ASSESSMENT OF MILK PRODUCTION PRACTICES AND MICROBIAL QUALITY OF COW MILK PRODUCED IN ALETAWONDO DISTRICT, SIDAMA REGIONAL STATE, ETHIOPIA

M.Sc. THESIS

ASHENAFI SHARO SHALAMO

HAWASSA UNIVERSITY

COLLEGE OF AGRICULTURE

HAWASSA, ETHIOPIA

JULY, 2021

ASSESSMENT OF MILK PRODUCTION PRACTICES AND MICROBIAL QUALITY OF COW MILK PRODUCED IN ALETAWONDO DISTRICT, SIDAMA REGIONAL STATE, ETHIOPIA

BY

ASHENAFI SHARO SHALAMO

ADVISORS: - MESTAWET TAYE (Ph.D, ASSOCIATE PROFESSOR)

SINTAYEHU YIGERM (Ph.D, ASSISTANT PROFESSOR)

ATHESIS SUBMITED TO THE SCHOOL OF ANIMAL AND RANGE SCIENCES, COLLEGE OF AGRICULTURE, HAWASSA UNIVERSITY

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN ANIMAL AND RANGE SCIENCES, (SPECIALAZATION: DAIRY SCIENCE AND TECHNOLOGY)

HAWASSA, ETHIOPIA

JULY, 2021

HAWASSA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

ADVISORS' APPROVAL SHEET

(Submission Sheet-1)

This is to certify that the thesis entitled ***"Assessment of Milk Production Practices and Microbial Quality of Cow Milk Produced in Aletawondo District of Sidama Regional State"*** submitted in partial fulfilment of the requirements for the degree of Masters with specialization in *Dairy Science and Technology,* the Graduate Program of the School of Animal and Range Sciences has been carried out by *Ashenafi Sharo Shalamo* ID.No.GpDaScR/0003/11, under my/our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Mestawet Taye (Ph.D, Associate Professor)	____________________	_____________________
Name of major advisor	Signature	Date
Sintayehu Yigrem (Ph.D, Assistant Professor)	___________________	______________________
Name of co-advisor.	Signature	Date

HAWASSA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

EXAMINER'S APPROVAL SHEET

(Submission Sheet-2)

We, the undersigned, members of the Board of Examiners of the final open defence by ***Ashenafi Sharo Shalamo*** have read and evaluated his/her thesis entitled ***"Assessment of Milk Production Practices and Microbial Quality of Cow Milk Produced in Aletawondo District of Sidama Regional State"*** and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfilment of the requirements for the degree.

________________________________	________________	___________________
Name of Major Advisor	Signature	Date
________________________________	________________	___________________
Name of Internal Examiner-I	Signature	Date
________________________________	________________	___________________
Name of Internal Examiner-II	Signature	Date
________________________________	________________	___________________
Name of External examiner	Signature	Date
________________________________	________________	___________________
SGS Approval	Signature	Date

Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the school of graduate studies (SGS) through the Department/school graduate committee (DGC/SGC) of the candidate's department.

Stamp of SGS________________ Date_________________________

ACKNOWLEDGEMENTS

First and for most, I would like to thank the Almighty God for the successful completion of this thesis and for all the achievements which I have been able to attain in my entire life.

I would like to thank my advisors Dr. Mestawet Taye and Dr. Sintayehu Yigrem for their relevant suggestion, help, constructive advice and time devotion to correct this manuscript.

I would like to acknowledge all the dairy science and technology laboratory staff for their technical support during laboratory analysis.

I would like to acknowledge the NORAD project for their financial support of the study.

I would like to express my heartfelt thanks to Aroressa Woreda of Sidama region for sponsoring my postgraduate study at Hawassa University for granting study leave and paying my salary during the study period.

Finally, I would like to thank my family and friends for their continued supports and encouragement during this research work.

STATEMENT OF AUTHOR

I declare that this thesis is my bonafide work and that all sources of materials used for this thesis has been duly acknowledged. This thesis has been submitted in partial fulfilment of the requirements for M.Sc. degree at Hawassa University, College of Agriculture and is deposited at the University library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however permission must be obtained from the author.

Name: Ashenafi Sharo Shalamo Signature: _____________

Place: College of Agriculture School of Animal and Range Science, Hawassa

Date of Submission: ___________________________

DEDICATION

I dedicate this thesis manuscript to my beloved mom, Godantu Gatamo, and my lovely father Sharo Shalamo and all my sisters and brothers for nursing me with affection and love and for their dedicated partnership in the success of my life.

