameness was 13.9% in intensive dairy farms in Bishoftu town. Similarly recently, a study by Mulatu (2018) indicated that the average animal level prevalence of lameness was found to be 8.98% in Sululta town. So information's on the status of lameness in dairy farms of Ethiopia is limited.

2.12. Reproductive Problems of Dairy Cattle

Reproductive disorders are the most common problems affecting the production and productivity of dairy cows (Dinka, 2013). The presence of the reproductive problems result in considerable economic loss to the dairy industry due to lesser number of calves, slower uterine involution, prolonged inter-conception and calving interval, early depreciation of potentially used cows, decreased milk yield per lactation as well as overall lifetime production, and increased costs due to veterinary services and earlier culling of cows (FAWC, 2009). Reproductive and production disorders of cross-bred dairy cattle significantly reduce their productivity because of reproductive disorders. These disorders are of great concern for dairy producers because of their effect on the future fertility of dairy cows (Khair *et al*., 2013). The major reproductive problems that have a most important influence on the reproductive performance of dairy cows are included abortion, dystocia, RFM, metritis, prolapse (uterine and vagina), mastitis, anoestrus, bovine brucellosis, and repeated breeding. These reproductive problems could be categorized as prepartum and postpartum reproductive problems (Dinka, 2013; Benti and Zewdie, 2014).

2.13. Brucellosis as a Reproductive Problem for Dairy Cattle

Brucellosis is a bacterial disease of animals and humans caused by the genus Brucella. Brucella abortus is a contagious disease of cattle, but occasionally sheep, swine, dogs, and horses may also be affected. Brucella is usually transmitted from animal to animal by contact following an abortion, pasture or animal barn contamination, ingestion, inhalation, conjunctival inoculation, skin contamination udder inoculation from infected milking cups and the use of pooled colostrum's for feeding newborn calves. Sexual transmission and artificial insemination can transmit the disease and semen necessity only be collected from animals identified to be free of Brucella infection (FAO, WHO, and OIE, 2006). Expansion of animal industries and urbanization and the lack of hygienic measures in animal husbandry and in food handling partly account for brucellosis remaining a public health hazard (WHO, 2006). The disease affects cattle, swine, sheep and goats, camels, equines, and dogs. It may also infect other ruminants and marine mammals. The disease in animals is characterized by abortions or reproductive failure. While animals typically recover and

will be able to have live offspring following the initial abortion, they may continue to shed the bacteria. Brucellosis in cattle (B. abortus) in sheep and goats (B. melitensis) and in swine (B. suis) are diseases listed in the World Organization for Animal Health (OIE) Terrestrial Animal Health Code. Infected cows usually abort during the second trimester to the term of first pregnancy after infection. Thereafter the disease usually localizes in the lymph nodes surrounding the reproductive organs and the udder. Bacteria are shed in milk, foetal membranes and discharges from the female reproductive tract after birth or abortion. The male animal develops sorchits, epididymitis, and hygromas (Matope1 *et al*., 2010).

Brucellosis is readily transmissible to humans, causing acute febrile illness – undulant fever –which may progress to a more chronic form and can produce serious complications affecting the muscle-skeletal, cardiovascular, and central nervous systems. Infection is often due to occupational exposure and is essentially acquired by the oral, respiratory, or conjunctiva routes, but the ingestion of dairy products constitutes the main risk to the public where the disease is endemic. There is an occupational risk to veterinarians and farmers who handle infected animals and aborted fetuses or placentas (Ocholi *et al*., 2004). Transmission of B. abortus mostly occurs via the oral route because cattle tend to lick aborted fetuses and the genital discharge of an aborting cow. Brucella organisms can also be transmitted through the Trans mammary route while calves born to healthy dams are infected when fed on colostrum or milk from infected dams (Radostits *et al*., 2007). However, some countries in Africa where seroprevalence of brucellosis had been reported of 10% were Benin 4.3%, Ethiopia 4.2%, and Ghana 6.6% (Asmare *et al*., 2013).

2.13.1. Status of brucellosis in Ethiopia

In Ethiopia, several serological surveys have shown that bovine brucellosis is an endemic and widespread disease, however, most of the studies on dairy cattle brucellosis have been carried out in central and northern Ethiopia and do not provide an adequate epidemiological picture of the disease in different dairy cattle production systems of the country (Megersa *et al*., 2011). A large number of reports indicated that individual seroprevalence ranging from 1.1% to 22.6% in intensive management systems (Tesfaye *et al*., 2011) and 0.1–

15.2% in the extensive management system (Haile Selassie *et al*., 2011; Megersa *et al.,* 2011). Furthermore, the seroprevalence study of bovine brucellosis was conducted in Debrebirhan and Ambo towns by Bashitu *et al*. (2015) reported that it was only 1% sero-reactor animal to Brucella. Similarly, the study of bovine brucellosis was conducted in three separate agro-ecological areas of central Oromia and the seroprevalence was 4.2% in the lowlands, 1.0% in the midlands and 3.4% in the highlands (Jergefa, *et al*., 2009). Relatively low individual animal seroprevalence in intensive farms were recorded (Taddesse, 2003), observed a prevalence of 0.14% in north Gondar zone, (Tadele, 2004) reported 0.77% in southwestern Ethiopia, and the seroprevalence in intensive farms were recorded was 0.8% in Addis Ababa dairy farms (Edao *et al*., 2018). However, most reports made thus far have either limited geographic coverage or are relatively confined to a single agro-ecology. This warrants the need for a comprehensive understanding of disease occurrence in dairy production systems and spatial distribution across the country, as to shape possible future intervention programs (Asmare *et al*., 2013). Therefore, it is important that public and private dairy industries and cooperatives require up to date and consistent scientific data on bovine brucellosis.

2.13.2. Indirect methods for the diagnosis of brucellosis

Rose Bengal Plate Test (RBPT): It is a quick natural light agglutination examine performed with a stained B. abortus suspension at a pH of 3.6 - 3.7 and plain serum. It is a screening test for small laboratories with limited resources. The drawbacks of RBPT include: low sensitivity particularly in chronic cases, relatively low specificity in endemic areas and prozones make strongly positive sera appear negative in RBPT (Starr *et al*., 2008). The overall sensitivity is 92.9%, so the use of RBPT individuals exposed to brucellosis and those having a history of Brucella infection. As sensitivity is high, false-negative results are rarely encountered. The present World Health Organization (WHO) guidelines recommend the confirmation of the RBPT by other assays such as serum agglutination tests (SAT) (Rhyan *et al*., 2001).

Complement Fixation Test (CFT): It is due to its high accuracy, complement fixation is used as a confirmatory test for B. abortus, B. melitensis, and B. ovis infections and it is the reference test recommended by the OIE for international transit of animals (Navarro-Martinez *et al*., 2001). However, this method has some disadvantages such as high cost, complexity for implementation, and the requirement for special equipment and trained laboratory personnel. In addition, the test presents limitations with hemolysed serum samples or serum with the anti-complement activity of some sera, and the occurrence of prozone phenomena (Moriyona *et al*., 2004).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location and physical characteristics

The study was conducted in the milk shed areas of Debre Berhan town and its surroundings, namely Basona Worana Wereda and Angolelana Tara wereda of the North Shewa Zone, Amhara National Regional State. Debre Berhan town is located at 130 km of Addis Ababa. The topography of the study area is predominantly characterized by undulating hilly landscape with gentle slopes. The study area is located between 9^0 30' and 9^0 50' latitudes and 39^0 20' and 39^0 44' longitudes (Figure 1). The elevation ranges from 2840 to 2943 masl (Molla, 2013).

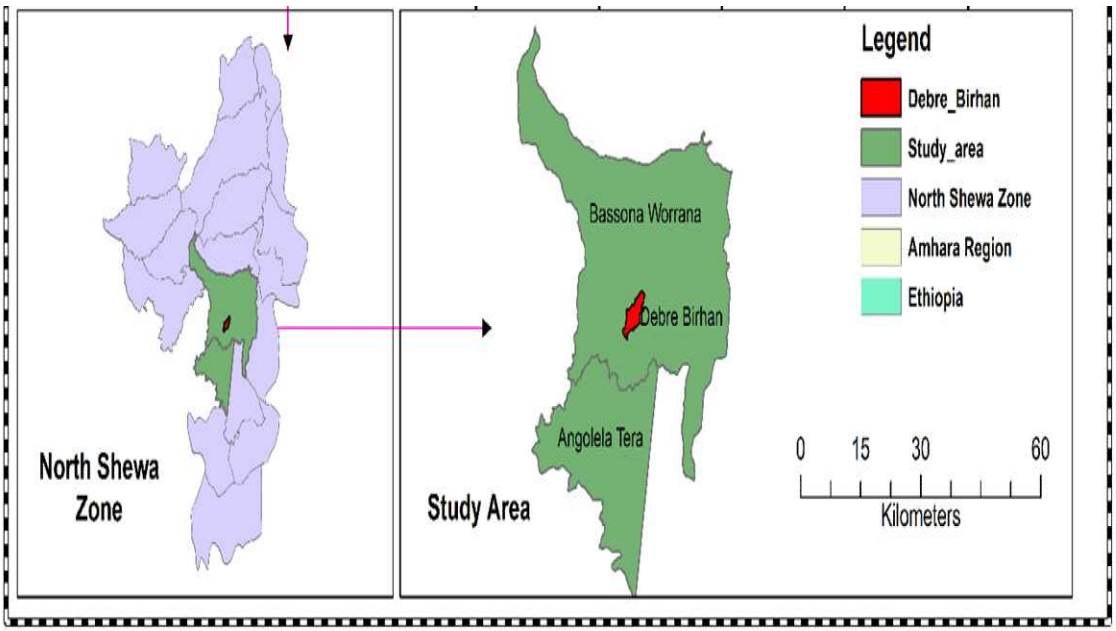

Figure 1. Map of the study areas

3.1.2. Agro-climatic conditions

The mean annual minimum and maximum temperatures are reported to be 6.7°C and 19.9°C,respectively.The mean annual rainfall is 1026 mm with potential evapotranspiration of 1396 mm. Rainfall distribution is bimodal, usually, the long rains (*meher*) lasts from June to the beginning of September, and the period of the short rains (*belg*) falls between February and May. About 86% of the annual rain falls between June and September which is the main cropping season (Molla, 2013). Crop residues and natural pasture are the major livestock feed resources, while fallow land, crop aftermath, and concentrates are occasionally available feed sources (Bekele *et al*., 2017). Rain fed mixed crop-livestock (MCL) farming system is the dominant system practiced primarily to meet the subsistence requirements for most of the farmers with their families. The staple food crops widely grown include barley (*Hordeum vulgare*), wheat (*Triticum durum*), faba bean (*Vicia faba*) and field pea (*Pisum sativum*). The cereals which covered the largest portion of the cropped area during the main season are the major sources of crop residues (CR) for livestock feeding. The livestock species reared include indigenous cattle (*Bos indicus*) and their crosses with temperate origin (*Bos Taurus*), sheep (*Ovis Aries*), goats (*Capra hircus*), donkeys (*Equus asinus*), horses (*Equus caballus*), mules (*Equus mule*) and poultry (*Gallus gallus domesticus*). Cattle production with indigenous and crossbred animals predominate the livestock production followed by sheep production (Bekele *et al*., 2017).

3.1.3. Human and livestock populations

The human population comprises of 150582 (50.4%) male and 148329 (49.6%) female. About 297568 cattle populations are found in the three weredas (Debre Berhan Town, Basona Worana and Angolela ena Tera) in which the Debre Berhan milk shed is located. Of the total cattle population in the three weredas, 39,576.544 (13.3 %) are crossbreds of the locals with Holstein Friesian (North Shewa Zone Agriculture Office, 2013).

3.2. Survey of Dairy Cattle Production System

3.2.1. Study design, sample size, and sampling methodology

A cross-sectional study was involved on a randomly selected dairy farms and farm owners from the urban (town) and peri-urban (around the town) was conducted. A multistage sampling procedure was employed to select sample farmers engaged in milk production and who deliver raw milk to the nearby milk collection centers (MCC). Debre Berhan milk shed was purposely selected based on its accessibility, cross bred dairy cattle population and the milk shed has good market accessibility in the local community, the zonal center Debre Berhan town and milk processing enterprises in Addis Ababa. Households who own cross bred animals were involved in the formal survey questionnaires. Each household was considered as a sample unit. The sampling frame of milk collection centers and dairy farms were obtained from respective weredas of livestock development agents. Depending on the frame lists and information obtained, from sixteen milk collection centers (MCC) found in Debre Berhan, Basona Worana and Angolana Tera weredas, six milk potential areas were randomly selected. Farmers sample size was determined using $N=0.25/SE^2$ with the assumption of a 3.78% standard error (Arsham, 2007). List of farmers obtained from the selected areas were categorized into urban and peri-urban to form the sampling frame. Accordingly, a total of 175 dairy farms/households (urban (n=85) and per-urban (n=90)) from (Debre Berhan (n=55) in urban, Basona Worana (n=60) in peri-urban and Angolana Tera weredas (n=60)) in urban and peri-urban were randomly selected for the survey interviews.

3.2.2. Data collection and sources

The overall data set considered in the current study included both primary and secondary data sources. The primary data was collected using a pretested semi-structured questionnaires via a face to face interview in 2017 and 2018. Data were collected on demographic characteristics of the farm households (age, marital status, education level, family size, income sources, farming experience, land size, cattle herd size, occupation);

dairy cattle management (breeding, calve rearing, common feed resources and feeding systems, housing, disease occurrence, culling systems and health care, record keeping practices); and production and reproductive performance of the cattle. Data were also collected on milk production, handling, milk marketing and processing, and milk consumption level. Questionnaire/checklists were prepared for group discussions on the major factors influencing milk production and marketing. Focus group discussions were conducted at each of the selected kebele. A total of 36 farmers (six per session) composed of different age groups have participated in the group discussion (Krueger and Krueger, 2002). Key informants' interviews were undertaken with the zonal and wereda level livestock production experts, local development assistants, knowledgeable farmers, community leaders and cooperative managers in the selected *Kebele*. Whereas the secondary data were extracted from previous studies and information documented at the zonal and agricultural offices. Data enumerators recruited were agricultural development agents, who were then trained to assist in primary data collection during face to face interviews and group discussions. Checklists for field observation were used to check different dairy farm conditions in practice at the study areas regarding housing, animal healthcare, hygiene, feed and water provision, and milking routines.

3.2.3. Milk sampling and laboratory procedures

Raw milk samples were randomly taken from producers (pooled), milk collection centers (from bulk milk), and from milk processing plant-based on a formula of Kothari (2004) for the unknown population ($n=Z^2SD^2/e^2$). Where Z, is the estimated standard deviation at 95% confidence interval (CI) which is considered the point of the normal distribution corresponding to the level of significance (Z=1.96), and standard deviation (SD) estimated at 20% and e, is the error considered at 0.05 or 5%. Thus, the sample size 'n' was calculated as:

$$n = \frac{(1.96)2 \times (0.20)2}{(0.05)2} = 61.5$$

Therefore, 62 samples of milk were collected per wereda (Table 1). The equipment (plunger and diaper) were washed with distilled water, and the operator's hands were

disinfected with alcohol (70 percent) before collection. Then a milk sample was collected into a sterile sample container labeled and stored on an icebox (0-4° C) and transported to the Ethiopian Meat and Dairy Technology Institute within 24 hours. The physioc-chemical analyses was done by testing chemical characteristics of the milk (fat content, solids not fat (SNF), protein, lactose, total ash, added water, and density and freezing point) using EKO MILK analyzer (BULTEH 2000 Ltd, Bulgaria).

Table 1. Sampling layout for the assessment of milk quality

Season	Physio-chemical			Microbial loads		
	MP	MCC	MPP	MP	MCC	MPP
Dry season						
Urban	62	8	4	24	7	4
Peri-urban	62	3	1	24	3	1
Wet season						
Urban	59	5	4	28	6	4
Peri-urban	58	2	1	28	3	1

MP= milk producers, MCC= (milk collection center), MPP= (milk processing plant)

Somatic cells count*:* Somatic cell count was conducted following the procedure of 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 a microscope at 100 times magnification. Somatic cells were counted in twenty different fields (A). Given the dimension of the microscope zoom (F; in this case = 0.0346) and the somatic cells count (N). N= A x 10000/F (Richardson, 1985; Kelly *et al*., 2011).

Coliform count (CC): One ml of the homogenized milk sample serially diluted at 1: 10^5 using peptone water and mixed thoroughly by using a milk mixer and transferred into sterile triplicate plates. About 15 - 20 ml melted (45 ^oC) Violet Red Bile Agar (VRBA) were added, then mixed nearly and allowed to solidify for 5-10 minutes. The mixture was then overlaid with a plating agar to inhibit surface colony formation and incubated at 37^0C for 24 hours, after which typical coliform colonies were counted (Richardson, 1985). The

total number of colonies expected was between 25and 250 cfu/ml (Richardson, 1985). 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).

Total Bacteria Count (Standard Plate Agar): one milliliter of milk collected with a sterile standardized loop and diluted it progressively (10^{-1}– 10^{-7}) with "Peptone Water" and transferred into sterile triplicate plates. About 15 - 20 ml of molten "Standard Plate Agar" (cooled to 45 °C) was added immediately and the dilutions were gently mixed thoroughly. The plated samples were allowed to solidify and counts were made after incubating plates at 37 ºC for 48 hours. The number of colonies counted multiplied by the dilution factor gives what is known as the standard plate count or the estimated number of bacteria per milliliter of the sample (Richardson, 1985). The colonies were counted and stated as Colony Forming Units (CFU) per milliliter of milk samples and calculated using the following formula (FDA, 2003).

$N = \Sigma C / [(1xn1) + (0.1xn2)] d$

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 were obtained.

3.3. Prevalence of mastitis and Associated Risk Factors in the Study Area

3.3.1. Study animals

The study animals were lactating cows in selected farms of Debre Berhan milk sheds of Deber Berhan town, Basona werena and Angolelana tera wereda. Individual lactating cows within a farm under study is the sampling unit. The study was conducted on a total of 510 lactating dairy cows (local (n=24), cross breeds (n=466), and Jersey breeds (n=20)). The

age of the animals were categorized as young (3 to 6 years) and adults (>6 years), and the parity of the animals also categorize as few with (1-3 calves), moderate (4-6 calves) and many (6 and above calves) respectively. Stage of lactation also categorized as early (1st to 3^{th} month), mid (4^{th} to 6^{th} month), and late (7^{th} month to the beginning of dry period)) and milk yield was categorized as 7 liters (low), between 8 -15 (medium) and greater than 15 litters (high) in small, medium and large scale dairy farms were study population based on their management systems and owners willingness.

3.3.2. Study design

A cross-sectional study design was employed to determine the prevalence, risk factors, and the major causes of mastitis using California mastitis test (CMT) and bacteriological isolation from cows which were kept under small, medium and large scale dairy farms. The dairy farms (26 small: 11 medium: 3 large farms from Debre Berhan town, 38 Small: 21 medium: 1 large farms from Basona worana and 54 small: 2 medium: 4 large farms from Angolelana tera wereda) were identified for each study site by the help of local livestock development agents.

3.3.3. Sample size determination

There was no previous reports of the prevalence of mastitis in the present study areas to estimate the desired sample size. Therefore, the sample size of the study was determined based on sample size determination described by (Thrusfield, 2007) with a 95% confidence interval and 5% desired precision. Since there was no similar research conducted in the area, an expected prevalence of 50% was assumed.

$$n = \frac{1.96^2 Pexp\ (1-Pexp)}{d^2}$$

Where Pexp = expected prevalence

d= absolute precision

n =sample size.

Therefore, the calculated sample size was 384 lactating cows. However, the number of included herds and the number of cows was based on accessibility and the willingness of the farmers to be parts of the research. Accordingly, the study was carried out on 510 lactating dairy cows to increase the precision (154 from Debre Berhan town, 148 from Basona worana and 208 From Angolelana tera wereda) were selected from a total of 160 dairy farmers; urban (n=82) and peri-urban (n=78) farmers respectively. Since large farms were few in number, all were included in this study. All lactating dairy cows in a selected farm were assessed for mastitis. Similarly, all lactating dairy cows in a selected farm were followed for 6 months to determine the incidence of lameness, identify the associated risk factors and assess the effect on milk production. Each of the selected farms visited every month to record new cases. For the assessment locomotion scoring the dairy cows were taken out of the barns and let the cows to exercise and were assessed the movement of cows after the morning milking.

3.2.4. Data collection

A questionnaire was developed at the time of sample collection. The data collected include cow level factors such as breed, age, lactation stage, parity, milk production, body condition, previous mastitis history and incidence of lesion on the skin of udder or teat and milking practice (washed hand and udder before and after milking, drying of udder before milking and milking mastitic cows at the end, length of cow track (meter), presence of lameness on lactating cow, locomotion scoring of the lameness, assessment of foot lesions, hoof trimming practices and type of floor were obtained by surveillance and by interviewing of farm attendants and owners. Animals age was determined from dentition characteristics and categorized as young (3 to 6 years) and adults (>6 years) (Ortegon, 2013); Stage of lactation was categorized as early (1st to 3^{th} month), mid (4^{th} to 6^{th} month), and late (7^{th} month to the beginning of dry period)) and milk yield was categorized as 7 liters (low), between 8 -15 (medium) and greater than 15 litters (high) (Mureithi and Njuguna, 2016). Parity was categorized as few with (1-3 calves), moderate (4-6 calves) and many (6 and above calves) (Yilma *et al*., 2017). The type of management system was categorized into intensive, semi-intensive and extensive, herd size was categorized into 5-10 animals (small); 11 - 20 animals (medium) and > 20 animals (large) (Alehegn *et al*.,

2016). The locomotion scoring systems; locomotion score 1 which is normal, locomotion score 2 which is mildly lame, locomotion score 3 (moderately lame), locomotion score 4 (Lame) and locomotion score 5 (severely lame) (Sprecher *et al*., 1997). In addition, environmental and management risk factors like sanitation and housing design (slipperiness, cracks, concrete type or not) were recorded for the diagnostic statistics.

3.2.5. Clinical examination of udder and milk

The udder of all lactating cows in selected farms was thoroughly examined for any abnormalities of secretions, abnormalities of size, consistency, and temperature. The gland was palpated for any hardening and the teats for evaluation of teat canal effectiveness. Pain reaction upon palpation, changes in the milk (blood-tinged milk, watery secretions, clots, pus), and change in consistency of udder were considered as indications of the presence of clinical mastitis.

3.2.6. California mastitis test (CMT)

The California Mastitis Test is a cow side-test to estimate the somatic cell count of milk was carried out as described by Quinn *et al*. (2002). Briefly, a squirt of milk, about 2 ml from each half was placed in each of shallow cups in the CMT paddle. An equal amount of the commercial CMT reagent was added to each cup. A gentle circular motion was applied to the mixtures in a horizontal plane for 15 seconds. The result of the test was evaluated on the basis of gel formation and the results graded as 0 for negative, 1 for weak positive, 2 for distinct positive and 3 for the strong positive. Milk samples for a test result of CMT 1, 2 and 3 were classified as evidence of subclinical mastitis (Radostits *et al*., 2007).

3.2.7. Milk sample collection, handling and transportation

After carrying out California Mastitis Testing on milk from the four quarter, a total of 150 milk samples were collected from cows that suffered from clinical and subclinical mastitis. The udder of the cow was thoroughly cleaned with water and dried before sample collection (Chauhan and Argawal, 2006). The teat orifice was also cleaned using cotton soaked in 70% ethyl alcohol (Quinn *et al*., 2002). After discarding a few streams of milk, by holding the sterile collection bottle nearly horizontal, about 5 ml of milk was collected aseptically according to the procedures recommended by the National Mastitis Council (NMC, 1990). The milk sample was pooled together from all the 4 quarters in case all are involved in case of clinical mastitis. Then the samples were labeled based on temporary ID given to a cow, kept on ice box and transported to Addis Ababa University College of veterinary medicine microbiology laboratory.

3.2.8. Bacteriological isolation and identification of causative agents of mastitis

Milk samples from both clinical and subclinical quarters were bacteriologically examined according to the procedures employed by using standard microbiological techniques (Quinn *et al*. 2002). A loopful of milk samples collected from each infected quarter were inoculated separately on to MacConkey agar and blood agar base enriched with 7% defibrinated bovine blood. The inoculated plates were then incubated aerobically at 37 $^{\circ}$C for 24 to 48 hours. Then plates were examined for growth, morphology and hemolytic characteristics on blood agar after 24 hours. Suspected colonies were sub-cultured on a new plate for further investigation. Identification of the bacteria on primary culture was made on the basis of colony morphology, hemolytic characteristics, Gram stain reaction including shape and arrangements of the bacteria, catalase, and O-F tests. Staphylococcus species, streptococcus species and E. coli were the targets, because, these pathogens are the major microorganisms which cause bovine mastitis (Potter, 2008). Suspected colonies were identified morphologically and microscopically. Staphylococci were identified based on the Catalase test, growth characteristics on Mannitol salt agar and purple agar and tube coagulase tests. Identification of Streptococci was made according to growth characteristics on Edwards's media, Catalase test and hydrolysis of esculin. Gram-negative

isolates grown on MacConkey agar were identified based on growth characteristics on MacConkey agar, Oxidase reaction, Catalase test, triple sugar iron (TSI) agar, the "IMVIC" (indole, methyl red, Voges-Proskaur, and citrate) test (Quinn *et al*., 2002).

3.3. Prevalence of Bovine Brucellosis and Associated Risk Factors in the Study Area

3.4.1. Study design

The cross-sectional study was employed to assess the prevalence of brucellosis on indigenous, Jersey and crossbred cattle to determine the seroprevalence of bovine brucellosis and their association with different risk factors using two serological tests Rose Bengal Plate Test (RBPT) and Complement Fixation Test (CFT). A structured questionnaire survey was performed to assess the associated risk factors. Relevant individual animal and farm level information was collected using a semi-structured questionnaire.

3.4.2. Sample size determination

There was no previous reports of the prevalence of brucellosis in the present study areas to estimate the desired sample size. Therefore, the average expected prevalence rate was assumed to be 50% within a 95% confidence interval (CI) at 5% desired precision as stated by Thrusfield (2007). Therefore, the calculated sample size was 384 heads of cattle. However, the study was carried out on a total of 744 serum samples (194 from Debere Berhan town, 237 from Basona Worana and 313 from Angolelana Tera Wereda) of both sexes having different ages were sampled to increase the precision of the result based on the willingness of the owners but individual animals within the herds were selected using simple random sampling method except for those cows with a history of abortion or active case of abortion which were included purposively.

$$N = \frac{1.96^2 (P)(1-P)}{d^2}$$

Where

N= Total calculated sample size

P= expected prevalence

d= absolute precision

Out the total 744 animals sampled, 93.4% were female and 6.6% male cattle at least 6 months of age and female's age 2 years and above, none milking, replacement heifers and bulls were included. A total of 117 small farms (34 Debre Berhan, 39 Basona Worana, 44 Angolelana Tera Wereda) (with an average herd size of 5-10), 20 medium farms (5 Debre Berhan, 14 Basona Worana, 1 Angolelana Tera Wereda) (with an average herd size of 11-20) and 8 large farms (3 Debre Berhan, 1 Basona Worana, 4 Angolelana Tera Wereda (with an average herd size greater than 20) were randomly sampled. Finally a total of 145 farms (67 in urban and 78 in peri-urban farms) were selected using random sampling method and individual dairy cattle were also selected randomly based on the willingness of the owners.