LIST OF ABBREVATIONS

ANOVA	Analysis of Variance
AWDARD	Aleta Wondo District of Agricultural and Rural Development
CAC	Codex Alimentarius Commission
CDC	Center for Disease Control and prevention
CDFA	California Development of Food and Agriculture
CSA	Central Statistical Agency
ESAP	Ethiopian Society of Animal Production
ES	Ethiopian Standard
EU	European Union
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
ILRI	International Livestock Research Institute
IDF	International Dairy Federation
MOA	Ministry of Agriculture
MOARD	Ministry of Agriculture and Rural Development
MSA	Manitol Salt Agar
PDA	Potato Dextrose Agar
SCC	Somatic Cell Count
SPC	Standard Plate Count
SPSS	Statistical Package for Social Science
VRBA	Violet Red Bile Agar

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Assessment of milk production practices and microbial quality of cow milk produced in Aleta wondo district, Sidama Regional State, Ethiopia

By: Ashenafi Sharo

Advisors: Mestawet Taye (PhD) and Sintayehu Yigrem (PhD)

ABSTRACT

The purpose of the study was to assess milk production practices and to evaluate microbial quality of raw cows' milk in Aleta wondo district of Sidama region, Ethiopia. A multi-stage sampling procedure with combination of purposive and random sampling technique was employed for selecting the study area and sampled households. Systematic sampling method was used to select respondents from each selected kebele proportionally. The study was conducted by interviewing purposively selected 195 smallholder milk producers from five kebeles from two agro-ecologies (highland and midland) who owned local and crossbred cows. Milk samples were collected from 40 milk producers, small shops, cafes and consumers for microbial quality analysis. The overall average daily milk yield and lactation length for local dairy cows and crossbred dairy cows were 1.55±0.08 liter/day, 8.21±0.99 months and 6.67±0.17 liter/day, 9.31±0.04 months, respectively. The estimated average daily milk yield varied significantly (P<0.05) among the agro ecologies. The result indicated that majority of the respondents (91.3%) did not have cow barn and milking area, 60% of them clean their barn once and more than once a week. Moreover, milking without hand washing, absence of udder washing and failure to use towel to clean the udder were practiced by 34.4%, 52.3% and 73.3% of the respondents, respectively. Households used equipment for milking, transportation, storage and churning, clay pot, plastic, gourd and aluminum/stainless steel utensils to keep milk and milk products. The major source of water for cleaning purpose was tap, rivers ponds and well water. Majority of households 70.3% used cold water for washing milk handling equipment. Concerning microbial quality, overall average total bacterial counts (TBC), coliform counts (CC), yeast and mould (YMC) and Staphylococcus species(SC) values of milk from current finding were 5.699 ± 0.017, 4.689 ± 0.023 log10 cfu/ml,5.366±0.023 and 5.625 ± 0.027, respectively. The microbial load was higher (P<0.05) in different milk sources in the study area except staphylococcus species. In general, overall quality of milk produced as well as marketed in the study area was poor. These were justified from poor hygienic practices and high values of CC that were significantly higher than the acceptable limits set by Ethiopian Standards for unpasteurized milk. Therefore, adequate sanitary and control measures should be taken at all stages from production to consumer level to produce and supply wholesome milk.

Keywords *Agro ecology, Cow Milk, Hygienic Practices, Microbial Quality, Milk Production,*

1. INTRODUCTION

Ethiopia holds large potential for dairy development due to its large livestock population, favourable climate for improved and high-yielding animal breeds, and the relatively disease-free highland environment. Given the considerable potential for smallholder income and employment generation from high-value dairy products, development of the dairy sector in Ethiopia can contribute a lot to poverty alleviation and nutrition in the country (Demissu, 2014). The main source of milk in Ethiopia is from cow. However, small quantity of milk is also obtained from camel, goat and sheep in some regions particularly in pastoralist areas. Five major systems of milk production can be distinguished in the country, which includes; pastoral, agro pastoral, highland smallholders, urban and peri-urban (small and medium dairy farms in backyards in and around towns and cities) and intensive dairy farming system.