3.4.3. Questionnaire for the assessment of risk factors for brucellosis

The potential risk factors for the prevalence of bovine brucellosis at herd and individual animal level such as parity, breed, age, farm type, herd size, farm location, breeding system and history of reproductive problem were extracted by face to face interviewing from farmers by using a semi-structured questionnaire. Furthermore, the clinical indicators such as history of abortion, testicular swelling and other reproductive problems were interviewed and recorded. The type of management system was categorized into intensive, semi-intensive and extensive, herd size was categorized into 5-10 animals (small); 11 - 20 animals (medium) and > 20 animals (large) (Alehegn *et al*., 2016). Presence or absence of separate calving pen, retained fetal membrane and aborted fetus disposal methods, use of personal protective equipment during handling aborted cows, retained fetal membrane and awareness of farmers on diseases causing abortion in late pregnancy, breeding system, source of replacement stock were the risk factors considered at the herd level. While types

of sex, age, breed and occurrence of previous abortion; retained placentas of the relevant animal were the risk and clinical factors considered at animal level.

3.3.4. Blood sample collection

Approximately 7-10 ml of blood was collected from the jugular vein of each selected animal using vacutainer plain tubes. All animals were restrained before puncturing and the jugular vein was disinfected by using 70% alcohol. For identification of each animal was labeled on vacutainer tubes and kept overnight at room temperature to allow clotting. The next morning, sera were collected into the sterile cryovial tube (2ml), labeled and kept at − 20 °C in Debre Berhan University Biology laboratory until serological tests were employed. All serum samples were screened by Rose Bengal Plate Test (RBPT). All RBPT positive sera were further tested using the Complement Fixation Test (CFT) for confirmation at the National Veterinary Institute (NVI) at Bishoftu.

3.3.5. Serological laboratory techniques

Rose Bengal Plate Test (RBPT):- RBPT was conducted following the procedure of OIE (2012). About 30µl sera sample was allotted onto the plate and equal amount of (30µl) RBPT antigen was dropped alongside the sera. The plate was shaken by hand for 4 minutes and the test was read by comparing it with the positive and negative control sera by examining for agglutination in natural light. Results of RBPT were interpreted as 0, +, ++ and +++ as described by (OIE, 2012). 0 = no agglutination; + = barely visible agglutination, ++ = fine agglutination and +++ = coarse agglutination. Samples with no agglutination (0) were taken as negative while those with +, ++ and +++ were recorded as positive.

Complement Fixation Test (CFT):-The procedure was undertaken on those samples which were found to be positive on RBPT as described in OIE protocol (2012). The preparation of the reagents was performed according to OIE protocol (2012). A titration of hemolysin and antigen was performed before the test. The minimum hemolytic dose was also estimated for each run. As for the interpretation of test results, positive reactions were indicated by sedimentation of Sheep Red Blood Cells (SRBC) and the absence of

hemolysis. Negative reactions were revealed by the hemolysis of SRBC. According to OIE (2012), sera with a strong reaction, more than 75% fixation of complement at a dilution of 1:10 and at least with 50% fixation of complement at a working dilution (1:5) was classified as positive.

3.4. Data Management and Analyses

Data collected through questionnaire were entered into Statistical Package for Social Sciences (SPSS, 2015) version 20. Preliminary data analysis like homogeneity test, normality test and screening of outliers were employed before conducting the main data analysis. Chi-square test was used to diagnose the independence of categories or to assess the statistical significance. Descriptive statistics cross-tabulation such as percentage, mean and standard deviation were used to summarize the results. Rank indices were calculated to provide the overall priority of farmers on the purposes of keeping crossbreed dairy cattle, dairy production constraints, milk marketing constraints, income sources of dairy farmers, crop residues used by dairy farmers and major dairy cattle diseases. The purpose or constraint with the highest rank index value corresponds to the highest priority, and the rest follow in order of importance. The formula used by Ebrahim and Hailemicheal (2012) was adopted to calculate the indices as indicated below:

$$\text{Index} = \frac{Rn*C1+Rn-1*C2\ldots. +R1*Cn}{\Sigma\ Rn*C1+R\ n-1*C2\ldots. +R1*Cn}$$

Where,

Rn= Value given for the least ranked level

Cn = Counts of the least ranked level

Data obtained from laboratory microbial analysis of milk were converted to the base- 10 logarithms of the number of colony-forming units per ml of raw milk samples (log cfu/ml), and from these means and their standard deviations were calculated. The data collected from TBC, SCC and CC were analyzed using the Generalized Linear Model (GLM) procedures of the Statistical Analysis System (SAS, release 9.1, 2004). Duncan Multiple

Range Test Mean (DMRT) comparisons was used for mean separation between sampling sources at P<0. 05. Associations of different variables were analyzed by using the correlation coefficient (R). Means were declared significant at (P<0.05). Therefore, the statistical model used in the data analysis was:

$$Yijk= \mu + A_i + S_j + P_k + e_{ijkl}$$

Where,

Yijkl= the response variables (Physico chemical and microbial properties of milk).

A_i=effect of i^{th} production systems (urban, peri-urban)

$\mathbf{S}_j$=effect of j^{th} season (dry, wet)

Pk =Effect of P^{th} value chain points where (milk producers (MP), milk collectors (MC) and milk processing plants (MPP),

e_{ijkl} = random error

Correlation between milk physico-chemical composition were analyzed using Pearson correlation coefficient model

$$r = \frac{\Sigma xy}{(\Sigma x2\ \Sigma y2)^{0.5}}$$

Where r = correlation coefficient

Σx2, Σy2 and Σxy = sum of variables

Data obtained from the prevalence of mastitis and lameness were thoroughly screened for errors and properly coded before subjecting them to statistical analysis. The data were analyzed using STATA software version 13. Chi-square test was used to assess the association between the risk factors with the occurrence of the mastitis namely the breed, age, production system, udder washing, floor type, management system and stage of lactation with the occurrence of the prevalence of Mastitis and lameness. Descriptive statistics were used to quantify the prevalence of clinical and subclinical mastitis in relation to different explanatory variables. The associations of the clinical and Subclinical mastitis with the different risk factors such as breed, age, lactation period, parity, towel usage, milk yield, floor, body condition and teat lesion were assessed by using logistic regression.

Univariable logistic regression models were fitted containing the appropriate independent variables with 95% confident interval and less than 0.05 level of precision. All risk factors that had a non-collinear effect and P-value ≤ 0.25 in the unavailable logistic regression analysis were subjected to multivariable logistic regression analysis. Descriptive statistics on prevalence of lameness between the farms as well as association of putative risk factors with the cow level prevalence of lameness was compared by $\chi 2$ test.

Data obtained from the prevalence of brucellosis were thoroughly screened for errors and properly coded before subjecting to statistical analysis. The data were analyzed using STATA software version 13. Brucella seroprevalence association with categorical risk factors was analyzed using Fisher's exact test. The total seroprevalence was calculated by dividing the number of RBPT- and CFT positive animals by the total number of animals tested. Univariate logistic regression was used to test the significance of the effect of different risk factors on sero-prevalence of brucellosis. Odds ratio (OR) was utilized to measure the degree of association between risk factors and Brucella seropositivity. All risk factors that had non-collinear effect and P-value ≤ 0.25 in the univariable logistic regression analysis were subjected to multivariable logistic regression analysis (Gebremedhin *et al*., 2015).

4. RESULTS

4.1. Socio-Economic Characteristics of Households

4.1.1. Demographic characteristics of the households

The details of results of the demographic characteristics of the respondents are presented in Table 2. The results of the study indicated that the overall average age of the respondent was 47 years old. Educational status of the respondents involved in dairy cattle production in the study areas ranges from illiterate to Diploma and above. The results of the study indicated that 84% of the household involved in dairy cattle production were male. The family size of sample households significantly ($P<0.05$) varied across the study areas.

Table 2. Demographic characteristics of the sample households in the study areas (Mean ±SD)

Descriptors (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Age (year)	46.9±1.2	47.1±1.3	47.0±0.9
Educational status			
Illiterate	8.3	16.7	12.5
Basic education	12.9	23.3	18.3
Primary	45.9	47.8	46.9
Secondary	29.4	12.2	20.6
Diploma and above	3.5	0.0	1.7
Marital status			
Married	85.8	90.0	88.0
Single	10.6	5.6	8.0
Divorced	2.4	3.3	2.9
Widowed	1.2	1.1	1.1
Sex of household head			
Male	83.5	83.3	84.0
Female	16.5	16.7	16.0
Family size	5.4 ±0.2 [a]	6.4±0.2[b]	5.9 ±0.2

n= number of respondents; a, b=values with different superscripts in a row differ significantly $P\leq0.05$

4.1.2. Occupational status and land holding per households in the study area

The results from Table 3 indicated that 68% of the respondents from urban and 92% from peri-urban areas were full-time dairy producers. The overall average land size in the surveyed areas was 1.6 ha per household, but this is significantly ($P < 0.05$) different between urban and peri-urban areas.

Table 3. Occupational status and land holdings (Mean ±SD) of the respondents'

Descriptors (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Occupational status			
Full-timedairy producer	68	92	80
Businessman	15	6	10.5
Government employee	11	0	5.5
Non-government employee	1	1	1
Retired personnel	4	1	2
Dairy Laborer	1	0	1
Landholding (ha)	1.2 ±0.1[a]	1.8 ±0.1[b]	1.6 ±0.1

n= number of respondents; a,b=values with different superscripts in a row differ significantly $P \leq 0.05$

4.1.3. Livestock holding per households in the study area

As shown in Table 4, the total number of local cattle per farm was higher in peri-urban than urban areas of the study. However, higher numbers of lactating crossbred dairy cows were owned by urban farmers. The highest average dairy producers holding of replacement heifers were reported from urban areas (1.27) as compared to peri-urban (1.27). The average number of calves estimated was lower in urban areas as compared with peri-urban areas.

Table 4. Livestock holdings per households in the study area (Mean±SE)

Descriptors	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Milking cow(crossbred)	2.71±0.14[a]	2.06±0.12[b]	2.4±0.09
Dry cow(crossbred)	0.44±0.08	0.33±0.07	0.4±0.05
Heifers(crossbred)	1.27±0.16	1.17±0.1	1.21±0.09
Calves(crossbred)	0.64 ±0.08 [b]	1.67±0.13[a]	1.17±0.08
Bull(crossbred)	0.52±0.08	0.64±0.09	0.58±0.06
Oxen(crossbred)	0.47±0.08	1.14±0.12	0.82±0.08
Ave. crossbred	6.04±0.37	7.01±0.31	6.54±0.24
Ave. local cattle	0.82±0.16	2.0±0.32	1.43±0.19
Overall Av. Cattle	6.86±0.40	9.01±0.47	7.97±0.32
Sheep	8.4±1.1	10.8±0.9	9.6±0.7
Goat	0.04±0.03	0.47±0.13	0.26±0.07
Equine	1.72±0.13	3.24±0.21	2.19±0.15
Chicken	6.6±1.07[a]	4.46±0.56[b]	5.04±0.60

n= number of respondents; a,b=values with different superscripts in a row differ significantly $P \leq 0.05$

4.1.4. Major income sources of households in the study area

The details of income sources and their corresponding index value of households were indicated in Table 5. Dairy production was the main source of income followed by crop production, with an index value of 0.39 and 0.29, respectively.

Table 5. Ranking of the source of income in the study areas (%).

Sources of income	Urban (n=85)		Peri-urban (n=90)		Overall mean (N=175)	
	HH	RI	HH	RI	HH	RI
Dairy production	85	0.40	90	0.38	175	0.39
Crop production	59	0.23	89	0.34	148	0.29
Forest (sold)	40	0.13	70	0.17	110	0.15
Trade	24	0.09	23	0.07	47	0.08
Public organization employment	16	0.06	3	0.01	19	0.03
Private company employment	28	0.08	11	0.03	39	0.06

HH = number of households who ranked the source of income, RI = Rank Index.

4.1.5. Experience in dairy production, source of crossbred dairy cows and farmers involved in the dairy cooperatives

Experience in dairy production and source of crossbred dairy cattle in the study area is presented in Table 6. It was found that, 39% of the respondents have 6-10 years of dairying experience in urban areas while 44% of the dairy farms have greater than 10 years' experience in crossbred dairy production in peri-urban areas. Most of the respondents (68%) and (49%) in urban and peri-urban areas, the source of their crossbred dairy cows were purchased from the local market followed by mating local cow with crossbred bull. The result indicated that (45.6 %) of the respondents' dairy farmers found to be a member of a dairy cooperative. However, more than half of sampled households (51.6%) in peri-urban areas were members of a dairy cooperative than urban areas (details in Table 6).

Table 6. Source of crossbred dairy cows, farmers 'experiences and involved in dairy cooperatives.

Descriptors (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Experience in dairying (crossbred cattle)			
1-5 years	29.0	27.0	28.0
6-10 years	39.0	29.0	34.0
>10 years	32.0	44.0	38.0
Source of crossbred dairy cows			
Crossing local cow with AI	9.4	3.3	6.3
Local cow with crossbred bull	15.3	34.4	25.1
Purchased from the local market	68.2	47.8	57.7
Supplied by the NGO	5.9	7.8	6.9
Gift from family	1.2	6.7	4.0
Member of dairy cooperative			
Yes	39.5	51.6	45.6
No	60.5	48.4	54.4
Sources of information			
From previous members	64.7	74.4	69.6
From cooperatives office	35.3	25.6	30.5
Benefited from membership			
Regular milk market	6.3	19.6	13.0
Access inputs and regular milk market	93.8	80.4	87.0

n = number of respondents

4.1. 6. Purpose of keeping dairy cattle in the study area

The primary reason of keeping crossbreed cattle by the farmers is for source of income generations through the sale of milk with an index value of 0.27 and the second main reason of dairy cattle keeping is for home consumption and assets with an index value of 0.23 (Table 7).

Table 7. Ranked purpose of keeping crossbreed cattle as indicated by respondents (%)

Purpose of keeping dairy cattle	Urban (n=85)		Peri-urban (n=90)		Overall mean (N=175)	
	HH	RI	HH	RI	HH	RI
Milk sale(income generate)	85	0.27	89	0.27	174	0.27
Milk for home consumption and sale	66	0.18	87	0.27	153	0.23
For asset	57	0.12	70	0.17	127	0.15
Manure	63	0.1	76	0.14	139	0.12
For sale of calves/heifer	71	0.13	50	0.09	121	0.11
Milk and meat	64	0.12	16	0.02	80	0.07
Growing males for ploughing	56	0.08	31	0.04	87	0.06

HH = number of households who ranked the purposes, RI = Rank Index.

4.1.7. Involvement of family members on dairy cattle managements

The main source of labor for dairy farming activities across the production systems was family labor (Table 8). Urban dairy farming also used hired labores but the contribution of the hired labor was insignificant in peri-urban areas. Herding, feeding, watering, milk selling and health care were main tasks of both male and female members of the households. Milking and barn cleaning were mainly the jobs of women in the study areas.

Table 8. Daily activities of the respondents on dairy cattle managements (%).

Responsible bodies	Milking	Herding	Feeding	Watering	Cleaning	Selling	Health care
Men	24.6	12.6	18.3	9.1	2.3	19.4	24.6
Women	65.1	15.4	16.0	13.7	50.9	8.6	14.3
Family *	-	40.6	46.9	46.3	26.3	33.7	47.4
Hired	2.2	8.6	8.6	9.1	9.1	8.6	8.0
Children	8.0	22.9	10.3	21.7	11.4	29.7	5.7

***** *= Group of peoples within on households who involved in milk production.*

4.2. Dairy Cattle Husbandry Practices in the Study Area

4.2.1. Feeding systems and feed resources

Zero grazing (indoor feeding) followed by partial grazing supplemented by indoor feeding was the main feeding system (Table 9). The result reveal that crop residues and concentrates and hay were commonly available and used dairy feed resources in peri-urban (66.70%), while crop residues and concentrates were commonly available and used dairy feed resources in urban (55.3%), dairy farmers.

Major of the respondent's (89.9%) in the urban areas purchased feeds from markets and/or other farmers from the surrounding areas, while, (67.2%) of the respondents in peri-urban areas used both production on farm and purchased feeds. Among the roughage feedstuffs, grass hay and crop residues of barley, faba bean, wheat, and oats were the major types of feed purchased by producers. Grass hay is typically sold in baled form, whereas crop residues are in a loose form and transported in a variety of means. According to the respondents, lactating cows were supplemented with concentrate feed ingredients of agro-industrial by-products (wheat bran, oilseed cakes and brewers' byproducts).

4.2.2. Frequency of providing feed supplements

The result indicated that majority of the respondents in urban (51.8%) and peri-urban areas of (55.6%) in the study areas experienced feeding of feed supplements twice a day for their dairy cattle. While, the remaining of the respondents from urban (40.0%) and peri- urban (35.6%) areas of the study areas, practiced feeding of feed supplements three times per day for their dairy cattle (Table 9).

4.2.3. Forage production constraints in the study area

The major problems in forage production were shortage of land, inadequate extension support services and lack of improved forage seeds/seedling.

Table 9. Dairy feeding system, feed resources, constraints of forage production in the study areas (%)

Descriptors	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Dairy feeding system			
Indoor	76.5	76.7	76.6
Partial grazing	23.5	23.3	23.4
Common feed resources			
Hay, crop residues and concentrates	27.10	66.70	46.9
Crop residues and concentrates	55.30	3.30	29.3
Private pasture, crop residues and concentrates	0.0	12.20	6.1
Private pasture, hay, improved forage, crop residues and concentrates	0.0	4.40	2.2
Areke (*Attela*) and crop residues	1.20	0.0	0.60
Hay, crop residues and brewery by products	2.40	13.30	8.0
Hay , crop residue, brewery by products and concentrates	7.10	0.0	3.4
Hay, crop residues, concentrate and Areke (*Attela*)	5.9	0.0	2.90
Hay, improved forage, crop residues and concentrates	1.20	0.0	0.60
Major feed supply			
Own farm produced	4.3	26.2	15.3
Purchased	89.9	6.6	48.3
Both farms produced and purchasing	5.8	67.2	36.5
Supplements feeding frequency			
Once per day	8.2	8.9	8.55
Twice per day	51.8	55.6	53.7
Thrice per day	40.0	35.6	37.75
Constraints of forage production			
Shortage of land	65.9	64.4	65.1
Shortage of improved seeds	9.4	12.2	10.9
Inadequate extension support services	21.2	16.7	18.9
Shortage of land and improved seeds	3.5	6.7	5.1

n = number of respondents

4.2.4. Types of available crop residues in the study areas

Among crop residues, barely (*Hordeum vulgare*) straw was largely used in the study areas followed by Faba bean (*Vicia faba L*), and Wheat (*Triticum aestivum*) (details in Table 10).

Table 10. The rank of crop residues used by the dairy owners in study areas (%).

Crop residues	Urban (n=85)		Peri-urban (n=90)		Overall mean (N=175)	
	HH	RI	HH	RI	HH	RI
Barely straw (*Hordeum vulgare*)	82	0.43	86	0.43	168	0.43
Faba bean straw (*Vicia faba* L)	57	0.19	69	0.22	126	0.21
Wheat straw (*Triticum aestivum*)	59	0.25	47	0.16	106	0.20
Oat straw (*Avena spp*)	31	0.12	63	0.17	94	0.15
Teff straw (*Eragrostis teff*)	2	0.0	8	0.02	10	0.01

HH = number of households who ranked the crop residues, RI = Rank Index.

4.2.5. Water source and watering frequency of dairy cattle in the study area

One of the most limiting factors in livestock production is availability of regular and clean drinking water. In the present study area, water sources were tap water, river and spring (Table 11). Of the interviewed farmers 65.9% from urban and 45.6% from peri-urban reported using tap water for dairy cattle in the study areas. The frequency of watering was two to three times a day. Farmers of the peri-urban areas (37.8%) mentioned the seasonal availability of water (source dry up during the dry seasons), far watering point and poor quality water, parasites contaminated water (leeches) among the major water related constraints. In the households who lived far from the source of water animals were forced to move long distance in search of drinking water (Table 11).

Table 11. Dairy cattle watering sources and frequency in the study areas (%).

Description (%)	Urban (n=85)	Peri-urban (n=90)	Overall (N=175)
Source of water			
Tap	65.9	45.6	55.4
River	30.6	48.9	40
Spring	3.5	5.6	4.6
Watering frequency/day			
Thrice and more	65.9	57.8	61.9
Twice	34.1	42.2	38.1
Constraints of water			
Seasonal availability	23.5	37.8	30.7
Poor quality problem	3.5	14.4	9.1
Far watering point	14.1	12.2	13.1
No problem	58.8	35.6	46.9
Distance for water			
Watered at home	80.0	16.7	48.35
<1km	12.9	37.8	25.35
1-5 km	7.1	45.6	26.35

n = Number of respondents

4.2.6. Major disease problems of dairy cattle in the study area

Thirty three pecent of producers encountered udder infection in their dairy herd and that was the repeatdly reported (1st) disease by the farmers interviwed. The other most common dairy cattle disease reported in study areas were blackleg (2nd) and foot and mouth disease (FMD) (3rd) were the most reported disease problems according to their importance (Table 12).

Table 12. Ranking of major dairy cattle diseases in the study areas (%).

Parameter	Urban (n=85)		Peri-urban (n=90)		Over all mean (N=175)	
	HH	RI	HH	RI	HH	RI
Mastitis	85	0.32	90	0.33	175	0.33
Black leg	57	0.24	59	0.23	116	0.24
Foot and mouth disease	47	0.17	65	0.23	112	0.21
Parasites	40	0.15	42	0.16	82	0.16
Lumpy skin disease	15	0.05	12	0.04	27	0.05
Anthrax	16	0.06	4	0.01	20	0.04

HH = number of households who ranked major dairy cattle diseases, RI = Rank Index.

4.2.7. Dairy cattle breeding systems in the study area

In the current study, all of the interviewed respondents revealed they use to detect estrous by follows up during morning & night time. Two breeding methods namely natural mating and artificial insemination (AI) or a combination (based on availability) were used. About 18.1% of the dairy farmers were used homebred bulls. The average bull service charge was expected to be 104 Ethiopian Birr (ETB)/service, which is expensive when compared to the AI services 83.3 ETB/service (for AI). Although animals showed typical signs of estrus, a significant number of respondents, 48.8 % from urban and 45.3% from peri-urban reported not to conceive after AI or failure to inseminate animals on time. Major possible problems of failure of AI reported by the respondents were; heat detection problem, distance to AI center, and absence of AI technician and inefficiency of AI technician.

Table 13.Breeding systems of crossbred dairy cows in the study areas (%).

Description	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Do you practice estrous detection?			
Yes	98.8	100	99.4
No	1.2	0.0	0.6
Method of estrous detection?			
Herdsman information	3.6	25.6	14.9
Follows up during morning&night	89.3	66.6	77.6
Using teaser bull	7.1	7.8	7.5
Breeding methods			
AI	30.6	26.7	28.6
Natural mating	27.1	40.0	33.7
Both	42.4	33.3	37.7
Source of bull			
Neighbor	82.8	81.2	81.9
Own	17.2	18.8	18.1
Price (ETB) (Mean ±SE)			
AI	96.4± 8.6	72.6± 8.0	83.3± 5.9
Bull	119.6±10.0	88.3±10.8	104± 7.5
Failure of AI			
Yes	48.8	45.3	47.1
No	51.2	54.7	52.9
Problems for AI failure			
Heat detection problem	34.79	25.93	30.4
AI technician inefficiency	21.27	38.89	30.1
Distance from AI center	18.87	36.11	27.9
AI technician absence	16.48	18.52	17.5
Other	8.59	0.0	4.3

ETB= Ethiopian Birr,n = number of respondents; AI, Artificial Insemination

4.2.8. Weaning ,Culling and Calf milk feeding systems

In the study areas, majority (66.9%) of the respondents have practiced calf weaning. Among the interviewed dairy producers 68.0% weaned their calves at more than four months of age, 26.3% at three months and 5.7% wean at fourth months of age (Table 14). The result indicated that majority (65.9%) of the respondents in urban areas practices culling of male calf as compared to peri-urban areas. Among the interviewed dairy cattle

producers, (81.7 %) were raised calves through partial suckling and followed by (18.3%) through bucket feeding.

Table 14. Weaning, culling and Calf milk feeding systems reported by the respondent in the study areas.

Description (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Do you practice calf weaning?			
Yes	72.9	61.1	66.9
No	27.1	38.9	33.1
Do you practice culling?			
Yes	65.9	36.7	50.9
No	34.1	63.3	49.1
Weaning age of calf			
< Four months	48.2	5.6	26.3
Four months	5.9	5.6	5.7
> Four months	45.9	88.9	68.0
Calf milk feeding systems			
Partial suckling	67.1	95.6	81.7
Bucket feeding	32.9	4.4	18.3

n = Number of respondents

4.2.9. Dairy Cattle Housing and Waste Management

Majority (89.4%) of the dairy farmers in Urban and 68.5% in peri-urban areas constructed dairy cattle barns with the corrugated iron roofing material for better stability, while the rest constructed with thatched grass and few (59 % in Urban and 1.1% in peri-urban) constructed with Plastic / Gio-membrane. The materials used to make the floor of the barns (65.9%) in urban and (88.9%) in peri urban of the respondents used stone for flooring. However, none of the respondents used bedding material for the dairy animals. Almost all (99.5%) of dairy farmers had the practice of cleaning manure daily, followed by those who cleaned once per week. About 51.8 % of respondents in urban area use manure for dung cake while, 74.4% of dairy producers in peri-urban area use animal manure for dung and manure (fertilizer).

4.2.10. Record-keeping practices in the study area

Most (88.6%) of the dairy farmers in the study area stated that they do not keep the necessary farm records belong to their dairy animals. However, only about 14.1% of the sampled dairy farmers in urban areas partially try to keep records on calving date, heat sign, and service dates.

Table 15. Dairy animals' house type, frequency of cleaning and record keeping practices (%).

Description	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Roof type			
Corrugated	89.4	68.5	79.0
Thatched	4.7	30.3	17.5
Plastic	5.9	1.1	3.5
Floor type			
Cement	22.4	10.0	16.2
Stone	65.9	88.9	77.4
Earthen	11.8	1.1	6.5
Bedding used			
No	100	100	100
Frequency of cleaning			
Daily	100	98.9	99.5
Once / week	0.0	1.1	0.5
Waste management			
Biogas production	9.4	0.0	4.6
Dung cake	51.8	24.4	37.7
Manure(fertilizer)	10.6	1.1	5.7
Dung and manure(fertilizer)	28.2	74.4	52.0
Record keeping (%)			
No	85.90	91.10	88.60
Type of data Recorded			
Milk yield only	1.20	0.0	0.60
Milk yield and calving dates	2.4	0.00	1.2
Calving date, heat sign, and service dates	3.50	4.40	4.0
Milk yield, service date and calving date	2.4	0.00	1.1
All of the above	4.7	4.4	4.60
No record	85.90	91.10	88.60

n = number of respondents

4.3. Productive and reproductive performances of crossbred cows

Daily milk yield, as well as milk production for the entire lactation length, was higher for dairy farms in urban area than peri-urban areas (Table 16). The mean age at first calving (AFC) reported for crossbred heifers was 31.58 months and lactation length (LL) and milk yield of crossbred cows was 9.9 months and 9.5 liters per day, respectively. The overall mean calving interval (CI) reported for the crossbred cow was 15.01 months. The overall estimated average number of service per conception (SPC) for crossbred cows was 1.77 and the average age at first service for crossbred cows was 22.3 months.

Table 16. Average daily milk yield and reproductive performances (Mean±SD) of crossbred dairy cattle.

Description	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Milk yield (l/cow/day)	10.7±6.3	8.5±4.4	9.5±5.4
Lactation length (months)	10.3±4.7	9.6±2.15	9.9±3.6
Calving interval (months)	14.90±2.60	15.3±2.51	15.10±2.60
Service per conception (number)	1.75±0.89	1.79±1.01	1.77±0.95
Age at 1st calving (months)	29.4±4.7	33.6±7.3	31.58±6.5
Age at 1stservice (months)	20.28±4.4	24.19±7.17	22.29±6.28

n = Number of respondents

4.4. Constraints of Dairy Cattle Production in the Study Area

The major constraints of dairy cattle production encountered by the small holder dairy producers of the study area in order of importance were feed shortage, high feed cost and prevalence of diseases (Table 17). The current result revealed that dairy producers stressed shortage of feed to be the most important limiting factor for productivity of their cattle.

Table 17. The overall ranking of major constraints of dairy production (%).

Constraints	1th	2th	3th	4th	5th	6th	7th	8th	9th	10th	11th	Index
Shortage of feed	76	38	52	9	0	0	0	0	0	0	0	0.20
High cost of feeds	18	46	27	22	17	7	5	1	2	5	4	0.15
Prevalence of diseases	15	32	39	17	11	6	6	2	3	1	2	0.13
Poor quality of feeds	40	18	10	16	4	3	6	2	4	2	2	0.11
Shortage of improved dairy cattle	1	7	21	6	15	17	10	18	8	2	2	0.08
Poor veterinary services	5	13	5	18	11	16	12	4	6	2	2	0.07
Inadequate water supply	5	5	4	13	27	11	7	3	5	5	8	0.07
Lack of land	7	3	6	8	8	13	10	12	7	9	7	0.06
Lack of AI/breeding service	1	1	7	13	6	7	10	11	11	15	1	0.05
Space limitation for dairying	1	2	1	9	7	11	11	12	8	13	2	0.04
Manure handling/disposal	5	6	8	4	2	4	2	6	10	10	33	0.04

Index = sum of [11 for rank 1 + 10 for rank 2 + 9 for rank 3+8for rank 4+7 for rank 5+6for rank 6+5 for rank7+4 for rank 8+3for rank 9+2for rank10+1for rank 11] for particular trait divided by sum of [11 for rank 1 + 10 for rank 2 + 9 for rank 3+8for rank 4+7 for rank 5+6for rank 6+5 for rank7+4 for rank 8+3for rank 9+2for rank10+1for rank 11] for all variables.

4.5. Dairy Production, Consumption and Marketing Practices

The mean milk yield produced per day by smallholder farmers and household's consumption of milk per day is shown in Table 18. The average proportion of milk consumption per household were higher in peri-urban area than urban area. The amount of fresh milk self-consumed per farm per day by producer families varied from 0.5 to 6 liters (mean= 1.63 liters). The average volume of milk for sale varied among production systems. The most market share of the urban dairy system is due to the market-oriented smallholder dairy farms, which are mainly concentrated adjacent to urban consumers in addition to the variation in daily milk yield. Majority (90.3%) of the dairy farmers in the study area stated that they have access for boiling milk prior to consumption, which is important to reduce health/ risk of disease transmission. Majority of the (73.7%) the respondents in the study areas drank milk once a day followed by 22.2% more than once a day and 4.2% once or twice per week respectively.

Table 18. The quantity of milk produced, consumed and sold (in liter) by smallholder farmers (Mean± SE).

Description	Urban (n=85)	Peri-urban (n=90)	Over all mean (N=175)
Average milk produced per HHs	27.19 ±2.05	14.80±1.02	20.82±1.22
Home consumption	1.49±0.10	1.76±0.11	1.63±0.08
Milk wastage or given to calf	1.98±0.19	0.90±0.10	1.76±0.17
Milk sold/delivered	25.14±2.01	12.98±0.99	18.89±1.19
Milk consumption systems (%)			
Raw and boiling	2.4	4.4	3.4
Ergo (fermented)	3.5	8.9	6.3
Boiling	94.1	86.7	90.3
Frequency of drinking (%)			
Drank it once a Day	74.1	73.3	73.7
More than once a day	22.2	22.1	22.2
Once or twice per week	3.7	4.7	4.2

n = number of respondents, SE= standard Error

4.6. Cow and Personnel Hygiene

Majority (95.4%) of the respondents in the study areas washed their hands before milking with tap water (Table 19). About 63.5% of dairy farmers apply cold water with soap to wash their hands, while the rest (36.5%) washed their hands with cold water only. A significant number of (45.6%) of the respondents have no hand drying before milking, while only 3.05% of them practice hand drying using a clean towel. According to the present study, about 51.4 % of dairy farmers used re-usable cloth for drying their hands. All of the farmers milked their cows twice per day in both areas. Majority (97.6%) of the respondents in the study areas wash their milking cows' udder prior to milking but most (56%) of the dairy farmers wipe the water from the udder by using their bare hands while 30% and 10.7 % of the interviewed farmers reported using an individual towel for each lactating cow and used Vaseline gel to lubricate the teat of the cows. Most (68.1%) of the small holder dairy farmers stated using warm water for cleaning the udder while the remaining 31.9% of dairy farmers used cold water. About 83.8% of the respondents in urban area practice washing of udder cloth daily while 83.1% of the respondents in peri urban area didn't practices washing of udder cloths. All (97.7%) of the sampled dairy producers of the study area did not practice teat dipping after milking.

Table 19. Source of water and personal hygienic practices of milkers in the study areas.

Description (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Hand wash during milking			
Yes	100	91.1	95.4
No	0.0	8.9	4.6
Water sources			
Tap water	90.6	66.7	78.3
River	9.4	26.7	18.3
Spring	0.0	6.7	3.4
Cleaning methods			
Cold water alone	25.9	47.1	36.5
Cold water and soap	74.1	52.9	63.5
Hand drying			
Re-usable cloth	54.8	48.0	51.4
Clean towel	4.4	1.7	3.05
Not at all	40.8	50.3	45.6
Udder washing			
Before milking	97.6	97.5	97.6
Before and after every use	2.4	1.10	1.7
Not wash udder	0.0	1.4	0.7
Udder drying			
Individual towel	50.60	11.10	30.85
Common towel	2.40	2.20	2.30
Bare hands	42.4	70.0	56.2
Massage with Vaseline	4.70	16.70	10.7
Washing practice			
Warm water	72.3	54.6	68.1
Cold water	27.8	45.5	31.9
Frequency of udder Cloth wash			
Daily	83.8	16.9	50.4
Weekly	8.1	0.0	4.1
Never	8.1	83.1	45.6
Teat dipping after milking			
Yes	4.7	0.0	2.3
No	95.3	100	97.7

n = number of respondents

4.7. Type of Milking Container and Sanitary Practices

Dairy producers across the production systems applied different milking equipment's for collecting milk (Table 20). Among the interviewed respondents (58.9%) used plastic containers for milking and milk storage. Majority (77.1%) of the respondent's cleaned milk utensils immediately after use while 16.6% of dairy farmers cleaned the equipment prior to use but not immediately after use. Majority (80.8%) of the dairy producers in the study areas indicated that they filtered the milk before delivering the milk to milk collection centers by using white cloth and sieve.

Majority (92.6%) of the dairy producers indicated that they purchased milking container from local market while 4.6% and 2.6% homemade and gift from NGOs. The study discovered that about 33.7% of the dairy producers wash milk apparatuses using cold water and soap whereas, the remaining 27.4% cleaned with hot water and soap (Ajax). Few dairy producers' practices (26.3%), was the use of water and leaves of shrubs such as *Pentasschimperiana (Weyinagift), Vernonia amygdalina (Grawa), Ocimum suave (Dama Kessie), Olean Africana (Woira) and Buddleja polystachia (Anfar).*

Majority (74.7%) of the respondents smoked milking utensils prior to cleaning and drying using a few species of *Olean africana (Woira), Clerodendrum myricoides (Missirich), Otostegia integrifolia (Tinjut), Ocimum suave (Dama Kessie)* and *Thymus vulgaris (Tosgne)*. According to the indigenous knowledge of the dairy producers in the studied areas, the practice of smoking the vessel by burning wooden chips of specific trees and shrubs has an advantage of imparting special taste and odour to the product, and to disinfect the vessels, thus reducing the numbers of micro-organisms and there by extending shelf life of the milk products (Table 20).

Table 20. Type of milking container and sanitary practices

Description (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Milking utensils			
Plastic	50.6	66.7	58.9
Metal	49.4	33.3	41.1
Milk filtration			
Yes	92.5	69.0	80.8
No	7.5	31.0	19.3
Filtration type			
White cloth	85.0	75.0	80
Sieve	10	12.5	11.3
Both	5	12.5	8.8
Source of the milk container			
Homemade	9.4	0	4.6
Purchased	85.9	98.9	92.6
Gift	4.7	1.1	2.9
Cleaning methods			
Cold water	8.2	38.9	24.0
Hot water alone	21.2	8.9	14.9
Cold water & soap	31.8	35.6	33.7
Hot water and soap	38.8	16.7	27.4
Cleaning of milking container			
Before & after every use	54.1	98.9	77.1
Before milking	34.1	0	16.6
After milking	11.8	1.1	6.3
Use of leaves for cleaning			
Buddleja polystachia(Anfar)	10.5	3.7	6.5
Olean Africana (Woira)	5.3	3.7	4.3
Ocimum suave(Dama Kessie)	21.1	3.7	10.9
Vernonia amygdalina (Grawa)	10.5	25.9	19.6
Pentasschimperiana (Weyinagift)	52.6	63	58.7
Smoking wood			
Olean Africana (Woira)	75.4	74	74.7
Thymus vulgaris(Tosgne)	2.9	1.3	2.1
Olean Africana (Woira) and Clerodendrum myricoides(Missirich)	11.5	20.8	16.5
Ocimum suave (Dama Kessie)	5.9	0	2.7
Otostegia integrifolia(Tinjut)	4.3	3.9	4.1

4.8. Storage conditions and Shelf Life of Dairy Products

The methods of milk processing and keeping the dairy products before delivering to milk collection centers is shown in Table 21. All of the interviewed dairy producers sold morning milk immediately while on the peri-urban areas, dairy farmer's kept evening milk at room temperature until sold the following morning. Therefore, the survey result showed that farmers used different techniques to preserve fresh milk without clotting, such as cooling by putting the container with milk into a cold-water bath which was practiced by (75.5 %) of the peri-urban and (42.4%) of the urban farmers. Cottage cheese is a soft curd-type cheese made by the churning of buttermilk mainly at the household level. After the cheese was drained sufficiently and became dry enough, spices were added to give a desirable flavor. The spices mainly used were the aerial parts of *Ruta chalepensis (Tena Adam) and Ocimum basilicum (Beso Bila), the rhizomes of Zingiber officinalis (Zigibl), Allium sativum (Netch Shinkurt) and the seeds of Aframomum corrorima (Corerima)*.

Table 21. Preservation for milk, traditional butter and cottage cheese in the study areas (%).

Description (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Storage conditions			
Cooling milk into a cold-water bath	49.5	75.5	62.9
Hanging the container with milk into a cold place	2.5	15.6	9.1
No cooling system	48.0	8.9	28.0
Traditional butter			
Spicing	21.5	75.6	48.6
Cooling in refrigerator	76.5	0.0	38.3
Consumption and selling	2.0	24.4	13.1
Cottage cheese			
Spicing	65.0	60.0	62.5
Cooling in refrigerator	7.0	3.0	5.0
Consumption and selling	28.0	37.0	32.5

n = Number of respondents

4.9. Milk Marketing and Mode of Transportation

The proportion of dairy producers who marketed milk at respective primary outlets and market places is shown in Table 22. About (0.6-45.6%) of the interviewed dairy producers in the study area stated that they sold their milk to dairy cooperative, private milk collection center, cafeteria, and private milk processing plants that process milk and supply to urban consumers through retailers- supermarkets and shops. however, price of fresh milk was highly influenced by different exogenous factors such as location, transport access, marketing system, seasonal variation, processors` demand and sometimes by its` quality. Producers living near the capital city and having a good transport accesses were selling their milk at a relatively good price compared to those living in remote areas. Dairy farmers selling their milk through private collectors received a little bit higher price per liter of milk than those selling their milk to the cooperatives. The result indicated that, there was significant ($p<0.05$) difference between urban and peri-urban farmers (12.45 versus 12.16 Ethiopian Birr (i.e. 0.43 *versus* 0.42 USD). From this study it was noted that various factors affect the price, demand and supply of milk products in the study area. Milk from the area of production was transported by using different transport means. Milk from the producers to the milk collectors transported by using various methods such as people back (96%) and cart or donkey (4.0%), respectively.

Table 22. Milk transporting system, distance to market points and price of milk in the study areas (Mean±SE).

Description (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Price of whole milk per liter (ETB)	12.45±0.09[a]	12.16±0.10[b]	12.31±0.07
Distance travelled to sell milk (Km)			
<1 km	71.8	22.20	46.3
1-5 km	24.7	63.3	44.6
>5-10km	3.5	14.40	9.10
Selling			
Cafeteria	1.20	0.0	0.6
Cooperative	40.0	51.1	45.6
Milk collection center	52.9	37.8	45.4
Processing plant	5.9	11.1	8.5
Transported their milk			
On foot	92.9	98.9	96.0
On cart or donkey	7.1	1.1	4.0

n= number of respondents; a,b=values with different superscripts in a row differ significantly P≤0.05

4.10. Milk Value Chain

According to the results of the present study, milk value chain contains the following major distinctive value point activities from the production of primary raw material until it reaches to the final consumer. These activities include input supply, production, collecting (bulking), wholesaling, processing (hard cheese, Pasteurized Milk (full cream), Pasteurized Milk (skim), Raw Milk, Skim milk, Flavoured yogurt and Yogurt), retailing and consumption. The key actors involved in the milk value chain in the study areas were input suppliers, producers, collectors, whole sellers processors, retailer and consumers (Figure 2).

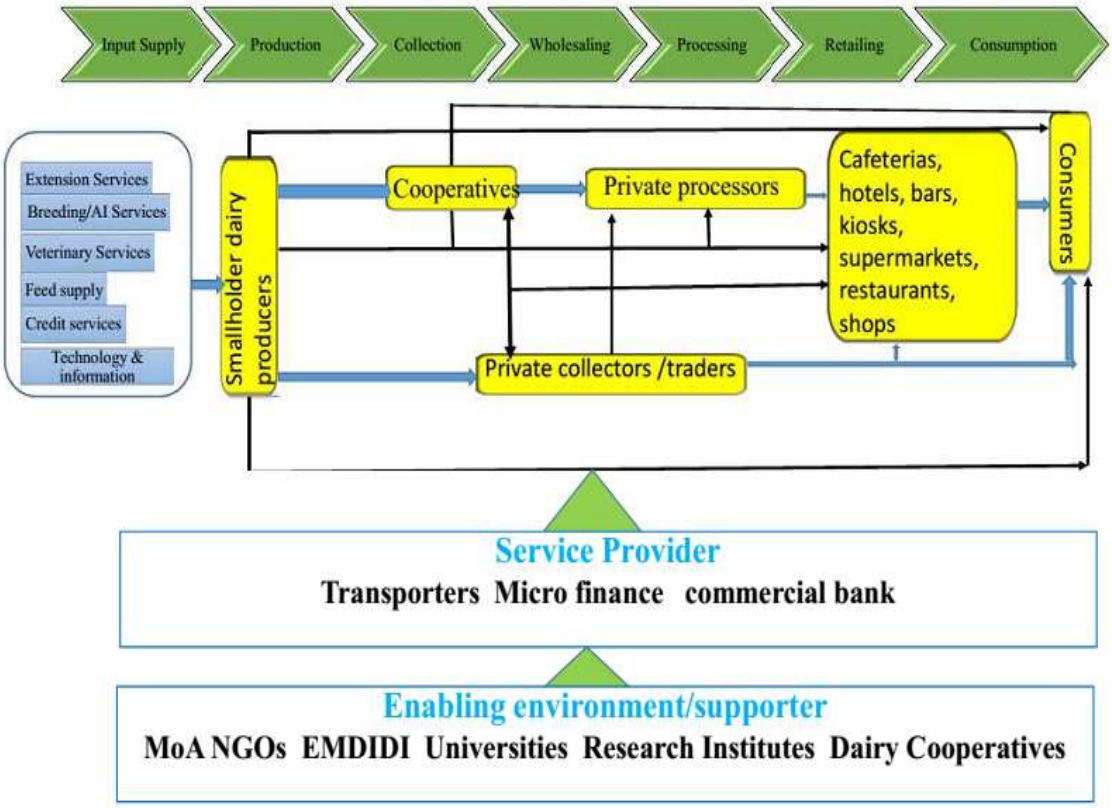

Figure 2.Milk value chain map in the study areas (Prepared by researcher).

4.12. Extension and Training Services to Dairy Development

Majority (91.3%) of the respondents were involved in various agricultural extension services (Table 23). The service was given by in collaboration with governmental and nongovernmental organizations. About 61.2% in urban and 56.7% in peri-urban of dairy cattle owners received training about the general aspects of farm management, proper milking, milk handling, record keeping, heat detection, feeding and dairy cattle health management. Most (49.5%) of the training were prepared by Bureau of agriculture, followed by NGO, cooperatives, private traders, microenterprises and urban agriculture development desks.

4.13.Credit and Veterinary Services in the Study Area

According to the present study, few (26.9%) of the respondents got credit services. Of which (78.2%) of the respondents received credit from local micro-finance, dairy cooperative and commercial bank respectively. The current study revealed that high-interest rates, lack of credit facilities and collateral requirement were the main challenges that farmers were not interested with the credit facilities. Majority (83.4 %) of the respondents in the study areas were had access to veterinary services. However, the services were provided by payment and farmers complain for higher price they pay to treat their sick animals. In the study areas, there was also few private animal health experts that support dairy producers. Since dairy farmers kept less resistant crossbred animals, it is important to confirm that dairy producers had access satisfactory veterinary service. Most (39.3%) of the dairy producers in the study areas devise access to veterinary services within 1-4 km radius and the remaining 37.3% and 23.4 % have access to veterinary services within ≥5 km and <1km radius.

Table 23. Training, extension, credit and veterinary services (%).

Variables (%)	Urban (n=85)	Peri-urban (n=90)	Overall mean (N=175)
Extension services			
Development agents	88.2	94.4	91.3
NGO	11.8	5.6	8.7
Training received	61.2	56.7	58.9
Training prepared by			
Government	72.5	26.0	49.5
NGO	17.6	68.0	42.6
Privet traders	5.9	0.0	3.0
Cooperative	3.9	6.0	5.0
Training			
Proper milking	28.0	90.4	59.8
Milk handling	42.0	1.9	21.6
Record keeping	2.0	0.0	1.0
Milk equipment hygiene	16.0	7.7	11.8
Dairy cows managements	12.0	0.0	5.9
Credit services			
Yes	15.3	37.8	26.9
No	84.7	62.2	73.1
Credit providers			
Commerciale Bank	8.3	2.9	4.3
Cooperatives	33.3	11.8	17.4
Micro finance	58.3	85.3	78.2
Limitation of credit			
High interest rate	77.8	57.1	68.8
Lack of credit	12.5	23.2	17.2
Collateral requirement	9.7	19.6	14.1
Veterinary services			
Government actors	80.0	86.7	83.4
Private actors	20.0	13.3	16.6
Distance to veterinary service			
<1km	22.4	24.4	23.4
1-4 km	34.1	44.4	39.3
≥5 km	43.5	31.1	37.3

n = Number of respondents

4.11. Milk Quality Analyses'

4.11.1. Physico-chemical properties of raw milk

Production systems:- The physicochemical properties of milk samples from different sources showed significant differences ($P<0.05$) in fat%, density%, protein%, added water% as well as ash% between the two production systems. Milk sample obtained from urban areas indicated highest percentage (1.029) of density than peri-urban areas. Milk protein showed significantly difference ($P<0.05$) between urban (3.22±0.297) and peri-urban (3.07±0.301) areas. Conversely, fat and added water was higher in peri-urban milk samples than urban samples. The difference was statistically significant ($P<0.05$).

Effect of season on milk composion:-the results from conducted tests on the milk samples taken during wet and dry season were presented in Table 24. There was a significant difference ($P<0.05$) in fat %, between season with the highest percentage (4.05) in milk samples during dry season. There was also a significant difference ($P<0.05$) in density values between season with the highest percentage (1.029) in milk samples during dry season. There was a significant difference ($P<0.05$) in protein %, between season with the highest percentage (3.19) in milk samples during dry season. Adulteration of milk was higher in wet season (7.01%). Milk total solid % was higher in dry than wet season.

Milk quality at different milk value chain points:- the physico-chemical properties of milk samples from different milk value chain are shown in Table 24. The result indicated that milk value chain had a significant ($P<0.05$) effect on the physico- chemical properties such as density, solid not fat, protein, adultration, ash and total solid %. Pooled milk obtained from farmers, showed higher density (1.028) than that of processing plant (1.025). There was a higher solid non-fat (SNF) values (7.59) of pooled milk obtained from farmers than milk collection centers and processing plants while significantly higher adulteration % was found for milk obtained from processing plant, milk collection centers than farmers. No significant ($P>0.05$) differences were found for fat, freezing point and lactose% between raw milk samples collected from different raw milk value chain points.

Table 24. Physico-chemical characteristics of cow raw milk in the study areas (Mean±SD)

Effect	Fat	S. gravity	Lactose	SNF	Protein	AW	FP	Ash	TS
Areas	*	*	NS	NS	*	*	NS	*	NS
U	3.82±0.88^{b}	1.029±0.005^{a}	3.85±0.43	7.72±0.76^{a}	3.22±0.297^{a}	4.57±7.17^{b}	-0.52±0.14	0.65±0.064^{a}	11.54±1.33
PU	4.04±0.83^{a}	1.027 ±0.003^{b}	3.76±0.46	7.46 ±0.75^{b}	3.07±0.301^{b}	6.93±7.64^{a}	-0.51±0.11	0.63±0.063^{b}	11.50±1.26
Overall	3.93±0.86	1.028±0.004	3.80±0.45	7.59±0.75	3.14±0.30	5.80±7.42	-0.51±0.13	0.64±0.064	11.52±1.30
Season	*	*	NS	NS	*	*	NS	NS	*
Summer	3.81±1.02^{b}	1.027±0.003^{b}	3.79±0.49	7.53±0.82	3.10±0.33^{b}	7.01±8.09^{a}	-0.52±0.06	0.64±0.07	11.34±1.48^{b}
Dry	4.05±0.68^{a}	1.029 ±0.005^{a}	3.81±0.41	7.65 ±0.70	3.19±0.27^{a}	4.65±6.72^{b}	-0.51±0.17	0.65±0.06	11.70±1.06^{a}
Overall	3.93±0.86	1.028±0.004	3.80±0.45	7.59±0.76	3.14±0.30	5.80±7.42	-0.51±0.13	0.65±0.064	11.52±1.30
Value chain									
	NS	*	NS	*	*	*	NS	*	*
MP	3.93±0.87	1.028±0.004^{a}	3.80±0.45	7.59±0.76^{a}	3.14±0.31^{a}	5.80±7.50^{b}	-0.51±0.13	0.64±0.06^{a}	11.52±1.29^{c}
MC	3.807±0.90	1.025±0.004^{ab}	3.54±0.77	7.03±1.24^{b}	2.90±0.42^{b}	11.59±14.35^{a}	-0.48±0.08	0.59±0.01^{b}	10.84±2.03^{a}
MPP	3.72±0.75	1.025±0.004^{b}	3.63±0.67	6.98±1.07^{b}	2.76±0.41^{b}	13.25±12.82^{a}	-0.47±0.08	0.59±0.09^{b}	10.70±1.57^{b}
Overall	3.92±0.86	1.028±0.004	3.78±0.49	7.53±0.81	3.11±0.32	6.46±8.33	-0.51±0.12	0.64±0.07	11.45±1.36

U=urban, PU=Peri-urban, AW =Added water, SNF= solid Non-Fat; FP= Freezing Point, MP=milk producers, MC=milk collectors, MPP=milk processing plants, N = number of samples* = significant at ($P < 0.05$).

4.11.2. Microbiological quality of milk in the study area

According to the present study, production system had no significant ($p>0.05$) effect on total bacterial count and coliform count (CC) log10cfu/ml while production system had a significant ($p<0.05$) effect on somatic cell count (SCC)/ml (Table 25). Significantly higher somatic cell count (SCC)/ml was found for milk obtained from urban than peri-urban. The result shown that the microbial load of dry season milk was significantly ($p<0.05$) higher than wet season milk. Significantly higher total bacterial count (TBC) and coliform count (CC) was found for milk obtained from processing plant than milk collection center and dairy farmers. The SCC collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were 5.68 log10 somatic cell/ml, 5.39 log10 somatic cell/ml and 5.87 log10 somatic cell/ml, respectively.

Table 25. Microbial quality of milk collected from different sources(means ± SD)

Effect	TBC(log10cfu/ml)	CC (log10cfu/ml)	SCC (log10sc/ml)
Areas	NS	NS	*
Urban	7.11±0.86	5.36±0.92	6.17±0.54^{a}
Peri-urban	7.18±0.61	5.40±0.85	5.42±0.43^{b}
Overall	7.15±0.74	5.38±0.89	5.68±0.47
Season	*	NS	NS
Summer	6.78±0.71^{a}	5.46 ± 1.01	5.41±0.88
Dry	7.58 ±0.50^{b}	5.29 ±0.69	5.78±0.42
Overall	7.14±0.62	5.38±0.88	5.68±0.58
Value chain	*	*	NS
MP	7.14±0.74^{a}	5.38 ±0.88^{a}	5.68±0.59
MC	7.43±1.11^{ab}	5.97±1.08^{b}	5.39±0.20
MPP	7.84±0.54^{b}	7.15 ±0.52^{c}	5.87±0.00
Overall	7.47±0.80	6.17±0.83	5.65±0.26

*MP=milk producers, MC=milk collectors, MPP=milk processing plants, * = showed significant difference, SE=Standard error, cfu= colony-forming units; SCC= Somatic cell count, Means with different superscript letters in columns are significantly different, (P < 0.05); TBC=Total Bacterial count; CC =Coliform count, NS means non-significant*

4.11.3. Milk quality parameters correlation coefficients

The overall correlation between the physicochemical components of raw milk sampled from Bebre Berhan milk shed areas are shown in Table 26. Protein content was strongly correlated with ash, SNF, lactose, total solids and density. This correlation appears positive and confirmed that the higher protein values, the higher the other physicochemical components. The fat content of milk was weakly correlated with protein, ash, SNF, lactose, density and total solid. On the other hand added water and freezing point of milk were negatively correlated with SNF, density, protein and lactose. The specific gravity of milk was strongly correlated with protein, ash, SNF, lactose and total solid.

Table 26. Correlation coefficients between different milk quality parameters.

Variable	Fat	Density	lactose	SNF	Protein	Adult	FP	Ash	Total
Fat	1	.114^{NS}	.275**	.318**	.323**	-.341**	-.133*	.322**	.820**
Density		1	.656**	.728**	.702**	-.716**	-.322**	.724**	.512**
Lactose			1	.950**	.705**	-.866**	-.241**	.944**	.747**
SNF				1	.891**	-.950**	-.375**	.999**	.804**
Protein					1	-.900**	-.503**	.897**	.741**
Adult						1	.398**	-.951**	-.788**
FP							1	-.377**	-.310**
Ash								1	.805**
Total									1

*** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed); SNF= Solid Non Fat; FP= Freezing Point; Adult = Adulteration, NS= have not significant difference correlation*

4.12. Raw Milk Marketing Constraints in the Study Area

Based on producers response, low market price (1st), lack of transport (2nd), inadequate market information (3rd), distance of collection center (4th), low quality of milk (5th), and inadequate infrastructure (6th), and labor shortage (7th), lack of access to credit and spoilage of milk during transportation (8th) (Figure 3). The details of other constrains in marketing raw milk were indicated in figure3.