Milk from good hygienic production practices and the udder of a healthy cow contains very few bacteria. However, poor hygiene introduces additional bacteria that cause the milk to spoil very quickly. To ensure that raw milk remains fresh for a longer time, good hygiene practices are required during milking and when handling the milk afterwards (Lore *et al.*, 2006). Production of quality milk is a complicated process (Pandey and Voskuil, 2011). Milk is a complex biological fluid and by its nature, a good growth medium for many microorganisms, because of its high water content, nearly neutral pH, and variety of available essential nutrients (Teshome, 2013). The microbial content of milk indicates the hygienic levels during milking that includes cleanliness of the milking utensils, proper storage and transport as well as the wholesomeness of the udder of the individual cow (Speer, 1998).

The most commonly used microbial quality tests for milk and milk products include determination of total bacteria count (TBC) or standard plate count (SPC) and coliform count (CC). Estimation of yeast and mould counts is also useful for evaluating sanitary practices. Microorganisms can enter milk via the cow, air, feeds, milk handling and milking equipments and the milker. Once they get into the milk their numbers increase rapidly. It is therefore more effective to exclude microorganisms than trying to control their growth once they get access into the milk (O'Connor, 1994). Therefore, the microbial content of milk is a major feature in determining its quality (Karmen and Slavica, 2008). Additionally, traditional milk products such as Irgo (traditional Ethiopian yoghurt) and kibe (traditional Ethiopian butter) are also produced using raw milk without any heat treatment. Hence, the possibility of contamination with disease causing organisms is too high (Garmessa, 2014).

Poor hygiene, practiced by handlers of milk and milk products, may lead to the introduction of pathogenic micro-organisms into the products (Abebe *et al.*, 2012). Hygienic practices are the major factors to produce safe and quality products for consumption with minimum microbial contamination, and thereby reduce loss of products and improve the position of smallholder milk producers in marketing of quality milk and milk products (Amistu *et al.*, 2015, Holloway *et al.*, 2002, Zelalem, 2010).

In Sidama region, particularly Aleta Wondo district, milk production represents an important activity for the livelihood of farming community. However, little study which assessed the microbial quality, hygienic practices on milk production, under small holder condition has been conducted. Therefore, detail investigation of sanitary condition and microbial quality is very important to identify existing hygiene related problems in order to reduce the risk of public health as well as to improve the livelihood of smallholder dairy farmers by engaging them in quality milk production, handling and marketing of dairy products in the district. So far to assess the hygienic milk production and the microbial quality of cow's milk in Aleta Wondo district of Sidama Regional State.

Hygienic practices, microbial quality of cow milk and its public health importance along the dairy value chains are reported to be different in Sidama highlands (Mesfin, 2015). Therefore, this study was designed to filling the gap to evaluate hygienic milk production practices and identify the microbial quality of cow's milk in Aleta wondo district.

1.1. Objectives

1.1.1. General objective

- The overall objective of this study is to assess milk production practices and microbial quality of cow milk produced in Aleta Wondo district, Sidama Regional State, Ethiopia.

1.1.2. Specific objectives

- To assess the hygienic practices and production potential of the existing dairy production in the study area.
- To identify the microbial load of raw cow milk collected from smallholder milk producers, shops and consumers in the study area.

2. LITERATURE REVIEW

2.1. Dairy Production System in Ethiopia

Dairying in Ethiopia is practiced almost all over the country with the intensity of small, medium or large-sized; subsistence or market-oriented farms. The dairy system of the country is categorized based on agro-ecology characterization of the area or climate, socio-economic structures of the population, holdings, type of breed and species used for milk production and the integration with crop production as criterion (Getachew *et al.,* 2014). There are different classifications of dairy production systems in Ethiopia given by different scholars, but according to the dairy development and polices inventory, dairy systems in Ethiopia can be categorized under five systems of operation; pastoral (traditional pastoral livestock farming), Agro-pastoral (Traditional low land mixed livestock farming), mixed crop livestock system (traditional highland mixed farming), Urban and Peri-urban (the emerging smallholder dairy farming) and Commercial (specialized commercial intensive dairy farming) (Getachew *et al.,* 2014).

2.1.1. Pastoral milk production system

Pastoral systems are mainly found in the lowlands where livestock production is the dominant form of production to sustain the livelihood of pastoral society with no cropping (Tegegne *et al.,* 2013). About 30% of the livestock population in Ethiopia is found in the pastoral areas; which comprise 50% of the total land area of the country. Pastoralism is the major dairy production system in the lowland. Livestock doesn't provide inputs for crop production but they are the very backbone of their owners providing all of the consumable and saleable outputs, like for example milk, and regarded as insurance against adversity. Milk production is dependent on season due to the rainfall pattern that influences feed availability (Hiwot, 2013).

2.1.2. Agro-pastoral production system

The system has similar but gradual to sedentary ecological characteristics and cattle type to the pastoral area. Its specific identification is livestock dependent but growing of crop and its further expansion in crop farming gradually allocating the pasture land to crop production. The crop residue and aftermath of crop farming is used as a feed source for animals in the area in addition to communal pasture grazing. As compared to the above system, this system has better consideration for milk market and its access for additional inputs such as animal health services and supplementary feed from industrial by products and development of forage to calves and milking cows near to the newly started farm land to some extent (Getachew *et al.,* 2014).

2.1.3. Mixed crop livestock production system

The highland smallholder milk production is found in the central part of Ethiopia where dairying is nearly always part of the subsistence, smallholder mixed crop and livestock farming. Local animals raised in this system generally have low performance with average age at first calving of 53 months, average calving intervals of 25 months and average lactation yield of 524 liters (Sintayehu *et al.,* 2008). Milk production is an integral part of the production system of small scale, non-commercial subsistence-farms which represent among the 83.9% of the population and are responsible for the major part of 98% of the total milk produced and 75% of commercial, liquid milk production (Getachew *et al.,* 2014).

2.1.4. Urban and peri-urban dairy farming system

This system is developed in and around major cities and towns located mainly in the highlands of Ethiopia. The main feed resources are agro-industrial byproducts and purchased roughage. The system comprises small and medium sized dairy farmers that own crossbred dairy cows. Farmers use all or part of their land for forage production. The primary objective of milk production is to generate additional cash income to the household (Hiwot, 2013).

2.1.5. Commercial dairy farming system

This system is a specialized market oriented dairy operation practiced by the state sector and very few private commercial farms. Most of these farms are located in and around Addis Ababa and basically keep exotic dairy stock (Hiwot, 2013). On specialized dairy farming milk production is on a commercial basis and is concentrated in the central highland plateau. The system comprised of small and medium sized dairy farms that are based on the use of purebred exotic or high grade and crossbred dairy stock. They are mostly operating in the urban and peri-urban areas and around major cities and towns with high demand for milk having population of more than 10,000 (Getachew *et al.*, 2014).

2.2. Productivity of Dairy Cattle in Ethiopia

Milk production performance of cows is measured by daily and lactation milk yield. However, both productive and reproductive performances are influenced more by genotype and environmental factors such as nutrition, management and climate (Zelalem *et al* 2011). According to the study conducted by Ulfina *et al* (2013) the average daily milk yield for local dairy cows were 3.3 and 2.8 liters in Ambo and Naqamta urban areas. According to Azage *et al* (2013) the average milk production from indigenous cows was 1.85 liters/head per day and ranged from 1.24 in the rural lowland agro pastoral system of Mieso to 2.31 in the rural highland system of Fogera. The average daily milk production for cross bred dairy cows was higher in urban (10.21–15.9 liters/head per day) than peri-urban (9.5 liters/head per day) systems. Lactation milk yield of indigenous dairy cows ranged from 271.4 liters/head in the rural lowland agro-pastoralist system to 434.8 kg/head in the peri-urban system. However, lactation length of indigenous animals was shorter and ranged from 5.9 months in rural lowland transhumance system to 9.8 months in the rural highland dairy system of Bure.

The estimated daily milk yield and lactation length for cross-bred dairy cows reported include: 7 litters/day/cow and 8 months for cross-breeds and 2ltrs/cow/day and 10 months in fogera district Belete (2006), 7.8 kg/day/cow and 336 days for cross bred cows in urban and peri-urban areas of North Western Highlands Yitaye (2008), and 8.9 ltrs/day/cow from cross breed cows and 1.7 litters/cow/days for local /indigenous Arsi zebu cattle Fikrineh *et al* (2012) on the other hand, the estimated daily milk yield and lactation length for local zebu cows, respectively, reported include: 1.0 kg/day/cow and 285 days for Arsi zebu breed Lemma *et al* (2005), 2.2 kg/day/cow and 249 days for Borana breed in Borana Zone Adugna and Aster (2007), and 1.2 kg/day/cow and 219 days for local zebu breed at Meiso district Kedija (2007).