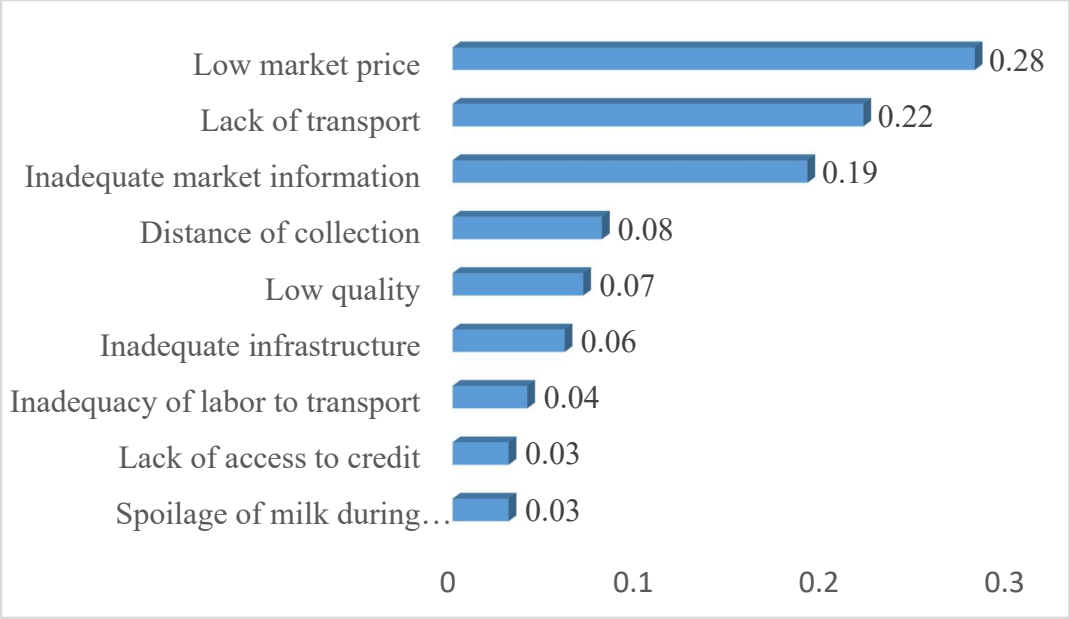

Figure 3. Major constraints of milk marketing (%)

4.13. Prevalence, Risk Factors and Major Bacterial Causes of Bovine Mastitis

In the current study, a total of 510 dairy cows were observed for the occurrence of both clinical and sub clinical mastitis thorough observation and screening by California Mastitis Test (CMT). In mastitis positive cows bacteriological isolation was done. The overall prevalence of mastitis was 72.2 %, out of mastitis cases, 17.3% was clinical and 54.9% subclinical. From a 2040 quarters examined, 55(2.70%) had blind teats. Similarly from the functional 1985 quarters examined, 316 quarters (15.9%) showed clinical mastitis (details in table 27).

Table 27.Prevalence of mastitis in lactating cow

Disease status	Number of animals examined	Number of positive (%)	RH	RF	LH	LF	Total quarter prevalence
Subclinical mastitis	510	280(54.90%)	194	211	202	210	817(41.2%)
Clinical	510	88(17.3%)	81	80	80	75	316(15.9%)
Blind teats	-	-	18	15	10	12	55(2.70%)
Negative (0)	510	142(27.8%)	217	204	218	213	852(41.76%)
Total	510	368(72.2%)	510	510	510	510	2040(100)

RF= Right Front; RH= Right Hind; LF= Left Front; LH= Left Hind

4.13.1. Risk factors associated with the prevalence of clinical mastitis in the study area

The age of cow was significantly associated ($\chi 2$=12.25, P=0.000) with the prevalence of clinical mastitis. Adult cows showed higher odd (OR = 2.38; 95% CI 1.45-3.92] being positive for CMT compared to younger cows. Similarly, breed was significantly associated with mastitis prevalence. Cows with previous clinical mastitis history were 5.26 [OR= 5.26; 95% CI= 3.22-8.59] time more likely to be positive to clinical mastitis. There was a significant (P<0.05) association between parity. There was also a higher mastitis prevalence of in cows having more than ≥4 calves ($\chi 2$=4.42, P=0.035) than in cows having less than 4 calves. In terms of teat lesion, the prevalence of mastitis positive was highest in cows with teat injury ($\chi 2$=78.12, P=0.000).

Based on milk yield, the prevalence of mastitis positive was highest in cows having high liters of milk production than cows producing low liters of milk production. The odds of having mastitis positive was 4.21 times more likely in cows producing high liters of milk than cows producing low liters and medium liters (OR= 4.21[2.10-8.41]). Higher mastitis prevalence was in animals from larger herds (≥21 herd size) with the odds of 3.31 times more likely in large herd size than small and medium herd size. The risk of having CMT is 4.8 times more likely in washed udder than that of not washed (OR= 4.76, CI= 1.7-13.4) (the details of association of different host and environmental factors with mastitis were indicated in table 28 and 29).

Table 28. Association of risk factors for the occurrence of clinical mastitis

Host Factors	Categories	Animal examined	Number Positive (%)	OR[95%CI]	χ2	P-value
Age	Young(≤6)	237	26(11.0)			
	Adult(≥ 7)	273	62(22.7)	2.38[1.45-3.92]	12.25	0.000
Breeds	Local	24	0(0.0)			
	Jersey	20	0(0.0)			
	Cross	466	88 (18.9)	1.12[0.51, 2.45]	10.04	0.007
Previous mastitis history	No	395	43(10.9)			
	Yes	115	45(39.1)	5.26[3.22-8.59]	49.77	0.000
No. parity	1-3 calves	355	53(14.9)			
	≥4 calves	155	35(22.6)	1.66[1.03-2.68]	4.42	0.035
Teat lesion	Absent	449	53(11.8)			
	Present	61	35(57.4)	10.49[5.83-18.88]	78.12	0.000
Milk Yield	Low	173	12(6.9)			
	Medium	182	39(21.4)	3.66[1.84-7.26]		
	High	155	37(23.9)	4.21[2.10-8.41]	19.87	0.000
Lactation stage	Early	132	26(19.7)			
	Mid	121	28(23.1)	1.23[0.67-2.24]		
	Late	257	38(13.2)	0.62[0.35-1.09]	6.40	0.057
Body condition	Poor	39	9(23.1)			
	Good	294	58(19.7)	0.82[0.37-1.82]		
	Moderate	177	21(11.9)	0.449[0.187-1.07]	5.79	0.072
Herd size	Small	243	23(9.5)			
	Medium	127	29(22.8)	2.83[1.56-5.14]		
	Large	140	36(25.7)	3.31[1.87-5.87]	21.38	0.000

CI=Confidence interval,OR= Odds ratio, χ2=Chi-square. $p<0.05$=Significant

Table 29. Association between clinical mastitis and environmental factors

Host Factors	Categories	Animal examined	Number Positives (%)	OR[95%CI]	χ2	P-value
Udder Washing	No	82	4(4.9)			
	Yes	428	84(19.6)	4.8[1.7-13.4]	10.48	0.001
Towel usage	No	297	47(15.8)			
	Yes	213	41(19.2)	0.79[0.5-1.25]	1.02	0.31
Udder drying	No	238	36(15.1)			
	Yes	272	52(19.1)	0.75[0.47-1.20]	1.42	0.23
Milking mastitis cow at the end	No	194	21(10.8)			
	Yes	316	67(21.2)	0.65[0.40-1.06]	2.97	0.085
Type of farm	Extensive	80	9(11.2)			
	Semi-intensive	95	29(30.5%)	2.5[1.47-4.26]		
	Intensive	335	50(14.9%)	0.72[0.34-1.54]	15.01	0.001

CI=Confidence interval, OR= Odds ratio, χ2=Chi-square. p<0.05=Significant

4.13.2. Associations of risk factors with the prevalence of subclinical mastitis

4.13.2.1. Host risk factors with the prevalence of subclinical mastitis

Age, breed, milk yield, lactation stage, teat lesion and herd size were statistically tested (P <0.05) on the prevalence of subclinical mastitis. Age of animal was significantly associated (P=<0.05) with the prevalence of sub clinical mastitis. The condition was 1.43 times less likely (OR: 1.43[1.02-2.05]) to be detected in young cows (50.20%) as compared to adult cows (59.0%). Breed difference also plays a vital role in the prevalence of sub-clinical mastitis with the highest prevalence of subclinical mastitis was observed in Holstein Friesian cross (55.8%) followed by Jersey (60%) and Indigenous zebu breed (33.33%). Regarding milk yield, the highest prevalence of subclinical mastitis was observed that milk production of more than 15 liters was (65.8%) and (50.0%) in 7 -15 liters and <7 liters was (50.3%) though the difference was statistically significant. The odds of having SCM was 2 times more likely in cows producing more than 15 liters of milk than cows producing less than 7 liters (OR= 1.90, CI= 1.22-2.97). According to the lactation stage, the highest prevalence of subclinical mastitis was recorded in late (48.6%), mid (54.5%) and early (67.4%) lactation stage. Stages of lactation was significantly associated (P=0.000) with the prevalence of sub-mastitis. Regarding body condition, the prevalence of sub-clinical mastitis was high in poor body condition (64.1%) followed by moderate body condition (53.7%) and good body condition (54.4%). While, both of them were no statistically significant (P<0.05). (Details in Table 30).

Table 30. Association between the occurrence of subclinical mastitis and risk factors

Host Factors		Animal examined	Mastitis Positive (%)	95%CI	OR	P-value
Breed	Local cows	24	8(33.33)			
	Cross breeds	466	260(55.8)	1.09-6.01	2.59	0.037
	Jersey	20	12(60.0)	0.87-10.30	3.0	0.081
Age	Young(≤6)	237	119(50.2)			
	Adult(≥7)	273	161(59.0)	1.0-2.02	1.43	0.048
No. parity	1-3 calves	355	187(52.7)			
	≥4 calves	155	93(60.0)	0.92-2.1.98	1.35	0.127
Lactation stage	Late	257	125(48.6)			
	Mid	121	66(54.5)	0.82-1.955	1.267	0.284
	Early	132	89(67.4)	1.41-3.389	2.19	0.000
Previous mastitis history	Yes	115	57(49.6)			
	No	395	223(56.5)	0.87-2.0	1.32	0.192
Teat lesion	Present	61	21(34.4)			
	Absent	449	260(57.7)	1.9-5.20	3.14	0.000
Milk Yield	Low	173	87(50.3)			
	Medium	182	91(50.0)	0.65-1.50	0.989	0.957
	High	155	102(65.8)	1.22-2.97	1.90	0.005
Body condition	Poor	39	25(64.1)			
	Moderate	177	95(53.7)	0.32-1.33	0.65	0.237
	Good	294	160(54.4)	0.33-1.34	0.67	0.255
Herd size	Small	243	121(49.8)			
	Medium	127	83(65.4)	1.22-2.96	1.90	0.005
	Large	140	76(54.3)	0.789-1.82	1.20	0.487

OR= Odds ratio, P<0.05= statistically significant

2.13.2.2. Environmental risk factors with the prevalence of subclinical mastitis

In the present study, the prevalence of subclinical mastitis related to washed udder before milking the cow also contributes a significant role for the highest prevalence of subclinical mastitis (59.58%) than that of not washed (31.7%).The risk of acquiring subclinical mastitis was 3.14 times more likely in washed udder than no washed udder(OR=3.14, CI= 1.9-5.2). The prevalence of subclinical mastitis related to towel usage showed that cows whose udder was washed and dried their teat with towel had high subclinical mastitis prevalence (55.9%) than that of not dried by a towel (54.2%). There was also more likelihood occurrence of poor farm hygiene when compared to regularly cleaned farm. The risk of having SCM is 1.67time more likely in poor farm hygiene than good farm hygiene (OR= 1.67, CI= 1.18-2.39).

Table 31. Association between subclinical mastitis and environmental factors

Host Factors		Animal examined	Mastitis Positive (%)	95%CI	OR	P-value
Farm location	Urban	247	155(62.8)	0.38-0.77	0.54	0.001
	Peri-urban	263	125(47.5)			
Type of farm	Extensive	80	30(37.5)			
	Semi-intensive	95	40(42.1)	0.66-2.23	1.2	0.54
	Intensive	335	210(62.7)	1.7-4.6	2.8	0.000
Udder Washing	No	82	26(31.7)			
	Yes	428	254(59.3)	1.9-5.2	3.14	0.000
Udder Drying	Yes	272	148(54.4)			
	No	238	132(55.5)	0.74-1.48	0.94	0.710
Towel Usage	Yes	213	119(55.9)			
	No	297	161(54.2)	0.66-1.33	0.94	0.710
Milking mastitic cow last	Yes	316	154(48.7)			
	No	194	126(64.9)	0.35-0.74	0.51	0.000
Farm hygiene	Good	276	136(49.3)			
	Bad	234	144(61.5)	1.18-2.39	1.67	0.004

OR= Odds ratio, P<0.05= statistically significant, CI=Confidence interval.

4.13.3. Analyses of multivariable logistic regression for subclinical mastitis

The risk factors with p-value ≤0.25 in the univariate logistic regression model were included in the separate multivariable logistic regression model. Breed, age, teat lesion, lactation stage, milk yield, herd size, farm hygiene, farm type, farm location and udder washing were included in the final logistic regression model. All variables with p-value<0.25 in the initial univariable analysis were checked for multicollinearity statistics test. Breed, age, farm type, stage of lactation, teat lesion, farm hygiene, udder washing and milking mastitic cows at the end were found to be statistically significant (P<0.05) with the occurrence of subclinical mastitis in lactating dairy cows.

Table 32. Multivariable logistic regression analyses identifying the association of risk of subclinical

Host Factors	Category	OR	95% CI for OR	P-value
Breed	Local Zebu	Ref		
	Cross breeds	3.11	1.19-8.13	0.021
	Jersey	3.6	0.91-14.19	0.068
Age	Young(≤6)	Ref		
	Adult(≥7)	2.06	1.34-3.18	0.001
Type of farm	Intensive	Ref		
	Semi-intensive	0.40	0.23-0.70	0.001
	Extensive	0.41	0.19-0.89	0.024
Herd size	<10			
	10-20	1.66	0.95-2.91	0.078
	≥21	1.31	0.69-2.51	0.410
Stage of lactation	Early			
	Mid	0.50	0.27-0.91	0.023
	Late	0.37	0.21-0.64	<0.001
Farm hygiene	Good	Ref		
	Bad	1.86	1.19-2.90	0.006
Teat lesion	Present	Ref		
	Absent	3.77	1.98-7.18	<0.001
Udder washing	No	Ref		
	Yes	0.32	0.18-0.58	<0.001
Milking mastitic cow last	Yes	Ref		
	No	2.0	1.18-3.40	0.010

OR= Odds ratio, P<0.05= statistically significant, Ref=reference

4.13.4. Microbiological Culture isolation

All milk samples from clinical mastitis and CMT positive were found positive for different Bacterial species. A total of 150 milk samples from 368 CMT positive cows tested were Cultured for bacterial isolation. Both contagious pathogens (*Staphylococcus* species, *Streptococcus*) and environmental pathogens (*E.coli*) were isolated. Among the bacteria isolated with high prevalence were staphylococcus species (57.3%), streptococcus species (24.0%) and *Escherichia coli* (8.0%) respectively. The rates of isolation of various bacterial species were shown in Table 33.

Table 33. Frequency distribution of isolated bacteria from mastitic dairy cows

Bacterial Isolates	Frequency	Prevalence (%)
Staphylococcus species	86	57.3
Streptococcus species	36	24.0
Escherichia coli	12	8.0
Mixed growth	13	8.7
Negative	3	2.0
Total	150	100

4.14. Prevalence of Lameness in the Study Areas

The current result revealed that the prevalence and major causes of lameness in lactating dairy cows were surveyed. Out of 510 observed lactating dairy cows 10(1.96%) were slightly lame, (locomotion scoring = 2), 33(6.5%) moderate lameness (locomotion scoring =3), 9 (1.8%) were lame (locomotion scoring = 4) and 5(1.0%) presented with severe lameness (locomotion scoring =5), respectively. Thus locomotion scoring systems revealed that 57 cows were observed as having locomotion scoring ≥ 2, and fourteen seven (47) of them were recorded as cows with locomotion scoring ≥ 3 in the dairy farms stayed. The overall cow level occurrence of lameness was found to be 9.2%. The risk factors for the prevalence of lameness at the cow level were production systems, length of cow track in

meter, floor type and hoof trimming practices. The details of the hypothesized variables and association with lameness were indicated in Table 34.

Table 34. Associations of lameness with animal risk factors

Variables		Number of animals examined	Number (%) positive animals	χ^2	p-value
Production	Urban	247	40(16.2%)	27.88	0.000
	Peri-urban	263	7(2.7)		
Breeds	Cross	466	45(9.7%)	2.56	0.280
	Jersey	20	2(10.0%)		
	Local	24	0(0.0%)		
Parity	1-3 calves	355	34(9.6%)	0.183	0.669
	≥4 calves	155	13(8.4%)		
Herd size	Small	243	16 (6.6%)	4.12	0.127
	Medium	127	16(12.6%)		
	Large	140	15(10.7%)		
Length of cow track in meter	None	265	17(6.4%)	8.41	0.015
	1 to 4 meters	174	25(14.4%)		
	>4 meters	71	5(7.0%)		
Barn Cleaning	>=3 times/days	59	8(13.6%)	1.51	0.220
	1-2 times/days	451	39(8.6%)		
Hoof trimmings	Yes	348	21(6.0%)	13.25	0.000
	No	167	26(16.0%)		
Age	Young (≤6)	237	17(7.2%)	2.21	0.137
	Old (≥7)	273	30(17.1%)		
Floor-type	Bad concrete	233	38(16.3%)	25.80	0.000
	Good concrete	277	9(3.2%)		

χ2=Chi-square. $p<0.05$=Significant

4.14.1. Effect of lameness on milk yield of lactating cows

The results indicating the effect of lameness on milk production was presented in Table 35. The result indicated that after the onset of lameness showing that lameness has affected a mean loss in milk yield of 1.77 liter per cow per day. The average daily milk yield of 47 dairy cows was recorded based on the information obtained from dairy producers and farm

records. There was a significant reduction of daily milk yield of milking cows after the onset of lameness ($p<0.05$).

Table 35. Effect of lameness on average daily milk production per cow

Milk yield (liters)	Coefficients	p-value	95% CI
Lameness	-1.77	0.024	-3.30- 0.23
Constant	10.83	0.000	8.40 -13.25

4.14.2. Major lesion encountered and limbs problems on individual lactating cow level

The results indicated that the major lesion encountered and limbs problems on individual lactating cow's level are presented in Table 36. The results revealed that about 33.3 % (16/47) of the dairy cows had locomotion scoring greater than or equal to three, which is the foot and limb difficulties were observed in hind limbs only and followed by foot and limb difficulties were observed in forelimbs and both limbs respectively. The study further indicate that a total of 47 lesion encountered and limbs difficulties were observed and of which about 8.3% (4/47) were foot rot problems followed by 22.9(11/47) sole abscesses and hemorrhages, 10.4 (5/47) heel and sole cracks, 48.9 (23/47) were excessive hoof growth, 4.2 (2/47) were swollen joints and abscesses and 4.2 (2/47) were wounds on their limbs associated with trauma respectively.

Table 36. Major lesion encountered and limb problems in milking cows.

Types of lesion	Frequencies	Percentage	Limb affected
Foot rot	4	8.5	Forefeet
Excessive hoof growth	23	48.9	Both feet
Heel and sole cracks	5	10.6	Rear feet
Sole abscesses and hemorrhages	11	23.4	Rear feet
Swollen joints and abscesses	2	4.3	Both feet
Traumatic Injury	2	4.3	Both feet
Total	47	100	

4.15. Seroprevalence of Brucellosis in the Study Area

A total of 744 animals, 49(6.6%) male and 695(93.4%) female animals above 6 months and 2years of age were sampled and tested for Brucella antibodies. Of the total 744 animals tested with RBPT, 11 were positive for brucellosis with seroprevalence of 1.5%. Of which 11 animals tested positive by RBPT, 9 animals were confirmed positive by CFT, giving seroprevalence of 1.21 % with a combined test of result of RBPT and CFT.

4.15.1. Association of risk factors with seropositivity on individual animal level

There was no significant differences between urban and peri-urban and farm types (P>0.05). However, a relatively higher proportion of seropositivity was observed in peri-urban and intensive farm types (0.8%) and (0.81%) respectively when compared to urban, extensive and semi-intensive systems. The occurrence of brucellosis was significantly higher in animals (1.1%) having age greater than 6years (P = 0.009), whereas, no animal less than 3 years old was found to be sero reactive. Higher Brucella seropositivity was observed in crossbreeds than local breeds and Jersey (P = 0.044) respectively. Regarding parity, the prevalence of brucellosis was higher in those cattle with multiparous.

The prevalence of bovine brucellosis was statistically significant higher between herd sizes of the studied animals (P = 0.034), herd size greater than 10 more likely to be infected with Brucella organisms than those with herd size less than <10 animals. All seropositive animals were females and were either pregnant or lactating. Among 695 female animals, 52(0.7%) showed a history of abortion and 34(0.7%) with a history of retained fetal membrane. The seroprevalence of brucellosis were significantly associated with cows with a history of abortion and cows with a history of retained fetal membrane (Table 37).

Table 38. Association of risk factors with brucellosis seropositivity at the individual animal level.

Risk factors	No. Tested	RBPT positive No. (%)	RBPT+CFT positive No. (%)	Fisher's exact test p-value
Areas				0.741
Urban	314	3(0.4)	3(0.4)	
Peri-urban	430	8(1.1)	6(0.8)	
Farm types				0.696
Intensive	413	6(0.81)	6(0.81)	
Semi-intensive	256	3(0.4)	2(0.3)	
Extensive	75	2(0.3)	1(0.13)	
Age				0.009
<3 years	100	0(0)	0(0)	
3-6 years	307	1(0.13)	1(0.13)	
>6years	337	10(1.34)	8(1.1)	
Sex				1.00
Female	695	11(1.5)	9(1.21)	
Male	49	0(0)	0(0)	
Breed				0.044
Cross	685	8(1.1)	7(0.94)	
Local	48	2(0.3)	1(0.13)	
Jersey	11	1(0.13)	1(0.13)	
Herd size				0.034
Small	449	3(0.4)	2(0.30)	
Medium	137	4(0.54)	3(0.4)	
Large	158	4(0.54)	4(0.54)	
Mating system				0.118
Non serviced	41	0(0)	0(0)	
Natural	418	8(1.2)	6(0.9)	
AI	202	1(0.14)	1(0.14)	
Both	34	2(0.3)	2(0.3)	
Parity				0.138
Null parous	73	0(0)	0(0)	
Mono parous	178	0(0)	0(0)	
Multiparous	444	11(1.6)	9(1.3)	
Abortion				0.000
Absent	643	6(0.9)	4(0.6)	
Present	52	5(0.7)	5(0.7)	
RFM				0.000
Absent	661	4(0.6)	4(0.6)	
Present	34	7(1.0)	5(0.7)	

RBPT= Rose Bengal Plate Test; CFT= Complement Fixation Test

4.15.2. Univariable logistic regression analysis of the variables associated with animal level sero-positivity

The results pertaining that the association of interpreter variable and Brucella seropositivity by univariable analysis are presented in Table 38.The results indicate that the highest seroprevalence was observed for animals in herd size greater than >20 of (0.54%) than animals found in herd size less than <10 and between 11-20 animals respectively. There was a significant association ($p<0.05$) between herd size with the odds of seropositivity being at least 6 times more likely to be infected with Brucella organisms. The results indicate that the odds for Jersey breeds were 9.69 times at high risk of infection compared to cross breeds and local breeds respectively.

Age showed statistically significant associations ($P<0.05$) with seropositivity of brucellosis. The odds of ages >6years were 8.08 at high risk of an infection with seropositivity of brucellosis. Similarly, animals with history of abortion and retention of placental were found to be significantly associated with seropositivity. The prevalence of brucellosis was significantly ($p=0.000$) higher (0.7%) in dairy animals with a history of abortion with 17.00 times more likely to be seropositive than dairy animals with no history of abortion. The prevalence of Brucella seropositivity significantly higher 5(0.7%) in animals having a history of retention of placenta with 28.32 times more likely to be seropositive than dairy animals with no history of placenta retention. The details of the association with seropositivity were indicated in Table 38.

Table 39. Univariable logistic regression analysis based on the individual animal level seroprevalence of brucellosis and associated risk factors.

Risk factors	No. Tested	RBPT+CFT positive (%)	95%CI	OR	P-value
Areas					
Urban	314	3(0.4)			
Peri-urban	430	6(0.81)	0.36-5.91	1.47	0.59
Farm types					
Intensive	413	6(0.81)			
Semi-intensive	256	2(0.3)	0.107- 2.67	0.53	0.445
Extensive	75	1(0.13)	0.109- 7.72	0.92	0.936
Age					
<3 years	100	0(0)			
3-6 years	307	1(0.13)			
>6years	337	8(1.1)	1.09-59.81	8.08	0.041
Breed					
Cross	685	7(0.94)			
Local	48	1(0.13)	0.25- 17.10	2.06	0.503
Jersey	11	1(0.13)	1.09-86.23	9.69	0.042
Herd size					
Small	449	2(0.30)			
Medium	137	3(0.4)	0.82-30.26	5.0	0.079
Large	158	4(0.54)	1.08-32.01	5.95	0.043
Abortion (n=695)					
Absent	643	4(0.6)			
Present	52	5(0.7)	4.42-65.41	16.995	0.000
RFM (n=695)					
Absent	661	4(0.6)			
Present	34	5(0.7)	7.22-111.04	28.32	0.000

RBPT= Rose Bengal Plate Test; CFT= Complement Fixation Test; OR= odds ratio

4.15.3. Brucella seropositivity at Herd-level risk factors analysis

The results pertaining that out of 145 herds studied, 9 (6.2%) were positive using combined RBPT and CFT result. The prevalence of Brucella seropositivity analysis revealed that herds with a history of retention of placenta and abortion were found to be strongly associated with seropositivity to Brucellosis ($p < 0.05$). Herds with the previous history of abortion and placenta retention showed 23 and 11times more likely to be seropositive to

Brucellosis than those herds with no history of abortion and placenta retention (p = 0.004) and (p = 0.002) respectively. The odds of large herd sizes were 45.6 times at higher risk (P=0.001) than small and medium herd sizes. There was no significant association (P>0.05) between urban and peri-urban production systems (Table 39).

Table 40. Univariable logistic regression analysis based on herd-level seroprevalence of brucellosis and associated risk factors

Risk factors	No. Tested	RBPT+CFT positive (%)	95%CI	OR	P-value
Farm location					
Urban	67	3(2.1%)			
Peri-urban	78	6(4.1%)	0.34-6.36	1.46	0.613
Herd size					
Small	117	2(1.4%)			
Medium	20	3(2.1%)	1.48-60.84	9.50	0.017
Large	8	4(2.8)	6.69-310.77	45.6	0.000
Abortion					
Absent	106	2(1.4%)			
Present	39	7(4.8%)	2.72-193.73	22.97	0.004
RFM					
Absent	122	4(2.8%)			
Present	23	5(3.4%)	2.42-50.12	11.02	0.002

RBPT= Rose Bengal Plate Test; CFT= Complement Fixation Test; OR= odds ratio

4.15.4. Analyses of multivariable logistic regression for Brucella seropositivity

The results from Table 40 indicated that the risk factors with p-value ≤0.25 in the univariate logistic regression model were included in the distinct multivariable logistic regression model. Age, breeds, herd size and history of abortion were included in the final logistic regression model. However, breed, herd size and history of abortion were significantly associated with Brucella seropositivity. In this case, retention of fetal membrane was not included in the final multivariable regression because of their multicollinearity with abortion. As a result the final multivariable logistic regression analysis shows that animals with a history of abortion are 10 times more likely to be seropositive to Brucellosis (OR= 10[2.53-42.42).