2.3. Traditional milking practices and Processing Practices in Ethiopia

The unhygienic and undesirable practices that decrease the quality of raw milk can be classified into three categories; issues related to the animal (Animals are not healthy or suffer from mastitis; and dirty, in particular the udder, the teats, the hind quarter and the tail), issues related to hands and clothes of the milkier. Milkers not clean and he/she practices unhygienic personal habits) and practices related to wrong milking procedures (like stripping) and used utensils not cleaned properly (Parekh and Subhash, 2008).

Dairy processing in the country is basically limited to smallholder level and hygienic qualities of products are generally poor (Sintayehu *et al.*, 2008). In areas where the climate is hot and humid, the raw milk gets easily fermented and spoiled during storage unless it is refrigerated or preserved. However, such storage facilities are not readily available in rural areas and cooling systems are not feasible due to lack of the required dairy infrastructure and when available high cost of facilities such as refrigerator for resource poor smallholder producers (Bereda *et al.*, 2013).

Cows are highly valued for their milk which is soured and converted to butter fat and partially fat extract sour milk which is essential part of the Sidama diet ‘ Kocho’ made from Enset (the false banana). The milk in these rural areas comes from local/indigenous zebu cows which are kept in traditional management (Ketema, 2013).

Milk production and product processing in Ethiopia is generally based on *ergo* (fermented milk in Ethiopia) with natural starter culture. Raw milk preserved at ambient temperature or kept in a warm place to fermentation prior to processing (Mogessie, 2002). Zelalem and Faye (2006) reported from central highland of Ethiopia that out of the interviewed small-scale producers, 45% did not treat milk before consumption, and organoleptic properties of dairy products were the most commonly used quality tests. Additionally in the Borena region of Ethiopia, butter was found to be an important source of energy as food for humans, and is used for cooking and as a cosmetic (Yohanis, 2015).

2.4. Hygienic Milk Production Practices

Primary production occurs on the farm, and farm and livestock management can have a significant impact on the productivity of the herd (Buncic, 2006). Because of the important influence of primary production activities on the safety of milk products, potential microbiological contamination from all sources should be minimized to the greatest extent practicable at this phase of production (primary). It is recognized that microbiological hazards can be introduced both from the farm environment and from the milking animals themselves. Appropriate animal husbandry practices should be respected and care should be taken to assure that proper health of the milking animals is maintained. Further, lack of good agricultural, animal feeding and veterinary practices and inadequate general hygiene of milking personnel and equipment and inappropriate milking methods may lead to unacceptable levels of contamination with chemical residues and other contaminants during primary production (CAC, 2004).

The hygienic quality of milk at the point of production is also of importance from both public health and consumer perception points of view, making important for milk to be produced with a low bacterial count and the count, by adequate temperature control, is to be kept low until the point of processing (Harding, 1999).

Milk is an ideal balanced diet for human beings. It is not surprising therefore that it also provides an ideal medium for growth of bacteria. Bacteria, when it find accidental access to milk, may give rise to consumer's health problems or product faults. Bacteria produce enzymes, which attack fat, protein or lactose and some of these enzymes even survive in milk after the bacteria have been killed by heat treatment, hence affecting the quality of pasteurized milk. Bacterial contamination of milk can all be minimized by starting the manufacturing process with raw milk of good hygienic quality (Aberra, 2010). Milk when it emerges from a healthy udder contains only a very few bacteria. However, milk is a perishable product. It is an ideal medium for micro-organisms and as it is a liquid, it is very easily contaminated and invaded by bacteria. Almost all bacteria in milk originate from the air, dirt, dung, hairs and other extraneous substances. In other words, milk is mainly contaminated with bacteria during milking. It is possible to milk animals in such a clean way that the raw milk contains only 500 to 1000 bacteria per ml. usually the total bacteria count after milking is up to 50,000 per ml. However, counts may reach several millions of bacteria per ml. That indicates a very poor hygienic standard during milking and the handling of the milk or milk of a diseased animal with i.e. mastitis (Pandey and Voskuil, 2011).

Milk from the udder of a healthy cow contains very few bacteria. Poor hygiene introduces additional bacteria that cause the milk to get spoilt very quickly. To ensure that raw milk remains fresh for a longer time, you need to practice good hygiene during milking and when handling the milk afterwards (Lore *et al.,* 2006). Production of quality milk is a complicated process (Pandey and Voskuil, 2011).

It is the concern of so many stakeholders, which include dairy farmers, dairy cooperatives, milk and milk product processors, retail distributors (shopkeepers and super markets), consumers of dairy products, state regulatory departments, extension staff and veterinarians.

An efficient hygiene program should begin at the farm. Essentially milk hygiene practice has interests in preventing the transmission of disease from animals to man, preventing the transmission of communicable diseases of man through milk, preventing diseases or physical defects that may arise from malnutrition and improving the nutritional status of man in general and of infants, children, and mother in particular (Barbuddhe and Swain, 2008). On the dairy farm, cleanliness and the use of good farming practices are paramount importance. Cleanliness of the premises, personnel, animals and equipment will not only protect public health, by reducing the risk of milk contamination, but also protect the health of the animals, by reducing the risk of mastitis. A reduction in mastitis in the dairy herd also results in improvements in milk quality as measured by the somatic cell count (SCC) in the milk (Buncic, 2006).

Good quality raw milk must be: free from debris and sediment free from off-flavors, low in bacterial counts, normal composition and acidity, free of antibiotics and chemical residues, safe for human consumption and free from disease producing microorganisms, high in keeping quality, high in commercial value, can be transported over long distances. Therefore, good hygiene is essential whether the animals are milked by hand or machine (Barbuddhe and Swain, 2008). This requires that, the milker’s hands and clothes are clean and he or she is in good health, the milking machine and milk storage equipment such as milk churns are kept clean and are in good condition, immediately after milking, the milk must be cooled preferably to 4°C. This requires mechanical refrigeration or milk cooling tanks.

2.5. Milking Procedures

It is important to remember that quality control must begin at the farm. This will make the milk to have fewer bacteria that cause spoilage and diseases. In order to ensure good quality and protect the health of consumers, one must always carry out milking in accordance with good hygienic practice (Lore *et al.,* 2006). A good milking technique is essential for the production of safe, raw milk. The procedure encompasses by cleaning teats, udder and adjacent parts before cluster attachment and teat dips/sprays must be used in accordance with manufacturer's instructions. Milk from each animal must be examined at each milking, when identified, abnormal milk must be kept separate and not used for human consumption, and milk from animals showing clinical signs of udder disease must be kept separate and not used for human consumption. Animals producing milk that is unfit for human consumption must be clearly identified, milking equipment must be kept clean at all times, and must be cleaned before milking and kept clean during milking and milk handling, exposed skin wounds must be hygienically covered (FSA, 2006).

2.6. Microbial Quality of Raw Milk

Raw milk should be free from dirt, foreign materials, drug residues, added water and contaminants (Murphy, 2008). A study conducted by (De Buyser *et al*., 2011) reported that due to unsanitary practices of milking and inappropriate control methods of mastitis have been caused and resulted in high bacteria counts of *S. aureus, Escherichia coli* and *Salmonella* in to raw milk. According to (Oliver, 2010) use of mastitis control methods is an important techniques to reduce bacteria counts and economical loses due to mastitis, improve milk yield and composition. Because of the composition milk serves as an excellent medium for growth of microorganisms that may come from interior of the udder, external surface of udder and teats, milk handling equipment and milking environment (Worku *et al*., 2012).

Bacterial contamination of raw milk can originate from environment, milking technique, milking equipment, housing and feeding system may affected the microbial quality of milk (Coorevits *et al*., 2008). In developing countries, milk and dairy products have been involved food borne diseases due to unsanitary milking condition and poor production practice (Zelalem and Faye, 2006).

Unsanitary practice and unhygienic milk production includes unclean udder and teat preparation, dirty equipment, contaminated water and poor milking procedure that can contribute to the presence of coliform in milk from different sources such as manure, soil, feed, personnel hygiene and water (Bille *et al*., 2009). Blowey and Edmondson (2010) and Amistu *et al* (2015) reported that high microbial counts observed in raw milk could be due to poor milking practice, dirty udder and teats, poor hygiene of milker, lack of knowledge on clean milk production, use of unclean equipment and plastic container for collecting and unhygienic milking, lack of sanitary storage container and lack of temperature control, that may result in poor microbiological quality of milk or the product.