Table 41. Multivariable logistic regression analyses identifying the association of potential risk factors to Brucella seropositivity in cattle.

Variable	Level	Odds Ratio	[95% Conf. Interval]	P-value
Age	<3 years			
	3-6 years			
	>6years	8.07	0.98-66.57	0.05
Breed	Cross	1		
	Local	3.04	0.27-34.74	0.37
	Jersey	27.26	1.75-424.28	0.018
Herd size	Small	1		
	Medium	5.88	0.81-42.73	0.08
	Large	10.01	1.30-77.50	0.027
Abortion history	Absent	1		
	Present	10.36	2.53-42.42	0.001

OR= odds ratio , 1=referring

4.15.5. The occurrence of reproductive problems on dairy cattle

The results indicating the occurrence of reproductive problems dairy cattle are presented in Table 42. The results indicate that repeat breeding followed by anoestrus, retention of placenta after birth, uterine prolapsed, and abortion, dystocia, stillbirth and 2.1% testicular swelling are reported to be major reproductive problems affecting the dairy cattle.

Table 43. The occurrence of Reproductive Problems of dairy cattle

Variables	Urban (n=67)	Peri-urban (n=78)	Overall mean (N=145)
Repeat breeding (%)			
yes	62.7	46.2	53.8
No	37.3	53.8	46.2
Anoestrus (%)			
yes	7.5	34.6	22.1
No	92.5	65.4	77.9
Abortion (%)			
yes	7.5	34.6	24.1
No	92.5	65.4	75.9
Dystocia (%)			
yes	34.3	14.1	23.4
No	65.7	85.9	76.6
Still birth (%)			
yes	14.9	10.3	12.4
No	85.1	89.7	87.6
Testicular swelling (%)			
yes	0	3.8	2.1
No	100	96.2	97.9
Uterine or vaginal prolapsed (%)			
yes	17.9	12.8	15.2
No	82.1	87.2	84.8
Retention of placenta after birth (%)			
yes	35.8	3.8	18.6
No	64.2	96.2	81.4

n= Number of observations

4.15.6. Occupational risk and awareness among dairy cattle farmers about brucellosis

Most of the respondents (93.1%) had no knowledge of the cause of abortion in dairy cattle and 95.9% of them had not isolated the aborted animals from others (Table 42). The result indicated that the majority (92.4%) of respondents in the study areas were not aware of bovine brucellosis. Half of the respondents disposed of retention of fetal membrane and dead fetus/after birth to open dump or thrown on the field in the environment followed by water canal or rivers, burning/burying and few respondents fed aborted materials to dogs respectively. Most of the respondents (71.6%) in urban areas and 48.7% of respondents in peri-urban areas practiced assisted parturition, of which only a few (6.9%) of them use a protective glove. Few numbers of the respondents in the study area consume raw milk. More than 87.6% percent of respondents in urban and peri-urban areas consume raw meat.

Table 44. Knowledge-attitudes and practices of farmworkers about Brucella infection in the study area.

Variables	Urban (n=67)	Peri-urban (n=78)	Overall mean (N=145)
Isolation of aborted animal from others			
Yes	7.5	1.3	4.1
No	92.5	98.7	95.9
Perception of the cause of abortion			
Yes	7.5	6.4	6.9
No	92.5	93.6	93.1
Awareness about brucellosis			
Yes	9.0	6.4	7.6
No	91.0	93.6	92.4
Raw milk consumption			
Yes	32.8	6.4	18.6
No	67.2	93.6	81.4
Raw meat consumption			
Yes	82.1	92.3	87.6
No	17.9	7.7	12.4
RFM and Dead fetus/After birth disposal			
Water canal	23.9	46.2	35.9
Burning/Burying	1.5	7.7	4.8
Thrown on field or Open dump	68.7	41.0	53.8
Give to dog	6.0	5.1	5.5
Assisted parturition			
Yes	71.6	48.7	59.3
No	28.4	51.3	40.7
Using protective glove during assisting			
Yes	10.4	3.8	6.9
No	89.6	96.2	93.1

The results of Table 43 indicate that both Natural and artificial insemination (AI) breeding system were common practices of breeding in the study area. The study further indicates that 59.7% of the respondents in urban and 74.4% of the respondents in peri-urban areas were raised their own replacement animals. The practices of the provision of separate pens for parturition were 100% in urban and 96.2 % in peri-urban dairy producers and majority of the respondents in the study areas were used flushing with water to clean their animals pens after parturition. Decrease in milk production due to age and reproductive problems

were prominent culling criteria in all farms. The majority (64.2%) of the respondents in the urban and 48.3% in peri-urban areas were used separate feed and water supply for each animal.

Table 45. Characteristics of dairy farms in the study area (%)

Variables	**Urban (n=67)**	**Peri-urban (n=78)**	**Overall mean (N=145)**
Service type (%)			
Natural	28.4	42.3	35.9
AI	28.4	23.1	25.5
Both	43.3	34.6	38.6
Replacement stock (%)			
Raised own	59.7	74.4	67.7
Purchased	3.0	1.3	2.1
Both	37.3	24.4	30.3
Parturition pen (%)			
Yes	0.0	3.8	2.1
No	100	96.2	97.9
Cleaning of calving pen (%)			
Flushing with water	98.5	15.4	53.8
Disinfect with detergent	1.5	5.1	3.4
No sanitation service	0.0	79.5	42.8
Culling criteria (%)			
Reproductive problem	21.7	36.0	26.8
Feed shortage	6.5	12.0	8.5
Decrease milk production	71.7	52.0	64.8
Feed and water supply (%)			
Own	64.2	34.6	48.3
Communal	22.4	9.0	15.2
Both	13.4	56.4	36.6

5. DISCUSSION

5.1. Socio-Economic Characteristics of Households

5.1.1. Demographic characteristics of the households

Most of dairy farms in the study areas were headed by male, which is similar with the findings of Husse *et al*. (2016) in Jimma Zone, Diriba *et al*. (2014) in Bako and Nekemte areas, Wondatir *et al.* (2011), Abebe *et al*. (2017) and Tahir *et al*. (2018) in Debre Berhan, Jimma and Sebeta areas. Moreover, it is in line with the report of CSA and World Bank (2013), which generally reflects the national profile. The martial status (88.0%) of household heads are comparable with report of Tsega *et al*. (2014) and Mekete (2018) in Debre Berhan areas. The overall mean age of household heads for the study areas was comparable with the report of Diriba *et al*. (2014) in Nekemte and Bako areas. The ages of most interviewed respondents in the current study were within the productive age category.

The educational status of the current finding was in agreement with the reports of Dereje and Yoseph (2016) and Abebe *et al*. (2017), who reported 6.58% of dairy farmers were first degree holders. When farmers have a higher educational level it helps for a better understanding of easy adoption of new dairy technologies and better dairy management (Gizaw *et al*., 2012; Lemma *et al*., 2012).

The family size (5.9 persons) of dairy farmers in the study area was higher than the national average of (5.14 persons) reported by CSA (2016). On the other hand, it is similar with the reports of Mekete (2018) and Abebe *et al*. (2017) in similar study area. In contrast, it was lower than the value (6.4 persons) reported by Admasu *et al*. (2017) in Wolayita Zone of Southern Ethiopia. Generally, the overall average family size in the present study was still much higher compared to the average family size for both the Amhara Region (4.62) and the North Shewa Zone (4.45), where the study site is located (CSA, 2016). Larger family

size might be an opportunity in the day to day labor of different routine activities such as feeding, herding, cleaning, milking and milk processing on a dairy farm.

5.1.2. Occupational status and land holding per households in the study area

The current study revealed that the involvement of farmers in dairy production in the current study (80%) was higher than reported by Kiros *et al*.(2018a) in urban and peri-urban areas of central highlands of Ethiopia and the value (13.7%) reported by Dereje and Yoseph (2016) in Sebeta Awsa areas. Similarly, Girma *et al*. (2014) reported that about 29.2% of interviewed dairy farmers in Shashamane were involved in dairy production. This implies that the increasing demand for dairy production.

In the present study the oveall average land size was higher than the average holding (0.95, 1.08 and 1.20 ha) reported by CSA (2016) for national, Amhara Region and the north Shewa Zone respectively. While, the current finding is similar to (1.4 ha) reported by Tahir *et al*. (2018) in North Shewa Zone. However, the result was lower than the national average value (1.60 ha) reported by FAO (2008) and (2.6 ha) reported by Asaminew and Eyassu (2009) in Bahir Dar Zuria and Mecha district respectively. The difference was probably due to increased competition on lands as populations increased which may increase demand for alternative uses such as crop cultivation and construction works due to urbanization.

5.1.3. Livestock holding per households in the study area

The present study revealed that most of the dairy farmers kept crossbreed animals than local animals which implies that crossbreed animals are paying a significant role for farmers' economy. The average cattle holding (7.97) in the present study was much lower than the value (8 cattle) reported by Negussie (2006) in Mekelle area. The difference in cattle holding might be associated with the availability of land for grazing and feed production. The average crossbred dairy herd per households was (6.54) heads which is similar to (5.1) reported in the Central Highland of Ethiopia (Abebe *et al*., 2017). Higher

numbers of crossbred cows/households were reported (5.4-11) from Sebeta, Bahir Dar and Hawassa areas (Ayenew *et al*., 2011; Haile *et al*., 2012 and Dereje and Yoseph, 2014). In this study, the dairy farmers own higher numbers of crossbred dairy cows than local breed ones.

5.1.4. Major income sources of households in the study area

Majority (39%), of the interviewed households in the study areas generating their income from dairy production, which agreed the reports of Asrat *et al*. (2013); Abebe *et al*. (2014); Dessalegn (2017); Abebe *et al*. (2017) and Kiros *et al*. (2018a) in central and southern parts of Ethiopia indicated that dairying on average contributed about 20-50% to the total income of the farmers. The differences in contribution of dairying to the total income of the farmers from place to place are due to differences in cattle herd size, income from other sources, land size, productivity of cow and milk market outlets (Asrat *et al.,* 2013; Abebe *et al*., 2017).

5.1.5. Experience in dairy production, source of crossbred dairy cows and farmers involved in the dairy cooperatives

The average farming experience in the present study shows similarity with the findings of Kiros *et al*. (2018a) in peri-urban areas of Assela (40%) and urban areas of Sululta (45%), respectively, have dairy rearing experiences of 4-7 years. Solomon (2014) also reported that (41.7%) of dairy farms in Mekelle city, have dairy rearing experiences of 6-10 years. In Bangladesh, the majorities of the dairy producers had 10 to 19 years of experiences in dairy farming and most of the highly experienced farmers reared crossbred cattle (Quddus, 2017).

The current study revealed that most of the respondents (68%) and (49%) in urban and peri-urban areas, the source of their crossbred dairy cows were purchased from the local market. Similar observations were made by Kiros *et al.* (2018b) in urban and peri-urban

areas of Sululta and Assela about 95% and 100% of respondents purchased their crossbreed animals from the local market. In agreement with the present finding, Dessalegn (2017) reported that most of the smallholders started the dairying by purchased the crossbred cattle from local markets.

The result from the present study was in agreement with Abebe *et al.* (2017), who reported (40.0%) of farmers in Debre Berhan milk sheds were involved in dairy cooperative. In agreement with the present finding, Mekete (2018) reported that dairy farmers who are members of the cooperatives are benefited from easy access to the milk market and/or farm input supplies, which would otherwise be difficult at the individual farmer level. In this regard, 87% of the sampled dairy farmers in the study area were motivated to join dairy cooperatives due to the regular fresh milk market, and supply of farm inputs and availability of regular milk market. These observations are similar to those reported by Abebe *et al. (*2017) (52.9 and 47%) dairy farmers were motivated to join dairy cooperatives due to the regular fresh milk marketing. In agreement with the present finding, Abebe *et al. (*2017) reported that dairy producers across the study sites got information about the cooperatives from previous members and cooperative offices prior to joining.

5.1.6. Purpose of keeping dairy cattle in the study area

The present study revealed that the primary reason for keeping cross breed dairy cattle was for generating additional sources of income from the sale of milk. In agreement to the current study, Sintayehu *et al*. (2008) and Belay and Geert (2016) reported that dairy farmers found in Shashemene –Dila and Jimma towns, the primary reason for keeping dairy cattle was the milk production for income generation. Similarly, the purpose of keeping cross breed dairy cattle has been persistently reported from several observations in different parts of the country (Belay and Geert, 2016; Dessalegn, 2017; Kiros *et al*.,2018b).

5.1.7. Involvement of family members in milk production

The labor division for dairy cattle management such as herding, feeding, watering, selling and health care were mainly the jobs of men and women in urban and peri-urban areas of the study sites. In one hand engaging children can benefit the family by reducing the burden of hiring an external hand thus helping the resource challenged family but while on the other hand it also leads to higher school dropouts and thus spiraling into the vicious cycle of poverty. Milking was done predominantly by housewives followed by husbands, hired labours, sons and daughter. In agreement with the present result, Abebe *et al*. (2017), Kiros (2019) and Dessalegn (2017) explained that milking was done predominantly by housewives. On the other hand, in a few areas such as the Fogera area of Amhara region, milking is entirely performed by males (Belete, 2006).

5.2. **Dairy Cattle Husbandry Practices in the Study Area**

5.2.1. Feeding systems and feed resources

The availability of feed resources in the area depends on seasons. However, crop residues, concentrates (agro-industrial by-products; brewery by-products), hay, communal pasture, private pasture, improved forage and local brewery by-products (*atella*) were the commonly used dairy feed resources in the present study areas. Comparable to the current results, in central highlands of Ethiopia, the major sources of dairy cattle feed resources were crop residues, concentrates, hay, communal pasture, private pasture and improved forage (Abebe *et al*.,2017; Kiros *et al.,*2018b). The current result is also comparable with the result of Getu (2019) in Sebeta, Bedele and Debre-Berhan areas. Azage *et al*. (2013) also stated that the roughage is a major feed resources for dairy animals across all the different production systems include natural pasture/grasslands, grass hays, crop residues, and non-conventional feed resources. According to Kechero *et al*. (2013) from Jimma Zone further reported that natural grazing lands, crop residues, pasture, forage crops, and agro-industrial by-products were the main livestock feed resources.

The majority of the respondents in the current study revealed that zero-grazing (indoor feeding) was the main feeding system. This is in agreement with Kiros *et al.* (2018b) from urban and peri-urban areas of Central Highlands. According to Getu (2019), zero-grazing (indoor feeding) was the main feeding system in Sebeta, Bedele and Debre-Berhan areas. In addition, reports by Dessalegn (2017) indicated that about 74.6% and 25.4% of the dairy farmers in Bishoftu and Akaki towns' use of zero-grazing (indoor feeding) is the major feeding practices. Adebabay (2009) also reported that the types of feeding systems noted in the Bure wereda of the Amhara region were communal grazing and zero-grazing (indoor feeding). Parallel to the feeding management in peri-urban town, Girma *et al.* (2014*)* also stated that stall feeding practiced in urban areas.

5.2.2. Types of available crop residues

Barely (*Hordeum vulgare*), Faba bean (Vicia faba L), Wheat (*Triticum aestivum*) and Oat (*Avena spp*) residues reported being the major crop residues (CR) available for dairy animals in study areas. The previous report of Abebe *et al*. (2017) indicated that crop residues were used as a feed source for dairy animals in Debre Berhan, Sheno and Sendafa areas. Mekete (2018) reported that crop residues (CR), grazing lands (GL), crop aftermath and fallow land were the major feed available in Debre Berhan milk sheds. Similarly, Kiros *et al*. (2018b), reported that wheat straw, barely straw and teff straw were the mainly used crop residues in central highlands of Ethiopia. In Gondar town, crop residues such as wheat, barley, teff straws and maize thinning were used by farmers as basal diets for dairy animals (Malede *et al*., 2015). However, around Ziway barley straw was the most preferred feed by dairy owners followed by maize stover (Zewdie, 2010). The differences could be attributed to the variations in availability and farmers awareness.

5.2.3. Frequency of providing feed supplements

The provision of feed supplements was mainly practiced twice and three times a day. In line with this, Kiros *et al*. (2018b) reported that in urban and peri-urban Assela, peri-urban Sululta, and peri-urban Bishoftu dairy farmers provide their animals with feed supplements twice and three times a day. On the other hand, Gebeyew and Beriso (2016) in Fafan town, Somali regional state of Ethiopia 52.08% and 41.67% of respondent's provide feed two times per day for lactating and non-lactating dairy cattle, respectively. As the same sources, 6.25% and 37.5% of respondents in Fafan town supply once a day for lactating dairy cattle and non-lactating dairy cattle, respectively. According to Nikkhah (2011) stated that delivering feed for dairy animals once per day is labor effective and it is more needed for many small and medium herd-size farms. The variation of supplement feeding frequency from place to place might be due to feed resource availability.

5.2.4. Constraints of forage production in the study area

In agreement with the current study, Zereu and Lijalem (2016) reported that the main limitation of land allocation for forage production may be due to the small size of land ownership and the priority given for staple food crop production. Inadequate extension support services and lack of improved forage seeds/seedling also potentially contributed to the shortage of forage production. Therefore, strengthening the promotion of forage innovations to increase the forage biomass yield per unit area and ensure the reliability of the forage seeds system could help to realize that improved forage production and utilization will pay the cost through improvement in the health and productivity of livestock.

5.2.5. Water source and watering frequency of dairy cattle in the study area

One of the most limiting factors in livestock production is the availability of regular and clean drinking water. The present study revealed that dairy farmers 65.9% from urban and 45.6% from peri-urban reported using tap water for dairy cattle. More than half of the

farmers watered at home. Farmers of the peri-urban areas (37.8%) mentioned the seasonality of water availability, poor water quality (water contaminated by *leeches* (*alkit*)) in peri-urban areas and far watering point as a major constraint. Similar findings were reported by Abebe *et al.* (2017) in urban and peri-urban areas of the Central Highlands of Ethiopia. The households who lived far from the source of water animals were forced to move long distances in search of drinking water. In agreement with the present result, Asfaw *et al*. (2010) reported that the trekking of dairy animals for a long distance has been reported to cause considerable energy wastage and decrease the watering frequency which in turn contributes to low dairy cow productivity (Kassahun *et al*., 2008).

The frequency of water provision in urban (65.9%) and peri-urban (57.8%) of the current study was comparable with the findings of Abebe *et al*. (2017) and Zewdie (2010) who reported dairy farmers mostly provide water three times a day for dairy cattle. Other findings reported in different parts of Ethiopia, dairy farmers watered their dairy cattle once, twice, and three times per day (Tilahun and Gebregiorgis, 2016; Bernabas *et al*., 2017; Abebe *et al*., 2018b). On the other hand, Alemshet (2014), reported that 28.9% of respondents in urban and 15.25% of respondents in peri-urban areas of Adigrat, Tigray, dairy farmers provide water to their animal's adlibitum. Availability of feed resources and water might contribute to the frequency of water provision.

5.2.6. Major cattle disease in the study area

The major reported cattle diseases prevailing in the study area were udder infection (33%) followed by blackleg (24%), foot and mouth disease (FMD) and parasites like *leeches* (*alkit*). The current result was agreed with other findings reported in different parts of Ethiopia (Azage *et al*., 2013; Abebe *et al*., 2017). On the other hand, a report by Shapiro *et al.* (2015) revealed that the most important diseases of cattle in Ethiopia are foot and mouth disease (FMD), Contagious Bovine Pleuropneumonia (CBPP) and brucellosis respectively. The majority of the respondents in the studies area have access to veterinary services. However, the services were provided by payment and farmers complain about the

higher price they pay to treat their sick animals. Some farmers, however, rely on the ethno veterinary medicines and they use the herbal extract of the plants *Allium Sativa (Garlic)* and *feto'* (*Lepidium sativum*) for treating their dairy cow against mastitis. The major reported sources of veterinary services were government, private, NGOs and both government and NGOs. This survey result is agreed with the finding of Adebabay (2009) at Bure wereda.

5.2.7. Dairy cattle breeding systems in the study area

In agreement with the current study, Dessalegn (2017), Misgana *et al.* (2015) and Abebe *et al*. (2017) reported that dairy producers in different parts of the country used both natural and artificial insemination for breeding their dairy cattle. On the other hand, Asrat *et al.* (2016) reported that 51.7% of the households used natural mating by local bulls and the remaining 48.4% used AI at Boditti town. Similar observation by Solomon *et al*. (2014) reported in Metekel zone, Northwest Ethiopia 100% of the respondents of dairy farmers used natural mating system for their dairy cows. Dejene (2014) confirmed that about 75% and 84.2% of respondents of lowland and mid-highland area of Borana zone farmers used natural service for breeding their animals. Similarly, Ayantu *et al*. (2012) and Dereje (2015) reported that majority of the farmers practiced natural, unplanned and uncontrolled mating systems. On the other hand, Alemselam *et al*. (2015) indicated that the common breeding methods for crossbred dairy cattle were both AI and natural mating by bull followed by AI and natural service. The aforementioned differences might be due to overall management practices. Sometimes the use of unselected bulls could have a negative implication on the productivity of the herd and might be contributing to disease transmission such as brucellosis. The majority of the dairy farmers prefer natural mating systems than artificial insemination because of their own reasons that artificial insemination has a high chance of resulting in the birth of male calves, and the trust that natural (bull) service has a high degree of conception. On the other hand, AI service was supported by government and dairy farmers are charged only 4 birrs per AI service. This might be due to the fact that AI technicians need additional incentive and service is mostly

provided by private AI technicians. The use of bulls for natural service is common in Ethiopia, and breeding bulls not reared in their herd, while only about 18.1% of them used homebred bulls. The average bull service charge was likely to be 104 ETB/service, which is expensive as compared to the AI services.

According to the respondents indicated that anoestrus was a significant problem for their herd. In line with this, Roelofs *et al*. (2010) reported that appropriate estrous detection and timing of service must be carried out by the farmer and each cow is mated once or twice during each heat period. A similar observation was reported by Kiros *et al*. (2018a) at peri-urban Sululta, urban Bishoftu, peri-urban Bishoftu, and periurban Assela. In the current study, the majority (99.4%) of the interviewed respondents revealed they use to detect estrous by follows up during morning & night time. Although animals showed typical signs of estrus, a significant number of the respondents, 48.8 % from urban and 45.3% from peri-urban reported not to conceive after AI or failure to inseminate animals on time. In agreement with these results, about 78.9% of owners in Bishoftu and 60% in Akaki faced failure of artificial insemination because of heat detection problems, distance to AI center, and absence of AI technician and inefficiency of AI technician (Dessalegn, 2007).

5.2.8. Weaning and Culling Systems

The present study showed that there was more Weaning and Culling practies by respondents in urban areas than peri-urban areas. Male calves are traditionally viewed as an unwanted invention of the dairy sector in urban areas. Consequently, many of the dairy farmers in urban areas cull male calves at a very early age than peri-urban areas to reduce rearing cost. This is similar to the observation of Roelofs *et al*. (2010) about 75-100% of dairy cattle producer's practices weaning at central highlands of Ethiopia. The main reported reason for weaning calves was to prepare the cow for mating, to get more milk and give rest time for next calving. The systems of weaning calves as reported by milk producers were isolation of calves from cows. Similar results were also reported by Kedija (2008). With regard to culling of male calves most of the dairy producers exercise culling

in urban areas than peri-urban areas. This finding is in line with the finding of Kiros *et al.* (2018b) and Abebe *et al.* (2017) at Central Ethiopia.

5.2.9. Dairy Cattle Housing and Waste Management

The present study revealed that all of the dairy producer farmers in the study areas keep their crossbred dairy cattle in separate house. This finding is comparable with the finding of Abebe *et al*. (2017); Ayalew (2017); Hulagersh *et al.* (2017) and Kiros *et al*. (2018b) at different location of Ethiopia. According to Wangdi *et al*. (2014) about 78% of the respondents delivered house to their crossbred dairy cattle. While, the rest 22% of the respondents did not supply houses to their dairy cattle. In contrast, Asrat *et al.* (2013) pointed out that 60% of dairy farmers in urban areas used the same house for family and animals in Boditti town, Wolaita Zone. The above explanations implies that dairy farmers keep their animals in different housing systems due to management practices.

Majority of the interviwed dairy Producer constructed dairy cattle barns with corrugated iron roofing material for better strength followed by constructed with thatched grass and few are constructed with *Plastic/Geo-membrane* respectively. Similar observations were made by Abebe *et al*. (2017) who reported majority (90.0%) of dairy farmers construct their cattle barns with corrugated iron roofing material and the rest (10.0%) constructed with thatched grass. In the present study, majority of the dairy farmers used stone for flooring for their animals' barn. Similarly, according to Abebe *et al*. (2017) the majority (70%) and all (100%) of dairy farmers used stone for flooring and none of them use bedding material for their dairy cattle respectively.

Majority of the respondents clean their animal's barn daily. This is in agreement with that of Abebe *et al*. (2017) and Dessalegn (2017) from central highland and Bisheftu and Akaki town respectively. Based on the observation housing conditions in many of the respondant farmers were unclean wet, craky and not providing a comfortable setting for the dairy animals. This may have a negative impact on the production of clean milk and milk

products, in addition to increasing animal health problems such as mastitis and lameness. Therefore, cow sheds must be designed in such a way that it gives comfort for the animals, and easy for routine daily activities like cleaning and feeding.

According to the present result, most of the farmers in the study areas were not keeping records, while few of the sampled farmers in the study areas were practices like milk production, health and breeding records. The results of the present findings were in agreement with the results obtained by Kiros *et al*. (2018b) at Central Ethiopia. Reports by Asrat *et al*. (2013) also emphasized that 95% of dairy producers did not practice record keeping. The main reason raised for not keeping records was farmer's lack of awareness on the benefits of keeping records. The lack of record keeping may have a negative impact on productivity, decision making on progress and also may lead to inbreeding between closely related herds (Desalegn, 2011). Markos (2006) also illustrated that the livestock development in Ethiopia has been handicapped to a great extent due to the lack of recorded data. It is therefore essential to provide training on this useful practice to dairy herd owners to make the decision for better livestock management and thereby optimize the utilization of the available resources in the study area.

5.3. Reproductive and Productive Performances of Cows in the Study Area

The average (9.5 liters) daily milk yield (DMY) of the present result was comparable to those observed in different parts of Ethiopia (Solomon, 2014; Abebe *et al.*, 2017) but the current result was slightly higher than reported by others researches (Mulugeta and Belaynhe, 2013; Kiros, 2019; Getu, 2019). On the other hand, it is lower than the values reported by Nigusu and Yoseph (2014) who found 14.1 liters/day/cow in urban and secondary town dairy production systems in Adama milk shed.

The average lactation length (LL) reported in the current study is nearly similar with the recommended standards for lactation length (10 months) (Lobago, 2007). Similar observations had been put forward by Mulugata and Belaynhe (2013) and Abebe *et al.*

*(*2017) in central Ethiopia. The observed result in the present study was comparable to 10.5 months by Megersa (2016) for western Shewa peri urban and urban dairy farms but was longer than the 9.13 month that reported by Belay *et al*. (2012) for dairy farms in Jimma town.

The mean age at first calving (AFC) (31.58 months) in the present study was comparable to the reports of Kumar and Tkui (2014); Abebe *et al. (*2017) and Kiros (2018) in different parts of Ethiopia, ranges from (30.5-38.3 months) respectively. Solomon and Alemu (2009) obtained higher values (47 months) for crossbred cattle in Amhara region. This result was higher than the values reported by Dessalegn *et al*. (2016) in Bishoftu and Akaki Twon. Reports by Ruiz-Sanchez *et al*. (2007) indicated that age at first calving has an impact on the productive lifespan of the cows and rearing cost of the dairy animals. The genetic factor, better-managed and well-fed heifers grew faster, served earlier and resulted in more milk and calves produced during their lifetime as well as low rearing costs (Masama *et al*., 2003).

The results further highlighted that the overall mean calving interval (CI) reported for the crossbred cow was 15.10 months. The values for the trait was close to the optimum values (12-13months) recommended for profitable dairy production (Gifawosen *et al*., 2003). Similar observations had been put forward by Kiros (2019) and Dessalegn *et al*. (2016) for crossbred dairy cows in Sululta town (13.3 months) and Bishoftu and Akaki towns (13.0 and 13.8 months) respectively. Reports by Addisu *et al*. (2012) also confirmed CI of 14 months for crossbred cows in Ethiopia. The ideal calving interval would result in a significant increase in the financial returns from milk production and the lifetime productivity of cows. Generally, the variation in the average values of CI and LL among the studies conducted in the country could be attributed to the difference in management practices, which brings different responses within the same breed.

The average number of SPC required in this study nearly matches with the recommended value (1.77) suggested by Radostits *et al*. (1994), and agreed with the results from central

highlands and mid Rift valley of Ethiopia (Yifat *et al*., 2009). However, a higher average SPC (2.8) was reported in Harar milk-shed (Mohammed and deWaal, 2009). Feed shortage and poor reproductive management such as lack of proper heat detection and timely insemination might have the most plausible explanation for the difference in the number of SPC recorded across the country (Kumar *et al*., 2014).

5.4.Constraints of Dairy Cattle Production in the Study Area

The main constraints prevailing in the study area are feed shortage and the high price of feed resources. These constraints as explained by the respondents are not different from those reported by other researches (Teshager *et al*., 2013; Zemenu *et al.*, 2014). Ketema (2014) reported that disease, scarcity of improved breed, lack of space and water shortage was identified as major constraints of dairy production. Moreover, reports by Haftu (2015) from Hossana town, feed scarcity, and high feed cost were the main constraints of dairy production. The same author further mentioned that space limitation was an additional dairy production constraint in the study area. Terefe *et al*. (2014) stated that feed shortage was also identified as the basic constraint of dairy production in Dale and Shebedino weredas. As reported by Malede *et al*. (2015) land shortage was the major limitation on dairy production in Gondar town. In addition, Asrat *et al*. (2016) point out that land shortage and feed scarcity were the primary constraints that hinder dairy production in Wolaita Sodo town. Similarly, several authors documented that high feed cost and land shortage were the major dairy production system constraints in both urban and peri-urban areas of the central highlands of Ethiopia (Belay *et al*., 2011; Azage *et al*., 2013; Abebe *et al*., 2017).

5.5. Milk Production, Consumption and Marketing Practices

The average rate of milk consumption at home was higher in the peri-urban farms than that of urban farms. Similar observations had been put forward by Ayenew *et al*., (2011) in Northwestern Ethiopian highlands. The amount of fresh milk self-consumed per farm per day by producer families was comparable with the result of Muia *et al.* (2011) who reported the daily milk consumption of 1 to 3 liters for dairying households in Kenya. In line with this, Azage (2018) confirmed that the country produces about 4 billion liters of milk per year. Moreover, FAO (2009) explained that the national average per capita consumption of milk was 20kg/year as compared to 44 kg/year for the African countries and 87kgs/year for the world per capita consumption recommended. From the same source, it has been illustrated that 22 billion liters of milk are required each year to bridge the demand and supply gap in the country because only 14.2% of milk is used for family consumption (Azage *et al*., 2013).So far, it has been frequently reported that per capita milk consumption oscillates between 16 and 19 liters (Effa *et al*., 2016). The result further highlighted that the daily volume of milk for sale was higher (mean= 18.89 liters) and varied among production systems. The more market share of the urban dairy system is due to the market-oriented smallholder dairy farms, which are mainly concentrated adjacent to urban consumers. This is similar to the reports of Azage (2004) and Anthony (2002). The majority (95.9%) of the respondents consume milk very frequently, of which 73.7% drank it once a day followed by 22.2% more than once a day and 4.2% consumed milk once or twice per week. The results of the present findings were in agreement with the results obtained by Lemma *et al*. (2017) in smallholder dairying in Ada'a wereda.

5.6. Cow and personnel hygiene

Majority (95.4%) dairy farmers of the study area washed their hands before milking was similar to the observations from different parts of the country (Saba, 2015; Dessalegn, 2017; Abebe, 2018). According to the assessment of Zelalem (2010) and Abebe (2018) milkers hand can be an important source of milk contamination, thus, keeping good

personal hygiene and milkers should be in good health during milking operation. The result indicated that about 78.3% of dairy producers had access to tap water to clean their hands and the udder of animals. This findings are similar to the observations of Abebe (2018) who reported that the majority of the respondents used tap water for cleaning of hands, udder of the milking cows and milk utensils. Therefore, all sources of water other than tap water used for cleaning of milk utensils are likely to be unsanitary thus could contribute to the poor quality of milk.

Most (63.5%) of the small holder dairy farmers in the study area used cold water and soap for washing their hands, which was compared with the finding of Mezgeb (2012) and Abebe (2018) who reported that dairy farmers used cold water and soap for washing their hands. Washing hands without detergent (soap) may not improve the hygienic conditions of milk (Zelalem, 2010). About 51.4 % of the respondents dried their hands with re-usable cloth and few of them dry or rub their hand on their body. Similar observation was reported by Mezgeb (2012) and Abebe (2018) in different study areas. In the same work, it has been stated that poor drying practices following hand washing and use of old and unclean clothes for other farm activities can be risk factor for milk contamination. Moreover, pre-milking udder washing is important to remove both visible dirt and bacteria from the outer surface of the udder. This finding is similar with the finding of FSA (2006); Zelalem (2010) and Abebe (2018).

Based on the above explanation, majority (97.6%) of the dairy cow owners cleaned their cow udder prior to milking was comparable with the previous reports in Hawassa, Mekelle and Adea Berga, Ejerie weredas of West Shoa and central Ethiopia by different scholars (Haile *et al*., 2012; Almaz, 2014; Saba, 2015; Abebe, 2018).Contrary to this, none of the respondent's practices washing of their cow's udder before milking in Gurage zone, Ezha wereda (Abebe *et al*., 2012). In the same work it has been stated that use of individual towel and following essential cleaning practices during milking is important for the production of quality milk as well as used to limit cross contamination of microbial load. However, about 66.9% of the smallholder households did not use towels for udder drying.

Of which about 56% of the dairy farmers wipe the water from the udder by using their bare hands while 30% and 10.7 % of the respondents reported using an individual towel for each lactating cow. There is an agreement between the findings of this study with that of Saba (2015), which stated that milking in dry condition significantly reduces bacterial count because of luck of surplus water remains in the surface of the udder to drip into the milk and due to less chance of leaching dirt and bacteria from udder, teats and hands into milk.

5.7.Type of Milking Container and Sanitary Practices

The results indicate that most of the interviewed milk dairy farmers used plastic made milk containers during milking and transported the milk to collection centers. Similar findings were reported in different parts of the country by Saba (2015), Tsadkan and Amaniel (2016) and Abebe (2018), plastic containers (82.5 - 100%) were the most frequently used materials for milking and transported the milk to collection centers. The assessment reported by Pandey and Voskuil (2011) the use of plastic containers can be a potential source for the contamination of milk. This is because of difficulties of removing all milk residues from such milk containers that are spongy by nature with common cleaning systems thus increases the microbial load of milk, which in turn acidifies and results in undesirable fermentation. Therefore, milk producers give pay attention to the type as well as cleanliness of milk equipment.

The results further highlighted that the majority (77.1%) of the respondent's cleaned milk utensils immediately after use while 16.6% of dairy farmers cleaned the equipment prior to use but not immediately after use. These observations are similar with the report of Abebe (2018) where delay in cleaning milk containers gives microorganisms adequate time to multiply and increase in number that are difficult to reduce to acceptable levels during cleaning. This could result into high microbial counts in milk handled in these containers and hence accelerated microbial spoilage leading to post harvest losses of the milk.

In agreement to the current study, Abebe (2018) reported that dairy farmers filtered the milk before delivering to milk collection centers to remove visible dirt that entered into the milk by using white cloth and sieve.

The results pertaining that about 27.4% of the respondents washed their milk container with warm water and detergent (Ajax).This is comparable with the result of Mezgeb (2012), Haile *et al*. (2012) and Saba (2015) who reported (23-85.6%) dairy producers used warm water to wash milk containers. On the other hand, only few (26.7%) women were accustomed to use hot water in Delbo area of Wolayta zone (Rahel, 2008).The results also indicated that few of the producers' practice (26.3%) use of water and leaves of shrubs for cleaning of milking equipment's. This is comparable with the result of Sintayehu *et al*. (2008) in shashemene-Dila areas.

Dairy farmers in the study areas exercise smoking for milk equipment's was comparable with study of Tsegaye (2016) reported that *Olea Africana* (Woira) was the most frequently used plant for smoking milk vessels followed by *Juniperus procera*. This result also agreed with the result of Sintayehu *et al* (2008); Zelalem (2010); Abebe *et al*.(2012) and Tsadkan and Amaniel (2016) who reported that milking utensils were smoked with different aroma producing plants like *Olea africana* and *Juniperus procera*. Furthermore, reports by Tsadkan and Amaniel (2016) smoked containers is important to slow the growth of lactic acid bacteria, which leads to desirable and slow development of flavor components.

5.8. Storage conditions and Shelf Life of Dairy Products

To increase the shelf life of milk and milk products, milk producers used different techniques to preserve fresh milk without clotting, such as cooling by putting the container with milk into a cold-water bath until sold the following morning. Similar result was reported in different parts of the country by (Ayenew *et al*.,2009; Saba,2015). After the cheese was drained sufficiently and became dry enough, spices were added to give a desirable flavor. The spices mainly used were the aerial parts of *Ruta chalepensis (Tena*

Adam) and *Ocimum basilicum (Beso Bila)*, the *rhizomes* of *Zingiber officinalis (Zigibl), Allium sativum (Netch Shinkurt)* and the seeds of *Aframomum corrorima (Corerima).* The traditional hard cheese was reported to be able to store averagely about 3 years before consumption without losing its desired flavor and taste by the local consumers (Sintayehu *et al*., 2008).

5.9. Milk Marketing and Modes of Transportation

In the study areas, raw milk is marketed through both formal and informal systems. The formal marketing channel which involved in direct sold their milk to dairy cooperative, private milk collection center, cafeteria, and private milk processing plants that process milk and supply to urban consumers through retailers- supermarkets and shops. This finding is in line with the finding of Dehinenet (2014) in Oromia and Amhara National Regional States, Ethiopia. Producers living near the capital city and having a good transport accesses were selling their milk at a relatively good price compared to those living in remote areas. In agreement to the current study, Dehinenet (2014) reported milk from the producers to the milk collectors transported by using people back and cart or donkey.

5.10. Extension and Training Services to Dairy Development

The sampled milk producers had information access related to milk production from extension agents and non-governmental organization but also from other sources such as previous family experience, neighbor and/or relative, while the rest from dairy cooperatives, private traders and microenterprises. This survey showed that informal knowledge flow plays vital role for sharing of experiences among milk producers that in turn build up indigenous knowledge. The majority of milk activity is geared by self-owned form of indigenous knowledge. This again indicated the necessity of taking indigenous knowledge into consideration in each and every modern milk development intervention. The results obtained in this study are similar to the observations of Dessalegn (2017) and Abebe (2018).Reports by Dawit (2010) confirmed that numerous knowledge sources can

bring change to the attitude and knowledge of farmers compared to a single knowledge source.

In agreement with present finding, Embaye (2010) reported that smallholder farmers that have access to credit are more likely to have access to feed, breed and veterinary services. The systems of credit services is not attractive for dairy producers. Reports by Zijlstra *et al*. (2015) also strengthen this idea, that is high-interest rates and small amounts of credit is not sufficient and attractive for livestock intervention.

5.11. Milk Quality Analyses

There was a significant ($P<0.05$) difference in fat, density, protein, added water as well as ash% between the two production systems. The overall mean of fat content of milk obtained in the current study (3.93%) was comparable with the findings of Aysheshim *et al.* (2015) from Dangila town. However, it was silently higher than reported by Genzebu *et al*. (2016). The overall mean density content obtained in the present study was comparable with finding of Dehinenet *et al.* (2013), who reported 1.028 % in Amhara and Oromia National Regional States. On the other hand, it was lower than the finding of Teshome *et al*. (2015) in Shashemene town southern Ethiopia and Sefinew *et al*. (2013) in and around Gondar town, Ethiopia. Normal milk has a specific gravity of 1.026– 1.032 g/ml (or 26–32 on the lactometer reading). If the milk is adulterated with water, the lactometer reading will be below 26. If any solid such as flour has been added, the reading will be above 32 (Kurwijila, 2006). Therefore, generally, milk that produce in the urban and peri-urban areas was not adulterated. The average protein content of raw milk sampled from peri-urban farms is comparable with the findings of Dehinenet *et al.* (2013) in Amhara and Oromia National Regional States. On the other hand, it is lower than the value reported by Aysheshim *et al.* (2015) in Dangila town, Western Amhara Region.

The average addition of water contents (5.80%) in the current study are higher than reported by Genzebu *et al*.(2016) from different value chain points in central Ethiopia. The

higher added water in the current study compared due to 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. The results pertaining that the overall ash content (0.64%) in the study areas are lower than the report of Teshome *et al.* (2015) from Shashemene town Southern Ethiopia .

Season had a significant ($p<0.05$) effect on most of the physico- chemical composition properties such as fat, density, protein, adulteration and total solid %. The protein content of wet season milk was lower than dry season. This result is similar to that reported of Kabil *et al*.(2015) indicating that the effect of seasonal variation on the chemical composition of cow's milk produced along a year in Egypt and these results are lower by Ayub *et al.*(2007). The higher milk protein in dry could be attributed to the diet containing high digestible protein content from the forage feed and concentrate feed, whereas the feeding during summer produce the lowest milk protein due to ration containing low protein.

The results of addition of water content (6.46%) in milk value chain was lower than the finding of Kassa *et al*.(2016) who reported (37.50%) addition of water content in raw cow milk from AngolelanaTera wereda. However, the current result is higher than the value (2.80%) reported by Genzebu *et al.* (2016) from Central Ethiopia. According to Bhatti (2010), has been noticed that the addition of water to normal whole milk was assumed to increase the quantity of milk. However, the addition of water to milk not only reduces the nutritional value of milk but contaminates water may also pose a health risk (Barham *et al*., 2014). 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.

The results further highlighted that there was no significant ($p > 0.05$) difference for freezing point of milk between the value chains. Similar finding was reported by Genzebu *et al*.(2016) in Central Ethiopia. The freezing point of milk could be affected by the

freezing point of milk during cooling, or the addition of wash water to the tank in most cases. The specific gravity of the current result of raw milk was similar to that reported by Teklemichael *et al*.(2015) in Dire Dawa town. In this study, the specific gravity of raw milk samples collected from MC and MPP were below recommended standards. This is could be due to the addition of water with milk.

The result of fat content of the present study is in line with the Gurmessa and Melaku (2012) and Alganesh (2016) who reported the fat content of (3.70%) and (3.76%) from different location of the country. In contrast, Teshome *et al*. (2015) obtained higher fat values (4.28 %) which is produced and marketed in Shashemene town. The lower fat content of milk may be due to cows of that farm were high milk producing cross breeds 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 % for whole milk should not be less than 3.5 % (ES, 2009). Consequently, the average fat content (3.92±0.86) observed from the three values chain points milk samples fulfilled the recommended standards.

A significance ($P<0.05$) difference within the SNF content of milk between milk value chain points was in agreement with the report of Kassa *et al*. (2016) who reported (4.59-7.82%) in AngolelanaTera wereda. Similarly, Genzebu also reported (7.78%) in Central Ethiopia. However, it is lower than the values reported by Dehinenet *et al.* (2013) who reported (8.44±0.72) in Amhara and Oromia National Regional States. In addition, higher (8.7) SNF content of raw cow's milk was obtained from Addis Ababa (Debebe, 2010). According to European Union quality standards for unprocessed whole milk, solids-not fat content should not be less than 8.5% (Tamime, 2009). Accordingly, the average solids not-fat content (7.53%) observed from value chain point samples were below the recommended standards.

The average lactose contents of raw milk samples collected from MP, MC and MPP were comparable (3.93%) with the finding of Genzebu *et al*.(2016) raw milk samples collected

from different milk value chain. On the other hand, the current finding is lower than the findings of Belay and Janssens (2014) who reported the lactose content (4.34%) at Jimma town. Therefore, the current average lactose content (3.78±0.03) found for the raw milk samples was below the recommended standards. The composition of milk can vary depending on the breed of the animals and management practices influenced the milk composition (O'Connor, 1995).

The results further highlighted that there was a significant difference for protein content ($p < 0.05$) between the three milk sampling points. Similar results were also reported by Kassa *et al*. (2016), Debebe, (2010) and Belay and Janssens (2014) from different parts within the country. However, it is slightly lower than the report of Debela *et al* (2015) who reported the protein content (3.94%) of raw milk in Yabello Wereda, Borana Zone. On the other hand, the present result is higher than the report of Dehinenet *et al*. (2013) in Amhara and Oromia National Regional States. Teshome *et al*., (2015) and Negash *et al.* (2012), report higher protein content than present study, in Dire Dawa town and Mid-Rift Valley of Ethiopia with the value of (3.42%) and (3.46%) respectively. According to Ethiopian standards Agency, the minimum percent protein content of whole milk should be 3.2 % (ES, 2009). Hence, the average protein content for the current study is similar to the recommended standards.

The overall (11.45) TS in the present result is in agreement with the result of Genzebu *et al*.(2016) in raw milk samples collected from different milk value chain. Similarly, the present result is slightly comparable with the result of Teshome *et al*. (2015) who found total solid in milk from Shashemene town (12.87) and also Mirzadeh *et al*. (2010) reported total solids content in some dairy farms in Iran (12.57). According to European Union established standards for a 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 (11.45%) found from study areas was below the recommended standards. The lower TS content of collected raw milk samples may be due to the 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.

The overall mean of ash content (0.64) found in the raw milk during this study is slightly similar with the findings of Imran *et al*.(2008) and Estifanos *et al*.(2015) who reported the ash in cow's raw milk collected from different locations were (0.64) and (0.68), respectively. But different from the finding of Teshome *et al*.(2015) who reported (0.78) in Shashemene town, Southern Ethiopia.

According to the result obtained, total bacterial counts were not significantly (P> 0.05) different by production systems and it was generally high as compared to the acceptable level of 1×10^5 bacteria per ml of raw milk (O'Connor, 1994).This implies that the sanitary conditions in which milk has been produced and handled were poor, subjecting the product to microbial contamination and multiplication (Biruk *et al*., 2009). Total bacterial count in the present study was comparable with the result of Negash *et al*. (2012) which indicated 7.08 ml^{-1} in milk sampled from Mid-Rift Valley of Ethiopia. Similarly, the present study is comparable with the result of Teshome *et al*. (2015) which indicated 7.125ml in milk sampled from Shashemene Town, southern Ethiopia. The present result is also comparable with the finding of Asaminew and Eyassu (2011) and Alganesh *et al*. (2007) who reported 7.58 ml in and 7.60 ml in different location of the country. The result of current study, on the other hand, was slightly lower than the result of Zelalem and Faye (2006) who reported the value of 8.34, 8.63 and 8.18 ml, respectively. Generally, the higher total bacterial counts are the indication of a diseased udder, unsanitary handling of milk, or unfavorable storage temperatures (Biruk *et al*., 2009).

The average coliform counts in the present study was comparable with the finding of Abebe (2018) who reported the value of 5.30 ml^{-1} milk collected from Central highlands of Ethiopia. In contrast, the result was lower than the value of 6.57 log10 cfu/ml raw cow's milk collected from central highland of Ethiopia (Zelalem and Faye, 2006). Similarly, Godefay and Molla (2000) reported the presence of large numbers of coliforms is an

indication that the product may potentially carry serious pathogenic coliforms that are hazardous to the consumers health. According to Walstra *et al*. (2006), occurrence of coliform counts over 2 logs CFU/ml of raw milk, it means that the milk was produced under unsanitary conditions and/or from the cow with mastitis infection. Therefore, the higher coliform count observed in the present study, could be due to the initial contamination of the raw milk samples either from the cows, the milkers, milk containers and the milking environment.

The somatic cell count in the urban and peri urban milk production system of the present result was similar with the result of Desalegn (2017), Tsedey and Asrat (2015), Negash *et al*. (2012) and Haile *et al.*(2012) who reported (7.17), (7.03), (7.08) and(7.6) log10cfu/ml but lower than the value reported by Zelalem (2010), Abebe *et al*. (2012) and Asaminew and Eyassu (2011) which is the value of (9.10), (9.82) and (7.58) log CFU/ml respectively. The current result of somatic cell count is generally high as compared to the acceptable level of 1x105 (5.0 log10cfu/ml) bacteria per ml of raw milk (Lore *et al*., 2005).

Microbial load of raw milk being directly dependent on the hygienic conditions of the farm and is a very important parameter with respect to milk quality having great effect on its price. Microbial load of dry season milk was significantly higher than that of wet season milk as the microbial load of wet season and dry season milk were 6.78±0.71 and 7.58 ±0.50 CFU/ml respectively suggesting that wet season milk was produced under more favorable hygienic conditions. These results agreed with the results obtained by (Nateghi *et al*., 2014) at Qazvin province of Iran.

The bacterial load was statistically significant across the value chains. This indicated that the 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 (Desalegn, 2017). 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°C after milking.

The current result of coliform counts/ml is higher than the findings of Teklemichael *et al.* (2015), Asaminew and Eyassu (2011) and Negash *et al.* (2012) the value of (4.13 cfu/ml), (4.49 cfu/ml) and (4.35 cfu/ml) from different location of the country. In contrary, it is lower than the value reported by Zelalem and Faye (2006) who reported a 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 water for cleaning of milking utensil (Grimaud *et al.,* 2007). Moreover; bulk milk coliform bacteria are used as an indicator of the hygienic condition during handling.

A finding of the somatic cell from this study is in agreement with other studies carried out by 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 EU and Sweden for the accepted value of 4x105and < 4.99x103sc/ml respectively (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. Therefore, producers should be washed their hands and udder of cow before milking, the milking utensils should be cleaned, and unhealthy cows should be treated.

5.12. Constraints of raw milk marketing in the study area

The low milk price was the major constraint encountered by dairy farmers of the study area is in agreement with reports of Ayele *et al*. (2003); Kassu (2016); Desalegn (2017) and Abebe (2018) who reported from different parts of Ethiopia. Therefore, improving the price

of milk, accessing adequate markets and delivering market information are important measure to tackle the market problems in the study areas.

5.13. Prevalence, risk factors and major bacterial causes of bovine mastitis

The overall prevalence mastitis was 72.2 % and it was largely accounted from sub-clinical mastitis (54.9%) and (17.3%) of from clinical mastitis. The present finding is comparable with previous reports of 71% Mekibib *et al*. (2010) in Holeta Town, 74.7% by Zeryehun *et al*. (2013) in and around Addis Ababa, Ethiopia. In contrast, the present study is lower than that of 88.9% and 89.5% Dabash *et al*. (2012) and Kifle and Tadele (2000) in and around the North Shewa Zone. Similarly, the higher prevalence was reported from Uganda (87.9%) (Abrahmsén *et al*., 2014) and Nigeria (85.3%) (Shittu *et al*., 2012). On the other hand, the lower prevalence was reported from Boran*a* (59.1%) (Bedane *et al*. (2012), 56.5% in Bat*u* and its surrounding reported by Bedacha and Mengistu (2011), 56.16% in West Algeria reported by Benhamed *et al*. (2011), and 50.03% in the weredas of North Shewa and Borana zones of pastoral area (Dinaol *et al*., 2016).

The prevalence of subclinical mastitis of the current finding at cow level was found to be 54.9%, which is a very clear indication of massive economic loss the dairy sector is suffering from the disease. In detail, the present finding support with earlier reports of 54.4% by Abera *et al*. (2013) in Adama town, 55.1% by Zeryehun *et al*. (2013) in Addis Ababa and 59.2% by Abebe *et al*. (2016) in Hawassa, South Ethiopia respectively. However, the current finding was higher than the findings of other authors in different parts of Ethiopia such as 28.6% by Abera *et al.,* (2012) and 23.0% by Biffa *et al.* (2005) in Southern Ethiopia, 25.2% by Almaw *et al.,* (2009) in and surrounding of Gondar town, 41.02% by Ayano *et al.,* (2013) in Holeta, 36.67% by Sori *et al*. (2011) in Sebeta, 36.86% by Fufa *et al*. (2013) in Addis Ababa, 13.6% by Getahun *et al.* (2008) in Selalle, 44.6% by Mekonnen and Tesfaye (2010) in Adama and 49.23% by Yilma *et al.* (2017) in Addis Ababa respectively. On the other hand, the current result is lower than the report of subclinical mastitis at cows' level 85.4% by Tadesse *et al*. (2014) in Addis Ababa, 62% by

Sefinew (2018) in North-Western Ethiopia and 73.3% by Ararsa *et al*. (2013) in Holleta, Central Ethiopia. The difference in the prevalence of bovine subclinical mastitis between findings may perhaps be recommended the difficulty of the disease which involves the interaction of several factors, mainly the difference in husbandry system, breeds considered, environment, management of the farms, factors related to the contributing agent, variation in veterinary service coverage and awareness of the owner toward the disease, and technical know-how of the researchers (Radostits *et al*., 2007). Additionally, the high prevalence rate is due to lack of post-milking teat dipping, poor housing facilities and improper milking hygiene in the present dairy farms studied.

The current result reveals that, out of 2040 examined quarters, 55 (2.70%) teats were found blind. Similarly from the functional 1985 teats examined, 316 quarters (15.9%) showed clinical mastitis and from those teats screened by CMT, 817 quarters (43.34%) showed indication of subclinical mastitis. The occurrence of blind teat in this work is higher than the value 1.1 % reported by Haftu *et al*. (2012) in Northern Ethiopia and 1.9 % by Bitew *et al*. (2010) in Bahir Dar and its Environs. While the prevalence of blind teat in this work is lower than the result (3.4%) of Kebebew and Jorga (2016) from Ambo town of West Shewa Zone, Ethiopia. The blind quarters observed in this study are a warning of a serious mastitis problem on the farms and the absence of culling that should have served to remove a source of mammary pathogens for the cows. According to Abebe *et al*. (2016) reported that lack of screening of subclinical mastitis and delay or not treating clinical cases could possibly lead mammary glands to blindness. Huge economic loss due to clinical mastitis problems were milk production loss, non-profitable loss of milk, veterinary service charges, medication cost, labor cost and culling of chronically infected cows.