2.6.1. Total bacterial count

According to EU standards, total bacterial count of raw milk should be less than 10^5cfu/ml (Fernandes, 2009). The number of bacteria in raw milk produced from udder of healthy cow is about 1000 cfu/ml whereas presence of high number of bacteria in milk indicates contamination by bacteria due to poor udder preparation before milking, unclean hand of milker and milking equipment's inappropriate storage time of milk and absence of cooling at the farm level (Bonfoh *et al*., 2003). Furthermore, lack of knowledge about clean milk production, absence of separate milking room, using plastic containers, using uncleaned and non-boiled water for washing purpose of milking and storage equipment and milk residues on the surface of equipment can increase the bacterial contamination of milk (Biruk *et al*., 2009). The research conducted in Ethiopia reported that 7.58 log10 cfu/ml and 7.32 log 10 cfu/ml counted total bacteria in raw milk (Asaminew and Eyassu, 2011; Derese, 2008).

2.6.2. Total coliform count

Coliforms are group of bacteria found in raw milk due to unsanitary condition of production, processing and storage of milk which found in the soil, grass, pasture and uncleaned water (Godefay and Molla, 2000). Thus of presence coliform in higher number in milk and milk products potentially cause of hazard to the consumers health. Below 100 cfu/ml total count of coliform is acceptable in pasteurized the milk for human consumption while below 10cfu/ml counts are used direct the raw milk for consumption (Ruegg, 2003). Coliforms are associated with fecal and environment source of contamination such as bedding materials, soil, water and inadequate cooling of milk (Douglas, 2003).

A study conducted by (Asaminew and Eyassu, 2011; Derese, 2008) has been reported that on the coliform count 49 log 10 cells/ml), 4.84 log cfu/ml. Coliform bacteria are shaded in faces of healthy animals and indicates poor hygiene of animal and personal, unsanitary milking practice, use uncleaned milking equipment, lack of cooling system, improper washed of udder and equipment's of milk, use uncleaned water and milking cow with wet and manure-soiled udder, absence of separate milking room are the most common ways of coliform bacteria enter in to raw milk at the farm level (CDFA, 2008; Omore *et al*., 2001).

Table 1: Ethiopian standard requirements on microbial quality of raw milk

Aerobic mesophilic bacteria count	
Quality	**Counts/ml**
Very good	0-200,000
Good	200,000-1,000,000
Bad	1,000,000-2,000,000
Very bad	>2,000,000
Coliform count Quality	**Counts/ml**
Very good	0-1,000
Good	1000-50,000
Bad	50,000-500,000
Very bad	>500,000

Source: (ES, 2008/2009)

2.6.3. *Total Staphylococcus count*

Staphylococcus is highly vulnerable to distraction by heat treatment and nearly all sanitizing agents. Thus, the presence of this bacterium is generally an indication of poor sanitation. The presence of large number of staphylococcus in milk and milk products may indicate poor handling or sanitation practices of dairy production (Bennet and Lancette, 2011). It is contagious pathogenic bacteria that cause infection of udder and cause food borne diseases of human being throughout the world. The milk and milk products can contaminated by *S.aureus* due to absence of mastitis control methods, inappropriate milking procedure and use of poor hygienic practice in the farm (Nickerson, 2014 and Dufour *et al*., 2011). Use of good hygienic condition of milk production, use mastitis control and adequate pasteurization of the milk can prevent the contamination of *S.aureus*.

2.6.4. Yeast and mould count

Yeasts and moulds are obligate aerobes (require free oxygen for growth), their acid/alkaline requirement for growth is quite broad, ranging from pH2 to pH9. Their temperature range (10-35^{o}c) is also broad, with a few species capable of growth below or above this range.

Moisture requirements of moulds are relatively low; most species can grow a water activity (^{a}w) of 0.85 or less, although yeasts generally require a higher water activity (Tournas *et al*., 2011). Contamination of milk and milk products by yeasts and moulds can result in substantial economic losses to producers, processors and consumer, may also be hazards to human or animal health because of their ability to produce toxic metabolites known as mycotoxins.

2.7. Factors Affecting Milk Quality

The microbial load of milk is a major factor in determining its quality. It indicates the hygienic level exercised during milking, that is, cleanliness of the milking utensils, condition of storage, manner of transport as well as the cleanliness of the udder of the individual animal (Gandiya, 2001). Sources of bacterial contaminations of raw milk can be divided into three general categories: environment, udder and milking equipment. Inadequate cooling of the milk, improper udder preparation methods, unclean milking equipment and the water used for cleaning purposes are considered as the main source of milk contamination (Mosu *et al.*, 2013).