The prevalence of clinical mastitis in crossbreed in this study is higher than the reports of 3% by Bitew *et al*. (2010) in Bahir Dar and its environs and 5.3% by Bishi (1998) in Addis Ababa. Mastitis is a complex disease and the difference in results could be due to a difference in management systems between the farms. Generally, the present study confirmed that the prevalence of 17.3% clinical mastitis was in line with the report of 19.6% by Zeryehun *et al*. (2013) in Addis Ababa, 21.5% reported by Workineh *et al*. (2002)

and 22.4% reported by Mekibib *et al*. (2010) around Holeta areas. The current results are comparable to the reports of 16.11% by Sori *et al*. (2005) in and around Sebeta and 16.67% reported by Tuke *et al*. (2017) in Allage ATVET College Dairy Farm, Southern Ethiopia. On the other hand, it is much higher than the values reported 0.93% by Nibret *et al*. (2011) in and around Gondar, 5.3% by Bedacha and Mengistu (2011) in Batu and its Environs, 7.8% by Ararsa *et al*. (2013) at Holleta Agricultural Research Center and 15% by Zenebe *et al.* (2014) in Adigrat, Northern Ethiopia. The prevalence of sub clinical mastitis varies in dairy cows this might be due to environmental factors that play an important role in the occurrence of the disease (Radostits *et al*., 2007). The current finding confirmed that lower prevalence of clinical mastitis compared with the sub clinical mastitis. Other studies also shared similar observations (Dinaol *et al*., 2016). This could be attributed to the indistinguishable and soundless character of subclinical mastitis in most of the time that gives little concentration by the dairy producers as well as veterinary professionals during treatment unlike that of the clinical mastitis which has given more emphasis in the treatment and control efforts of the disease. As the result indicated by Hussein *et al*. (1997), most of the time in Ethiopia dairy producers especially smallholders are not well informed about the invisible loss from sub clinical mastitis, since dairying is a sideline business among these farmers. This was also true in the study area that none of the dairy farm owners screening their cows for sub clinical mastitis except seeking veterinary assistance at times of clinical cases. To maximize milk production in the area, the office of the livestock production, health and marketing systems should work together to enhance awareness on sub clinical mastitis to dairy farm owners. Mastitis positive cows should also be milked at the end to prevent cross-contamination with healthy animals. Moreover, the high mastitis prevalence realized in the current study area is a serious problem that not only reduces milk production but adversely affects the quality of milk and leads to economic losses and public health hazards. Perhaps the main high prevalence of mastitis could either be due to lack of application of regular mastitis prevention and/or control strategies other than treating clinical cases. From the information that observed none of the dairy herds implementing routine mastitis prevention practices such as post-milking teat disinfection, wearing of gloves during milking, treatment of mastitis during the non-lactating period, culling of

chronically infected animals and others substantiate the assumption. Furthermore, none of the farmers were doing CMT or other tests routinely to screen their cows for sub-clinical mastitis. On the other hand, the risk factors contributing to mastitis were more predominant.

Among the risk factors considered, breeds, age, herd size, previous history of mastitis, milk yield, parity, udder washing and teat lesion were found to be statistically significant (p-<0.05). The age of the cow was significantly associated ($\chi 2$=12.25, P=0.000) with the prevalence of clinical mastitis. Adult (≥7 years) cows had an odd ration of 2.38 higher odds to be positive for CMT compared to younger cows. There was also a higher infection rate of cows having more than ≥4 calves ($\chi 2$=4.42, P=0.035) than in cows having less than 4 calves. This result is similar to reported by Tesfaheywet and Gerema (2017) in Eastern Harrarghe Zone, Eastern Ethiopia, cows at the age group of adults and cow giving birth six calves had a prevalence of 66.7% and 62.5% respectively. The clinical prevalence in cross breeds in this study was comparable with that of Bitew *et al*. (2010). The odds of finding cows with previous clinical mastitis history were 5.26 times higher. This may be due to the possibility of carryover infection to subsequent parities. The rate of infection revealed significant variation between larger herds (≥21 herd size) of odds of having mastitis positive was 3.31 times more likely in large herd size than small and medium herd size. This indicates that, beside the lack of knowledge of the community regarding to the animal husbandry the large size can affect the health of animals due to high stocking density, dirty ground, infected utensils and poor ventilation. In this study milk yield, also found to be associated with the occurrence of clinical mastitis; being lower in higher yielding animals. This could probably associate with high attention given to higher milk producing animals than medium and low milk producing ones in terms of management.

The host risk factor considered for this study was age, Breed, lactation stage, milk yield, milking mastitic cow last, teat lesion and herd size were statistically tested (p <0.05) on the prevalence of subclinical mastitis. In the present study, the condition of age was factor to

increase livestock 1.43 production times to be detected in adult cows as compared to young cows. The finding of the present study was agrees with reported by Abebe *et al*. (2016) in dairy herds at Hawassa milk shed, South Ethiopia. Similarly, Tesfaheywet and Gerema (2017) also confirmed that age of cows was significantly associated with subclinical mastitis. On the other hand, age did not significantly (P>0.05) influence the occurrences of sub clinical mastitis (Yilma *et al*., 2017).

In the current study, the highest prevalence of subclinical mastitis was observed in Jersey (60%) breeds followed by HF cross (55.8%) and indigenous zebu (33.33%) there was statistically significant (P<0.05) association with subclinical mastitis. This finding is comparable with the report of other studies such as Yilma *et al*. (2017) in Addis Ababa. Sharma and Maiti (2010) also found that Holstein and Jersey's cows are at higher risk (94.54%) for subclinical mastitis than Holstein Friesian-local zebu cross cows (31.25%). This variation of subclinical mastitis prevalence in breeds level could be that the disease influence the animals by some inheritable characteristic such as the capacity of milk production (high yielding cows are more susceptible to mastitis than low-yielding ones), teat characteristic and udder conformation (Abaineh, 1997).

Similarly, the risk factors considered for this study were, teat lesion, stages of lactation and milk yield. The occurrence of mastitis based on these risk factors like teat lesion, stages of lactation and milk yield showed a statistically significant effect with the occurrence of subclinical mastitis. This was also reported by several investigators to have an association with the occurrence of mastitis (Biffa *et al*., 2005; Mekibib, 2010; Nibret, 2012; Hagos, 2015).

Based on milk yield, the prevalence of mastitis positive was highest (65.8%) in cows having higher milk production and lowest (50%) in cows producing Medium of milk production. According to Grohn *et al.* (2004) and Yilma *et al*. (2017) high producing cows were susceptible to subclinical mastitis than low milk-producing cows. This is due to the reason that higher milk production has affected the capacity of the immune system of dairy

cows to combat infections, and the associated bacteria have adapted to changes in their hosts and environment (Tripura *et al*., 2014).

In the present study, the presence of mastitis was significantly influenced by herd size. The odds of finding a cow with a positive CMT result was 1.90 times higher in herds with more than ten cows than in herds with ten or fewer cows. It was observed that all the herds with more than ten cows were intensively managed and thus, the higher odds of mastitis occurrence might be associated with increased exposure of the cows for mastitis pathogens in their environment due to high stocking density, dirty ground, infected utensils, and poor ventilation. This observation is supported by the findings of Abebe *et al*. (2016). Among the risk factors considered to have an effect on the occurrence of mastitis, udder washing was found to be statistically significant ($P < 0.05$). This is because of using a common source of water (bucket) for washing for different lactating cows. This observation is in agreement with the reports of Fufa *et al.* (2013) who reported 54.28% prevalence in farms where the towel was used and 43.55% in farms in which the towel not used.

The present result indicated that the cows with a previous history of mastitis were found more likely to be mastitic. This observation is supported by the findings of Biffa *et al*. (2005). Prevalence of mastitis was significantly ($P<0.05$) associated with milking hygiene practice. The results revealed that animals with poor hygiene of the milking process had a high prevalence of mastitis. Poor hygiene of the milking process also was identified as a risk factor for the occurrence of bovine mastitis in another study in Ethiopia (Abdurahman, 2006). This might be due to the absence of udder washing, milking of cows with common milkers which have cuts and chaps on their hands and using common udder cloths, which could be vectors of spreading especially for contagious mastitis.

The results pertaining to the multivariable logistic regression analysis of important risk factors for subclinical mastitis were presented. With this, breed, age, farm type, teat lesion, udder washing, lactation stage and Milking mastitic cow last were found to be statistically significant ($P<0.05$) association with the occurrence of subclinical mastitis in lactating

dairy cows. In the present study, the presence of mastitis was significantly influenced by age. The odds of finding a cow with positive CMT result were 2.06 times higher in the age of more than 7 years (≥7 years) than the young ages of cows. This is in agreement with the findings of previous works by Moges *et al*. (2011), Zeryehun *et al*. (2013) and Zenebe *et al*. (2014). Cows in herds that did not milk mastitic cows last were significantly more likely to have mastitis than those that did that. The current finding conforms to reports of different parts of the country (Abebe *et al*., 2016; Belayneh *et al*., 2013). It is obvious that failure to milk mastitic cows last would favor the spread of mastitis pathogens between cows by milker's hands resulting in contagious mastitis (FAO, 2014). In this study, it was observed that cows without skin lesions on their teats and/or udder had a high prevalence of mastitis. This is consistent with the finding by Farns worth (1995) that identified a positive association between teat-end without lesion score and subclinical mastitis. This may most probably be due to treatments given to remove the gross lesion. This study also revealed a significant association between farm hygiene and the presence of mastitis. Thus, the odds of mastitis presence was 1.86 times higher in the result of poor hygiene of the dairy farms. In agreement with the present study, different reported by other studies (Abrahmsén *et al*., 2014; Iraguha *et al*., 2015; Mureithi and Njuguna, 2016). Therefore, a dirty floor would be a potential source that favors the proliferation and transmission of mastitis-causing organisms. This substantiates the importance of sanitation in the epidemiology of subclinical mastitis (Mureithi and Njuguna, 2016). Thus, the floor was a potential source for mastitis organisms, particularly the environmental pathogens, to enter the udder through the teat orifice. This could be due to the lack of waste drainage system and accumulation of manure and urine.

Cows in the early lactation were significantly less likely to have mastitis than cows in the mid and late lactation stages. Evidence on the trend of prevalence increment at the early stage was also produced in previous studies (Elbably *et al*., 2013; Zeryehun *et al*., 2013; Zenebe *et al*., 2014; Iraguha *et al*., 2015). Perhaps this could be linked to the fact that leukocyte of neutrophils into the mammary gland takes a longer time in recently calved cows Radostits *et al*. (2007), and increased oxidative stress and reduced antioxidant

defense mechanisms during early lactation (Sharma *et al*.,2011). Moreover, the absence of a dry cow therapy regime could possibly be among the major factors contributing to higher prevalence at early lactation. In contrast to the present finding, Belayneh *et al*. (2013) reported a higher prevalence of mastitis in the late stage of lactation.

The present study shows a high prevalence of bovine mastitis with Staphylococcus, Streptococcus and Escherichia coli was the dominant bacterial isolates in the study area. This agrees with the findings of Abera *et al*. (2012) and Sefinew (2018) who confirmed Staphylococcus, Streptococcus, and Escherichia as major pathogens. Similar observation also reported by other studies in different parts of the country indicated that S. aureusas was the predominant pathogens (Abera *et al*.,2013; Belayneh *et al*.,2013; Gebremichael *et al*.,2013; Zeryehun *et al* .,2013; Duguma *et al*., 2014). Reported by FAO (2014) indicated that S. aureusas as the chief aetiological agent of mastitis in dairy cattle by many studies from African and Asian countries. Lack of culling of chronically infected cows, absence of post milking teat dipping, absence of dry cow therapy and using the same bucket for washing the udder of their cows could be associated with the high prevalence of *Staphylococcus aureus.* Contagious microorganisms are usually found on the udder or teat surface of infected cows and are the primary source of infection between uninfected and infected udder quarters, usually during milking (Abebe *et al*., 2016). Even though in all the assessed dairy farms farmers used to wash their hands before milking, while all of them wash their hands only before milking the first cow. Therefore, it is implied that the causative organisms could be transmitted easily from infected to uninfected udder quarters or cows through the milkers' hands. Radostits *et al*. (2000) asserted that *Staphylococcus aureus* is well adapted to survive in the udder and usually establishes a mild subclinical infection of long duration, from which it shed in milk, facilitating transmission to healthy animals, mainly during milking procedures. Based on the results of this study, it is recommended implementation of a strict fortnight mastitis control program, improved milking hygiene, and prevention of skin lesions, culling of chronic mastitis carriers, and treating of clinically infected cows in the study area.

5.14. Prevalence of Lameness in the Study Areas

The overall cow level prevalence of lameness in this study was found to be 9.2%. The current result is comparable to other reports from different locations within the country (Lobago *et al*., 2001; Manske *et al.,* 2002). While it is lower than reported by Espejo *et al.* (2006). On the other hand, the current result is higher than the report prepared by Sulayeman and Fromsa (2012). The risk factors supposed at the cow level were production systems, length of cow tack, hoof trimming practice and flower type were thought to be risk factors associated with the occurrence of lameness. The current result is comparable with the report of Abunna *et al*. (2017), Barker *et al.* (2010), Ito *et al.* (2010), Alawneh *et al*. (2011), Shearer and van Amstel (2011) and Bicalho and Oikonomou (2013). This might be due to overstocking and animal confinement on a hard surface will lead to hooves damage. In addition, poor hygiene of barn was considered in a flooring category of wet and crackly might be a risk factor associated with lameness prevalence in tied dairy cattle (Popescu *et al*., 2010; Bicalho and Oikonomou, 2013). The absence of regular hoof trimming practices across the majority of the surveyed dairy farms was the major problem. Therefore, in this study, the lack of hoof trimming practices was found to be an important risk factor that associated with the prevalence of lameness. These findings were comparable to findings of Cook *et al*. (2016). It is recommended that predictable foot trimming practices is very crucial. Because of manure accumulation and contaminations, hind legs are more susceptible to causes of lameness infection. This is therefore in agreement with the previous report made by some authors (Winckler and Willen, 2001). The results further highlighted that the average daily milk yield/cow was significantly dropped by 1.77 liters with the case of lameness. The result as assessed in the present study show similarity with the findings of Sulayeman and Fromsa (2012) where a mean loss in milk yield was 1.63 liter per cow per day in Hawassa dairy cattle.

5.15. Seroprevalence of Brucellosis in the Study Area

In the present study, bovine brucellosis at the individual animal level was 1.21% (9/744) using CFT (95%, CI=1.08-4.85). This finding is similar to the report of (1.2%) by Haile Selassie *et al*. (2010) in Western Tigray. It is also comparable with the earlier reports of 1.0% by Meles and Kibeb, (2018) in Chencha district of Gomogofa zone, Geresu *et al.* (2016) who reported (1.4%) of in Asela and Bishoftu towns, Asmare *et al*. (2010) who reported (1.66%) of prevalence from Sidama zone, Moti *et al*. (2012) who reported (1.97%) of from East Wollega and Tsegaye *et al*. (2016) who reported (1.7%) from Arsi Zone. Similarly, reported by Senein and Abdelgadir (2012) and Scacchia *et al*. (2013) who reported 2% and 2.77% from Sudan and Eritrea. Lower prevalence of brucellosis also has been reported in intensive farms (Bashitu *et al*., 2015; Edao *et al.,* 2018; Pal *et al*., 2016). On the other hand, the present study is lower than the previous report of Kebede *et al*. (2008) 11%; Berhe *et al*.(2007) 3.2%; Hunduma and Regassa (2009) 11.2%; Ibrahim *et al*.(2010) 3.1%; Hailesillasie *et al*.(2011) 4.9%; Megersa *et al*.(2012) 8.0%; Tibesso *et al*.(2014) 4.3% and Alehegn *et al*.(2016) 4.9% from the highland areas of Ethiopia based on the same diagnostic tests. This variation in the seroprevalence findings might be seen due to relatively better farm management and location.

In the present study the seroprevalence of brucellosis was significantly associated with a cow with a history of abortion and placental retention. Therefore, history of abortion and retention of placenta were found to be 17 and 28 times more likely to be seropositive when compared to no history of abortion and retention of placenta respectively. These risk factors as explained by the respondents are were reported by other researchers (Ibrahim *et al*., 2010; Adugna *et al*., 2013; Tsegaye *et al*., 2016; Yohaness, 2017; Abeje, 2018). The results further illustrated that in most case, the occurrence of abortion leads to placenta retention. The results as obtained in the current observation are in agreement with the previous reports by (Schelling *et al*., 2003).

Cow with a history of retained fetal membrane was significantly affected herd seropositivity. The herd seroprevalence of brucellosis was higher in herds that had a history of RFM (3.4%), compared with no history of RFM (2.8%).This could be explained by the fact that retained placenta is typical outcomes of brucellosis. Similarly, the presence of a cow with a history of abortion had significantly affect herd seropositivity. Seroprevalence of brucellosis was higher in herds that had a history of abortion (4.8%) compared with non-aborted (1.4%). This finding is in agreement with the previous reports by (Kebede *et al*., 2008; Adugna *et al*., 2013; Yohaness, 2017; Abeje, 2018).

The final multivariable logistic regression model showed that animals kept in large (OR = 10, 95% CI = 1.30-77.50) and medium (OR = 5.88, 95% CI =0.81-42.73) herd sizes were more likely to be exposed to Brucella infection than those maintained in small herds. This finding was in line with that of Berhe *et al*. (2007), Mekonnen *et al*. (2010), Geresu *et al*. (2016), Yohaness (2017) and Abeje (2018) indicated that herds of larger and medium sizes had higher seroprevalence of bovine brucellosis as compared to smaller herds. This can be explained by the fact that an increase in herd size is usually accompanied by an increase in stocking density, one of the determinants for exposure to Brucella infection especially following abortion calving (Crawford *et al*., 1990). On the other hand, reports by Kebede *et al*. (2008), Jergefa *et al*, (2009) and Asmare *et al*. (2013) reported that the risks of seropositivity were independent of herd size. Similarly, among the potential risk factors considered in the present study, the breed of cattle was shown to have a significant effect on the serological prevalence rate of bovine brucellosis [(OR=27.26, 95% CI=1.75-424.28)].In this study, breed prevalence of 0.94% (7/744) of the seropositive animals were cross-breeds. This finding was in line with that of Abeje (2018) the seropositive associate with cross-breeds animals. While, the present finding was contradicting with higher prevalence rates reported in indigenous cattle in Nigeria (32.2%), Junaidu *et al*. (2008). On the other hand, reports by Kebede *et al*. (2008), Amenu *et al*. (2010), Yohannes *et al*. (2012); Asmare *et al.* (2013) and Geresu *et al*. (2016) indicated that the seropositivity of Brucella infection was independent of the breed. Radostits *et al*. (2000), confirmed that there is no association between the breed of cattle and the seroprevalence of bovine

brucellosis. The present result indicated that a previous history of abortions were significantly associated (P<0.001) with animal level brucellosis sero positivity. This finding was in line with that of Adugna *et al* (2013), Alemu *et al*. (2014), Yohaness (2017) and Abeje (2018). In contrary to this finding, Brucella infection is not associated with abortion history (Kebede *et al*., 2008; Asmare *et al*. 2013).

The present findings revealed that the occurrence of major reproductive problems was mainly repeat breeding, anoestrus, abortion, retention of placenta, dystocia, and stillbirth and uterine prolapsed. Similar findings were reported by a study conducted in the central zone of Tigray region, northern Ethiopia (Bahlibi, 2015).In the present study, majority of the interviewed farmers or farm workers were not aware of bovine brucellosis (92.4%).Animal attendants with a primary and lower level of education are hence likely at a higher risk of exposure to the disease. Similar findings were reported by a study conducted in Addis Ababa dairy cattle (Edao *et al*., 2018).The majority (83.4%) of farm workers were male. This could be due to the fact that farm works in urban and peri-urban dairy production are labor demanding, as a result of which most farm owners prefer to employ male farm workers. Practices affectation a high risk of Brucella transmission are very common, because of most participants reported assisting in animal parturition, disposing of aborted fetuses/after birth in thrown on the field or open dump without protective gloves or masks and consumption of unpasteurized milk. The reason could be poor knowledge of the disease and risks of transmission but also lack of resources used for personal protection such as gloves, aprons, and antiseptics. The creation of awareness of the farm owners and attendants is important to control brucellosis.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

Dairy cattle were essential part of livestock keeping in the study areas and they were mainly kept for source of income generation, mainly from milk sell and sometimes sell of animals. Dairy products also significantly contributed to family nutrition. Based on the findings of the current study, it could be concluded that the educational level of dairy producers was diverse, most dairy farms were male-headed and young people were not participating in the dairy production systems. Crossbred dairy cattle were commonly used than local breeds. Artificial insemination and improved dairy bulls were the common methods for cattle breeding in the study areas. The result showed that 39% of the respondents in urban area have 6-10 years of dairying while, in peri-urban areas 44% of the dairy farms have greater than 10 years' experience in crossbred dairy production. All farmers use separate housing system to keep their dairy cattle but the barns were not made by considering the animals‟ comforts and ease of routine activities. The majority of the farmers had access to veterinary services but a substantial proportion of the respondents complained about shortage of veterinary clinics and veterinarians and thus high costs of veterinary services. Feeding of dairy cattle was mainly based on indoor feeding system. Record keeping was not effectively practiced by dairy producers because of the absence of awareness about its benefits. The major feed resource available for dairy animals were concentrates, hay and crop residues of barely straw, faba bean straw, wheat and oat straw. The provisions of feed supplements and water were mainly practiced twice a day in the dairy farms. Tap, river and spring waters are reported to be the common sources of water for the dairy animals. Although the smallholder and medium sized dairy farms were significant in number almost all share shortage of land, shortage of improved and good quality dairy feeds. Similarly, high cost of improved replacement heifers, cost of concentrate feeds, access to credit and training services, diseases and disease related production decreased and cost of treatments were among the common problems affect dairy production in the study area. The majority (95.4%) of respondents used to wash their hands before milking of which 78.3% had access

to tap water to clean hands, milk utensils and the udder of cows. About 77.1% of the respondent's cleaned milk utensils immediately after use with cold water and detergent while 16.6% of dairy farmers cleaned the equipment prior to use but not immediately after use. Plastic containers were common for milking, and milk storage and these plastic containers could contribute to the unhygienic condition of the milk. The total bacterial count of cow milk produced in the urban and peri-urban were 7.11±0.86 $\log_{10}$ cfu /ml and 7.17±0.61 $\log_{10}$ cfu/ml, respectively. Higher (SCC/ml) was found in urban (6.17) areas of the study compared to the peri-urban areas (5.42). Microbial load of dry season milk was significantly ($p<0.05$) higher than wet season milk. Significantly higher total bacterial count (TBC) and coliform count (CC) was found for milk obtained from processing plant than milk collection center and dairy farmers. The total bacterial count (TBC) collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were 7.14±0.74 $\log_{10}$cfu/ml, 7.43±1.11 $\log_{10}$cfu/ml, and 7.84±0.54 $\log_{10}$cfu/ml respectively. The SCC collected from milk producers (MP), milk collectors (MC) and milk processing plants (MPP) were 5.68 log10 somatic cell/ml, 5.39 log10 somatic cell/ml and 5.87 log10 somatic cell/ml, respectively. Lack of clean water, lack of well-organized milk storing and cooling facilities, lack of processing technologies, limited awareness of milk handling, and cost and availability of milk utensils were the most frequently challenges affecting clean milk production. The overall prevalence of mastitis at cow and quarter level was 72.2% and 55.95%, respectively. The present study also showed that the occurrence of mastitis at the cow and quarter level was high, which can have high economic importance. The most important pathogens causing mastitis in the study area was Staphylococcus species followed by Streptococcus species, Hoof overgrowth with no hoof trimmings practice, wet and crackly floor were the management risk factors found positively associated with the prevalence of lameness. Repeat breeder, RFM and abortion were the most important reproductive problems.The present study revealed that the overall seroprevalence of bovine brucellosis at the animal level was 1.2%. In this study, it was found a very low-level seroprevalence at the individual animal level. History of abortion and retained placenta were found to be important risk factors associated with the occurrence of bovine brucellosis. Lack of calving pen and poor awareness of dairy owners on the zoonotic

importance of brucellosis and consumption of unpasteurized milk, assisting parturition and handling of aborted materials were to be risk factors for human brucellosis and induce the high risk of to animals and public health.

6.2. Recommendations

Based on the findings, the following recommendations could be drawn:

- Dairy production is found to contribute to food security; family income, and job opportunity. However, the problem of land, feed shortage and quality, shortage of replacement stock should be resolved. To bring these farmers, professionals, different institutions, and policymakers should work together. Especially improved dairy technologies, like reproductive technologies that improve yearly calving and production of improved feed within limited space and increasing the digestibility and nutritive quality of available feed should be done on. Awareness should be created to farmers through repeated training.
- Government and non-governmental organizations, feed supplying companies be made-up to initiating expansion of improved dairy feed production and feed processing plants.
- Dairy breed stock/replacement breeding center should be established to improve growth rate,production and productivity of dairy cattle in the study areas
- Strong standardization and regulatory system should be implemented on feed processing plants as well as dairy product processing plants so as to the importance of quality feed and hygienic milk production.
- Record keeping should be set up at farm level for sound breeding plan and farm managements. Strengthen veterinary services to reduce the mortality and morbidity of dairy cattle.
- Strengthen enabling institutions that support farmers, such as dairy cooperatives, milk collection centers, marketing, credit, and extension and training services.

- Introduce and strengthen regulatory functional system in place, awareness should be created among households as to the importance of hygienic milk production, handling, transporting and processing. Moreover, creating awareness among handlers of milk on the nutritional, health as well as income benefits of hygienic production, processing and further handling of milk.
- Avoid microbial contamination of milk through properly milking, timely delivering to milk collection center and proper storage.
- Farm owners must be educated on the importance of regular testing for subclinical mastitis as well as, standard milking procedure, such as pre and post milking udder washing should be applied to reduce the risk of transmission.
- Adequate housing with proper sanitation of the cow's barn and bedding to reduce environmental mastitis.
- Dry cow therapy should be applied to reduce the occurrence of new infection after parturition.
- Awareness creation on the impact of lameness in dairy sector is needed. Claw/hoof trimmings should be exercised as well as attention to the hygiene of dairy cattle and flooring quality of the barn should be given.
- Control measures such as isolation or culling of aborted animals, proper disposal of the aborted fetuses, pasteurization or boiling of milk before consumption should be carried out to reduce the risk of infection and transmission of the disease in animal and human in the study area.
- Further research is needed detailed characterization of various pathogens that might cause public health hazards in milk and antimicrobial sensitivity of the organisms must be investigated.
- Further research is needed on the major reproductive health disorders in the area.
- Further isolation and identification based on biochemical and molecular techniques should be carried out to isolate and identify Brucella species in order to design evidence-based disease control measures.

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8. APPENDICES

APPENDIX 1. Analysis of variance and other supplementary tables

Appendix Table1. Summary of ANOVA table for milk composition (%) of production systems

Fat	**DF**	**Sum of squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	2.96	2.96	4.00	0.05
Error	239.00	176.87	0.74		
Corrected Total	240.00	179.82			
Lactose	**DF**	**Sum of squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	0.50	0.50	2.46	0.12
Error	239.00	48.06	0.20		
Corrected Total	240.00	48.55			
Density	**DF**	**Sum of squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	4.03	4.03	7.10	0.01
Error	239.00	135.67	0.57		
Corrected Total	240.00	139.70			
Protein	**DF**	**Sum of squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	1.29	1.29	14.36	0.00
Error	239.00	21.39	0.09		
Corrected Total	240.00	22.67			
Water	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	335.71	335.71	6.10	0.01
Error	239.00	13147.93	55.01		
Corrected Total	240.00	13483.64			
Freezing_point	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	0.01	0.01	0.78	0.38
Error	239.00	3.75	0.02		
Corrected Total	240.00	3.76			
Ash	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	0.03	0.03	7.19	0.01
Error	239.00	0.97	0.00		
Corrected Total	240.00	1.00			

Appendix Table 2. Summary of anova table for milk composition (%) of different milk collection points

Fat	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	0.67	0.33	0.45	0.64
Error	266.00	198.63	0.75		
Corrected Total	268.00	199.29			
Lactose	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	1.44	0.72	3.05	0.05
Error	266.00	62.65	0.24		
Corrected Total	268.00	64.09			
snf	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	8.41	4.20	6.34	0.00
Error	266.00	176.27	0.66		
Corrected Total	268.00	184.68			
Protein	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	2.26	1.13	11.04	<.0001
Error	266.00	27.21	0.10		
Corrected Total	268.00	29.46			
Water	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	1041.51	520.76	7.50	0.00
Error	266.00	18462.72	69.41		
Corrected Total	268.00	19504.23			
Freezing point	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	0.04	0.02	1.19	0.30
Error	266.00	3.92	0.01		
Corrected Total	268.00	3.95			
Ash	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	0.07	0.03	7.08	0.00
Error	266.00	1.25	0.00		
Corrected Total	268.00	1.32			
Total	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	13.67	6.84	3.69	0.03
Error	266.00	492.27	1.85		
Corrected Total	268.00	505.94			

Appendix Table 3.summary of Anova table for milk composition (%) by season.

Fat	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	3.55	3.55	4.82	0.03
Error	239.00	176.27	0.74		
Corrected Total	240.00	179.82			
Lactose	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	0.02	0.02	0.10	0.76
Error	239.00	48.53	0.20		
Corrected Total	240.00	48.55			
Snf	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	1.03	1.03	1.78	0.18
Error	239.00	138.67	0.58		
Corrected Total	240.00	139.70			
Protein	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	0.61	0.61	6.65	0.01
Error	239.00	22.06	0.09		
Corrected Total	240.00	22.67			
Water	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	333.69	333.69	6.06	0.01
Error	239.00	13149.95	55.02		
Corrected Total	240.00	13483.64			
FP	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	0.00	0.00	0.20	0.66
Error	239.00	3.75	0.02		
Corrected Total	240.00	3.76			
Ash	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	0.01			
Error	239.00	0.99	0.01	2.08	0.15
Corrected Total	240.00	1.00	0.00		
Total solid	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1.00	8.42	8.42	5.14	0.02
Error	239.00	391.60	1.64		
Corrected Total	240.00	400.02			

Appendix Table 4.summary of anova table for milk microbial quality (%) by production systems

TCC	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	0.07	0.07	0.09	0.77
Error	93.00	79.63	0.86		
Corrected Total	94.00	79.71			
TBC	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	1.23	1.23	2.30	0.13
Error	93.00	49.59	0.53		
Corrected Total	94.00	50.81			

Appendix Table 5.Summary of Anova Table for Milk Microbial Quality (%) By Season.

TCC	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	0.75	0.75	0.96	0.33
Error	103.00	80.19	0.78		
Corrected Total	104.00	80.94			
TBC	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1.00	16.90	16.90	43.33	<.0001
Error	103.00	40.16	0.39		
Corrected Total	104.00	57.06			

Appendix Table 6. Summary of ANOVA table for milk microbial quality (%) by collection point

TCC	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2.00	29.06	14.53	18.17	<.0001
Error	130.00	103.95	0.80		
Corrected Total	132.00	133.00			
TBC	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	2.00	4.94	2.47	3.94	0.02
Error	130.00	81.56	0.63		
Corrected Total	132.00	86.51			

Appendix II. The questionnaire used to collect household level data

Questionnaire ID _____1. District/Town _____kebelle_____

1. Producer (households') characteristics

1. Gender of household head 1/Male……2/ Female……

2. Age of household head (yrs) _____

3. Marital status: 1/ Married… 2/ Single… 3/ Divorced…. 4/Widowed…

4. Number of family members in the household_____

5. Education level of the respondent

   1/ Illiterate…… 4/ 9-12 grades

   2. Reading and writing 5/Diploma holder

   3/1-4 grades 7/ Degree holder

   6/ 5-8 grades……..... 8/Others, specify_____

6. Major occupation of household head:
   1/ Government employee… 2/ Retired government employee…...
   3/ Non-government employee… 4/ Daily laborer… 5/ Trader…… 5/ Other, specify_____
7. Land holding/farm size (hectares) _____
8. Rank of major income sources of dairy producers?

Sources of income	**Rank (1,2,3…)**
Dairy production	
Crop production	
Trade	
Public organization employment	
Private company employment	
Other sources	

9. Experience in keeping dairy animals (yrs)? 1) 1-5… 2) 5–10…3) >10 …
10. How did you get the (dairy) cattle when you first set up your dairy farm? 1/Gift from family …. 2/ Gift from NGOs … 3/ Purchased from local market …. 4/ Given from relatives and/friends …. 5/ Rearing (own source) … 6/ Other, please specify_____

11. Livestock Type and Herd Composition

	Livestock type	Composition	Average Number
Cattle	Milking cows	Local	
		Crosses	
	Pregnant cows	Local	
		Crosses	
	Non-pregnant cows	Local	
		Crosses	
	Dry cows	Local	
		Crosses	
	Total cows	Local	
		Crosses	
	Oxen	Local	
	Heifers	Local	
	Bull	Crosses	
		Crosses	
	Female calves	Local	
		Crosses	
	Male calves	Local	
		Crosses	
Sheep			
Goats			
Chicken			
Horses			
Donkeys			
Mules			

12. Who is responsible for following dairy management activities? (Tick)

activities	< 14 Children		15-30 age		31-60 age		>61 age		Heired labour	
	male	Female	male	Female	male	Female	male	Female	male	Female
Herding										
Milking										
Fedding										
Watering										
Barn cleaning										
Milk deliver										

13. Rank Purposes of cross breed dairy cattle keeping?

Purpose of keeping dairy cattle	Rank (1,2,3….)
Sell milk(income generate)	
Milk for home consumption and sell	
For asset	
Manure	
For sale of calves/heifer	
Milk and meat	
Growing males for ploughing	

2. Reproductive and production performance of dairy cattle

S. No.	Performance/Parameters	1. Crossbred 2. Local 3. Jersey	
1	Age at first service (month)		
2	age at first calving (month)		
3	Calving interval (month)		
4.	Intervals from calving to conception (CCI)(days)		
5.	Average milk yield /day/cow (in liters)	early lactation	
		mid lactation	
		late lactation	
6	The average number of SPC		
7	Lactation length (days)		
8	Calf weaning age (month)	Male	
		Female	
9	Culling age of cafe (month)	Male	
		Female	

3. Dairy cattle husbandry practices

A. Housing system and wat managements

14. What kind of housing materials do you use? (Tick)

Housing material	Floor	Wall	Roof
Iren sheet			
Grass			
wood			
soil			
stone			
concert/cement			

15. Is there separate house for dairy cattle? 1/ Yes 2 /No
16. If yes what is the housing type for dairy cattle? 1/. Open sided house 2/Closed sided house 3/ Normal house 4/ No separate house 5/ Others _____
17. If no separate house, how you keep them? 1/ Together with other animal 2/ Together with family 3/ Freely in the compound 4/ Others _____
18. What facilities do you have in barn? 1/ feed trough 2/ water trough 3/ other (specify)_____
19. Frequency of barn cleaning per day? 1/ once per day 2/ twice per day 3/ three times per day 4/ once per day
20. Waste management specifies the use of dung? 1/Bio gas production 2/ Dung cake 3/ for manure 4/ Dump in a pit for dry season use

B. Feed resources and feeding systems

21. What are the main types of dairy cattle feeding systems? 1/ Grazing 2/ Tethering 3/ Stall feeding 4/ Combination of feeding systems 5/ Other ____
22. Do you use feed supplements for your dairy cattle? 1. Yes 2. No
23. Frequency of providing feed supplements for dairy cattle and/cows 1/. Once a day 2/. Twice a day 3/. Three times a day 4/. Four times a day 5 / Nosupplements
24. How frequently do you provide water for dairy cattle and/cows? 1/ Roam freely 2/ Once a day 3/Twice a day 4/ Three times a day 5/ Every other day 6/ Other ____

25. Feeding source for dairy cattle?

	Type of feeds (%)	Owned	Purchased	Communal	Availability Season (a. wet, b. dry)	Feed constraints (a. poor quality, b. seasonal vailability, c.high price)
1	Feed resource					
2	Hay /Bale					
3	straw /Bale/*kirbet*					
4	improved forage					
5	Areki (ethanol) residues					
6	Brewery by product					
7	Oil seed cake					
8	Wheat bran					
9	Common salt					

26. Which Crop residue mainly used for dairy cows? (Rank them 1-6) 1/ teff straw—2. Barly straw____3/ wheat straw___4/bean straw____5/faba bean starw__6/oat straw_____
27. Do you have experience of growing improved forages? 1/ Yes……2/ No….
28. If no, why not to grow? 1/ Land problem….2/ Seed problem…….3/ Luck of awareness… 4/ Others……....
29.

C. Water provision

30. Source of drinking water for your dairy herd, distance from farm and way of watering

	Source of water	Distance from the farm, Km	Mode of watering (a. move animals to watering point, b. transport water from water source to farm)	Drinking water constraint (a. seasonal availability, b. poor quality, c. long distance)
1	Tap			
2	River			
3	Spring			
4	Borehole			
5	Rain water			

31. How frequently do you provide water for dairy cattle and/cows? 1/ Roam freely 2/ Once a day 3/ Twice a day 4/ Three times a day 5/ Every other day 6/ Other ____

D. Breeding system

32. What is your breeding system?

	Type of mating	Tick it (√)	Source if natural mating (a. bull station, b. own, c. neighbor farmer)	Source of semen if AI (a. NAIC/BoA, b. ALPPIS, c. Private AI technician, d.NGO)	Payment per service
1	AI				
2	Natural mating				
3	Both				

33. 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_____
34. Do you have experience/system of detecting estrous? 1/ Yes…… 2/ No……
35. If yes, how do you detect estrous period? 1/ Herdsman information… 3/ Follows up during morning &night.. 2/ Using teaser bull… 4/ Other, specify_____
36. Do you have an experience of using AI? 1/ Yes… 2/ No……
37. 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_____
38. Distance from insemination centre _____1/ <1Km …. 2/ 1-5Km … 3/ >5Km…
39. Have you faced failure of artificial insemination? 1/ Yes… 2/ No….
40. If yes how many times? 1/ One… 2/Two… 3/ Three… 4/ More than four..
41. 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_____
42. What alternative do have taken when AI service interrupted? -----1/ Privet exotic bull 2/ Home bred exotic bull…3/ Using own local bull … 4/ Using exotic bull at communal. 5/ Extending the mating time ..... 6/ Other, Specify_____
43. 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 _____
44. 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 breed bull… 5/Community owned cross bred bull…
45. Replacement females 1/ Rise on own farm… 2/ Buy……3/ Rise own and buy 4/ Other, specify___

E. Disease and Veterinary services

46. Ranking of major dairy cattle diseases in the study areas? ----------

Parameter	**Rank them according to their importance (1, 2, 3, 4…),**
Mastitis	
Black leg	
Foot and mouth disease	
Parasites	
Lumpy skin disease	
Anthrax	
Other benefits (please specify)	

47. Who provides dairy veterinary services? 1/ Government actors … 2/Private actors….
48. Distance to veterinary services 1/ <1km.. 2/ 1-5km…3/ 6-10km…4/ >10km…

F. Record keeping practices

49. Is there any practice of recording keeping? 1/ yes 2/ no
50. If yes for the above question, which record? 1/ service date 2/heat record/estrus day 3/calving date 4/milk production per day 5/ Other (Specify) _____

4.**Constraints of dairy cattle production**

51. What are the major constraints of dairy production in your farm?

S. N	Constraints	Rank them 1-11
1	Shortage of feed	
2	High cost of feeds	
3	Prevalence of diseases	
4	Poor quality of feeds	
5	Shortage of improved dairy cattle	
6	Poor veterinary services	
7	Inadequate water supply	
8	Lack of land	
9	Lack of AI/breeding service	
10	Space limitation for dairying	
11	Manure handling/disposal	

6. Milk production and selling practies

52. How frequent do you milk your cows per day? 1/ thrice 2/ twice 3/once
53. If hand milking, who milks? 1/ husband 2/ housewife 3/daughter 4/ son 4/hired labour
54. What types of suckling practice do you follow? 1/ Partial suckling (for few minutes before milking) 2/ Partial suckling (for few minutes after milking) 3/Partial suckling (for few minutes before and after milking) 4/ Bucket feeding
55. How long do you allow partial suckling your calf? 1/ full lactation 2/until 5-7 months 3/ until 2-4months 4/ 8-12 months 5/no suckling at all
56. Where do you sell your fluid milk and other milk product(s)? _____
57. 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…
58. Milk production and consumption per day

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

59. If you consume the milk at home in what form of do you use? 1/ Raw milk …2/ Ergo (naturally fermented) 3/ boile …4/Raw milk and boil form..
60. How often do you deliver milk to the center? 1/Twice a day. 2/ Once a Day ..3/ Once every other day..
61. Price of milk/liter at collection center or copperatives? __
62. How do you transport milk to market place/retailing shops? 1/ Bicycles … 2/ Motor vehicles …3/ Go by foot…....4/ Cart ……5/ Situated on site……..
63. how far is your place to deliver the milk? 1/ Less than 1 km.. 2/ 1-5 km …3/ >5 km.

61. Has your milk been rejected by the collection center /buyers in the last one month? 1/ Yes… 2/ No…

64. If yes, why was it rejected?.....1/ Abnormal colour.. 2/ Failed alcohol test….3/ Abnormal smell…4/Dirtiness…5/Adulteration…6/Other (Specify)_____
65. Do you do any milk test before delivering milk to the collection centre? 1/ Yes…2/ No

66. If yes, which are these tests? 1/ Alcohol test ….. 2/ Clot on boiling test...3/ Microbial test… 4/ Organoleptic test…..5/ Lactometer test…...

7. Cow and personal hygiene

67. Type of milking and storage equipment?1/ clay pot 2/ metal/can 3/ plastic equipment
68. If you wash your hand, what do you use? 1/ water alone 2/ water and soap/disinfectant 3/ others (specify) _____
69. If you wash your hands, do you dry them before milking? 1/ yes 2/ no
70. If you dry your hands, what do you use? 1/ disposable towels 2/ re-usable towels 3/ others (specify) ---
71. Do you wash your cow"s udder during milking? 1/ yes 2/ no
72. If yes, when do you wash it? 1/ washing udder before milking 2/ washing udder after milking 3/ washing before and after milking
73. If you wash the udder, what do you use? 1/ individual towel 2/ collective towel 3/ bare hands
74. If you use the udder cloth, how often do you wash it? 1/ daily 2/ weekly 3/ never
75. If you wash the udder during milking, what do you use? 1/ cold water alone 2/ only with warm water 3/ with soap and warm water 4/ not washing at all
76. What kinds of sanitary measures are taken for milking, storage and churning equipments of products? 1/ washing with hot water 2/ smoking with plants 3/ washing with plants 4/ others (specify)----------
77. What types of plant use for smoking to the milk utensils? 1/ Woira (Olea africana) 2/ Tid (Juniperous procera) 3/ others (specify) -----------
78. Why do you use these smoking plants? 1/ for good aroma and flavor 2/ to increase the shelf life of milk 3/ facilitate fermentation 4/ others (specify)----------
79. How frequent do wash milk utensils? 1/ always after used 2/ once a day 3/ twice a week 4/ others (specify)---------
80. Source of water used for cleaning purpose (cleaning udder, hands and milk utensils)? 1/ tap water 2/ river 3/ borehole 4/ others (specify)-------
81. What do you use to filter the milk? 1/ Muslin close 2/Sieve 3/ Others (specify)
82. What are the constraints/challenges you are facing in milk marketing?

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

8. Membership of dairy cooperatives

83. Are you a member of dairy cooperatives? 1/yes 2/ no
84. If YES when did you join (year)? -----Name of dairy cooperative ----------
85. Initially where did you get information to be a member of dairy cooperative?1/ district cooperative office 2/ NGO 3/ member of dairy cooperatives 5/ others (Specify) -------
86. What are the main reasons that motivated you to be member of dairy cooperatives? 1/ To get secured/regular market outlet for the milk I produce 2/ To get easy access to dairy farm inputs (feed, credit and breed…) with fair price 3/ Others (specify) –

9. Service providers

87. Inputs/service providers involved milk production

	Providers	Support provided: a. extension services, b. credit Services, c. Provision of AI services, d. Feeds, e. Fodder seeds, f. Breed, g. Churner, h. others (specify)							
		A	B	C	D	E	F	G	H
1	Wereda Agri. Office								
2	NGO (describe it)								
3	Wereda cooperative office								
4	Private dairy input provider								
5	Micro finance institution								
6	Commercial bank of Ethiop								
7	Research center (specify)								
8	University (specify)								

88. If your answer is no to Question 63, what are the reasons? 1/ No credit facility in the area 2/ Lack of information of financial services 3/ High interest rate 4/ Others (please specify) _____

89. Did you receive any kind of training about milk production? 1/ Yes 2/ No

90. If yes, who provided the training?

Training provider	Rank	Frequency of training	Year of training was provided
My Cooperative			
NGOs			
Union			
Government			
Private traders			
Other (specify)			

87. What was the training about? (rank) 1/ Proper milking practices____2/ Quality management ___3/ Proper animal handling____ 4/ Milk storage system____5/ Record keeping___6/ Other (specify)_____

88. Please kindly indicate how you benefited from the training? 1/ Increased milk production 2/ Improved quality of product 3/ Timely marketing to fetch higher prices 4/ Advanced marketing strategies 5/ Effective dissemination of information among players 6/ Other, specify..

10. Questionnaire format mastitis prevalence

Owners Name: _____Address_____
Date of sample Collection_____
1. Cow History:
Breed_____age___calving date____parity_____previous history of mastitis___milk yield___
Teat Lesion: present_____absent_____
Gross milk quality: watery____bloodtinged____clots/flakes___ normal___
Sample collected from: RR___RF____LF___LR_____
CMT score: RR___RF____LF___LR_____
2. Milking practice:
Manual_____ or using milking machine_____
Do you wash udder before milking? yes____ no____
Do you dry after washing? yes____ no____

Do you use the same cloth for all teats? yes____ no____
Do you practice milking mastitic cows last? yes____ no____
Do you wash your hand before milking and after milking one cow? Yes___ no___
3. Housing:
Floor concrete_____stone_____soil_____slopy_____leveled_____
Roof: metal sheet_____ grass_____
Wall: concrete_____stone _____other_____
Manure removal: daily_____weekly____monthly____other (specify) _____
5. Do you practice good milking procedures? Yes___ no____
6. Have you ever used teat dipping after milking? Yes___ no___ if yes, what type?

11. Interpretation of CMT findings source: Quinn *et al*. (1999)

Score	Interpretation	Visible reaction
0	Negative	Milk fluid and normal
T (Trace)	Trace	Slight precipitation
1	Weak positive	distinct precipitation but no gel formation
2	Distinct positive	Mixture thickens with gel formation
3	Strong positive	Viscosity greatly increased strong gel that is cohesive with a convex surface

12. Description of the five point locomotion systems.

Locomotion score	Picture	Description by Sprecher *et al*. (1997)	Description by Konig (2009)
1		**Normal** Normal gait. Level back posture while walking	**The cow does not have uneven gait at all** - No signs of uneven gait - Even weight bearing between legs - The back is flat while walking - No signs of head bob
2		**Mildly lame** Normal gait. Level back posture while standing, but back arched while walking	**The cows has a slightly uneven gait** - The cow might walk almost normally - The gait is often slightly uneven and the cow is likely to take shorter strides - But, there are no evident signs of limping or uneven weight bearing. - The back might be arched - No signs of head bob.
3		**Moderately lame** Gait affected, short Striding. Back arched while standing and walking	**The cow has uneven gait** Abnormal gait pattern - Walks with short strides on 1 or more leg(s) - In most cases, a trained observer will be able to tell which leg is affected (mild signs of uneven weight bearing) - The back is usually arched - But there may or may not be signs of head
4		**Lame** Back always arched. Only one deliberated step at a time, one or more limbs Favored.	**The cow has a very much uneven gait** - The cow is obviously limping on 1 or more leg(s) - An untrained observer will usually be able to detect the affected leg(s) - In most cases, the back is arched - Head bob will be evident
5		**Severely lame** Additionally, extreme reluctance to bear weight one or more limbs	**The cow has an extremely uneven gait** - The cow is unable, unwilling, or very reluctant to bear weight on the affected leg(s) - The back is arched - Head bob is evident and can be extreme

13. Questionnaire survey format for lameness

Enumerator‟s full Name _____-
Woreda:_____ Kebele_____

Farm owner‟s (attendant‟s) Full Name_____ sex___Age_____

1. Do you let your animals for exercise outside the barn? A. Yes B. NO

1.1. If yes, for how many hours do your animals be out of the barn? _____

2. Do you have farm production record? A. Yes B. No

2.1. Average milk yield per Cow per day _____litter.

3. What kind of beddings do you use on the farm? A. sagatora B. Straw C. No beddings

4. Do you have any footbath practices? A. Yes B. No

5. Do you have regular hoof trimming practices? A. Yes B. N

6. Is there any abnormal gaits observed before? A. Yes B. No

6.1. If yes, which legs do have gait problems predominantly? A. Hind Legs B. Front legs C. Both

7. What do you do with identified lame animals at your farms? _____

8. Do those lame cows give similar amount of milk per day/lactation as they were healthy ? A. Yes B. No

14. Observational data registration format

No	Animal id	Name of the farm	Age	Foot and leg problems						LS(1-5)	Leg Affected	Average daily milk yield
				Foot rot	Excessive hoof growth	Heel and sole cracks	Sole abscesses and hemorrhages	Swollen joints and abscesses	Traumatic Injury			
1												
2												
3												
4												
5												
6												
7												
8												
9												

15. Information on brucellosis and other reproductive disease

1. Herd size …….
2. Farm location: 1. Urban 2. Peri-urban
3. What type of farm management system do you have?
   1. Intensive 2. Semi-intensive 3. Extensive
4. What is the number of anestrus animals in the farm? 1. Cows____2. Heifers:____
5. Were any of your cattle encountered reproductive diseases or problems in the past? 1. YES 2. NO

5.1. If yes, what reproductive diseases or problems were observed?

_____

6. Did any of your cows suffer from abortion? 1. YES 2. NO

6.1. If yes, what month of the pregnancy abortion was occurred? 1. Before 3 months 2. Over 6 months 3. 3 to 6 months

7. Did any of your cows or heifers give birth to a dead calve at a normal gestation length (9 months) in the past? 1. YES 2. NO

7.1. If yes, how many cows? _____

8. Did any of your cows suffer from dystocia in the past? 1. YSE 2. NO

8.1. If yes, how many of your cows suffered from dystocia? _____

9. Did any of your cows suffer from Metritis in the past? 1. YSE 2. NO

9.1. If yes, how many of your cows suffered from Metritis?

10. Did any of your cows or heifers suffer from vaginal, uterine prolapse in the past? 1. YSE 2. NO

10.1. If yes, number of cows or heifers with vaginal prolapse? _____; uterine prolapse? ____

11. Did any of your cows encounter retained fatal membranes in the past? _____

12. Have any of your cows or heifers been repeater (repeat breeder)?

12.1. If yes, what do you think the cause/s for the animal to come back in to estrus again? _____

13. Did any of your animals come to estrus, but missed insemination or mating in the past? 1. YES 2. NO

13.1. If yes, why was the animal not inseminated or mated? 1. Lack of bull 2. Lack of AI technician 3. Lack of means of communication to AI technician 3. Called AI technician, but did not come to inseminate or did come very late 4. Reproductive tract problem 5. Size of the animal was very small to breed 6. .Lack of nutrition 7. All or some of the above causes

14. Did any of your animals suffer from any health problem other than reproductive health?

14.1. If yes, please describe the disease and signs the animals showed_____

15. What type of mating service do you have for your animals? 1 .AI 2. Bull 3. Both
16. What type of breed of cattle you reared at your farm? 1. Local breed 2. Jersey 3. Cross
17. Where do you get the replacement stock? 1. Market 2. Raise own replacement 3. Both
18. Are there separate parturition pen? 2. Yes 2. No
19. How many animals did you see with abortion at any time within 5 years? 1. Yes 2. No
20. Have you seen any retention of placenta after birth? 1. Yes 2. No
21. What do think the cause of abortion (just to know farmers' perception?) _____
22. What is the local name for disease that causes abortion? If any 9. Do you assist the dairy cows during parturition? 1. Yes 2. No

22.1. If yes do you use protective gloves (masks) when assisting with the parturition (abortion of animals) handling placentas and aborted fetuses? 1. Yes 2. No

23. Where do you dispense placentas, dead fetus and aborted fetuses? 1. Water canals 2. Throwing on field 3.Burying 4. Feed to dog
24. What do you do when your animal is infected with Brucella? 1. Separate the infected animal 2. Hot sell to neighbor 3. Sell to neighbor 4. Sell to market 6.Call the local veterinarian 7.Buy a vaccine or treatments 5.Sell to butcher
25. Do you separate aborted animal from to other? 1. Yes 2. No

26. Have you ever heard of brucellosis ? 1. Yes 2.No
27. Do you consume raw meat of cattle? 1. Yes 2.No
28. Do you consume raw milk of cattle? 1. Yes 2. No
29. How do you clean of calving pen? 1. Flushing with water 2. Disinfect with detergent 3. No sanitation service 4. Other (specify)
30. Do you believe that brucellosis can be transmitted to humans? 1. Yes 2. No

30.1. If yes, what do you believe the means of transmission? 1. Physical contact with animals 2. through contact with Fetuses' or total membranes 3. Through drinking

30.2. contaminated raw milk 4. Through contact with untested humans

31. What are the symptoms of this disease? (Mention) 1. No symptoms 2. Abortion 3. Drop in milk production 4. Fever 5. Loss of appetite 6. Loss of body weight 7. Other (specify)_____
32. How do you delivering of feed and water supply? 1. Own 2. Communal 3. Both
33. Have you ever cull your animals from your farm. 1. Yes 2. No
34. If yes culling criteria? 1. Reproductive problem 2. Feed shortage 3. Decrease milk production 4. Other (specify) _____

16. Questionnaire formats for serum sample collection to individual cattle

NO	Were da	PAS	Production systems	Herd Size	Breed	Sex	Age	Parity	Mating	R. Status	Abortion	Rfm	Testicular swealing
1													
2													
3													
4													
5													
6													
7													
8													

Thank You Very Much!!!

Appendix III. Sample pictures of interview with urban and peri-urban dairy producers and situation of dairy farms.

Figure1. Sample pictures of interview with urban and peri-urban dairy producers

Figure2. Blood sample collection

Figure3. Dairy cattle housing

Figure4.hoof overgrowth of lactating cow

Figure5. Milk transporting system

Figure 6. CMT result

Appendix IV. List of publications

Admasu, L., Gebeyehu, G., Ashenafi, M., Gezahegne, M., & Tilaye, D. (2019): Dairy Cattle Husbandry Practices in Selected Urban and Peri-Urban Milk Shed Areas of North Shoa Zone, Ethiopia, *World Journal of Agricultural Sciences***15** (2): 86-92.

Lakew, A., Goshu, G., Mengistu, A., Mamo, G., & Demissie, T. (2019). Socio-Economic Characteristics of Urban and Peri-Urban Dairy Production Systems in Selected Weredas of North Shoa Zone Milk Shed Areas, Ethiopia.*Advances in Biological Research* **13** (1): 24-29.

Lakew, A., Goshu, G., Mengistu, A., Mamo, G., & Demissie, T. (2019). The Effect of Different Seasons on the Milk Quality in Central Highlands of Ethiopia, *Global Veterinaria,* **21** (2): 77-81.

Lakew, A., Goshu, G., Mengistu, A., Mamo, G., & Demissie, T. (2019). Handling, processing, and marketing of milk in and around Debre Berhan milk shed areas, Central Highlands of Ethiopia, *http://www.academicjournals.org/AJAR*.

Lakew, A., Goshu, G., Mengistu, A., Mamo, G., & Demissie, T. (2020). Physicochemical properties and microbial quality of raw cow milk collected from Debre Berhan milk shed, central highlands of Ethiopia, *http://*www.*academicjournals.org/ajmr.*