The conditions necessary for bacterial multiplication are moisture, suitable temperature, air and nutrient. Milk which supplies all these essentials to bacterial existence is one of the most favorable media for the growth of microorganisms (Garry, 2003). Although the air of the milking environment rarely contributes a significant number of the total microbial count of milk, extremely dusty conditions may increase the counts. Milk handling personnel (milkier, butter maker, cheese maker, etc.) may contribute various organisms including pathogens especially when they are careless, willfully negligent, directly to milk (Amistu *et al*, 2015).

In addition, microorganisms attached to the exterior of the teats can enter the teat canal and cause mastitis. Inadequate cooling of the milk, improper udder preparation methods, unclean milking equipment and the water used for cleaning purposes are considered as the main source of milk contamination (Alehegne, 2004).

In order to produce milk of good bacteriological quality, dairy farmers should be aware of the sources of contamination and importance of proper milk handling, cooling and storage (Shunda *et al.*, 2013).

2.7.1. Interior of the udder

For many years, it was believed that milk drawn directly from the udder of a healthy cow was a sterile fluid, that is, it contained no living microorganisms (Alehegne, 2004). It starts its journey in the udder of a mammal as a sterile substance, but as it passes out of the teat, it is inoculated by the animal's normal flora. Being a nutritionally balanced food stuff with a low microbial load (less than 10000ml^{-1}) when drawn from the udder of a healthy cow, milk gets contaminated at various stages including the cow itself, the milker (manual as well as automated) *i.e.* the milker's hand or milking equipment, storage vessels and water supply particularly when used for adulteration (Edward and Inya, 2013). It has been demonstrated; conclusively that freshly drawn milk usually contains bacteria (Alehegne, 2004). The numbers of bacteria, which are present in freshly drawn milk, vary with individual animals, quarters of the udder, environment of the animal (cleanliness of quarters), health of the animal, and other factors. Natural flora within the udder of healthy animals is not considered to contribute significantly to the total numbers of microorganisms in the bulk milk, nor the potential increase in bacterial numbers during refrigerated storage. Natural floras of the cow generally have little influence on standard plate counts (SPC) (Alehegne, 2004).

2.7.2. Exterior of the udder

The exterior of the udder can be an important source of contamination. But the exterior of the udder is influenced by the environment of the cows, in which cows are housed and milked (Alehegne, 2004). The bacteria which are naturally present on the skin of animal enter into milk from the surface of the udder and teats; these also include the bacteria which are present in milking and housing places of animals (Ali *et al.*, 2011).

When cows are housed, bedding material and feed stuffs can be contamination sources. In both cases (housing and pasturing) faeces and dung are also an important contamination sources. Contamination of bedding material can be very high due to absorption of urine and faeces (Alehegne, 2004). The exterior of the cows' udder and teats can contribute microorganisms that are naturally associated with the skin of the animal as well as microorganisms that are derived from the environment in which the cow is housed and milked (Nangamso, 2006). Microorganisms are mainly transferred from the farm environment to milk via dirt (e.g. faeces, bedding and soil) attached to the exterior of teats; in addition, microorganisms attached to the exterior of the teats can enter the teat canal and cause mastitis (Vissers and Driehuis, 2008).

The groups of microorganisms isolated from teats are mainly micrococci and aerobic spore formers. The method of sampling teats can give different results but in general most bacteria found are aerobic spore formers. This can be a problem in producing milk in that the spores may survive pasteurization temperatures and spoil the milk and milk products during storage (Bacillus spores) and semi-hard cheese during ripening (clostridial spores). Teat surfaces are also sources of clostridial spores in milk. Sources of these spores are feed stuff, silage and bedding. The number declines markedly when cows go out to pasture because the pasture environment is cleaner than housing conditions (Alehegne, 2004).

2.7.3. Milking and storage equipment

Contamination of milk via the milking equipment occurs when microorganisms adhere to surfaces of the milking equipment and milk residues that remain in the equipment after the cleaning cycle. Under these conditions, growth of adhered microorganisms may occur, especially in cracked and decayed rubber parts that are sensitive to accumulation of microorganisms. During the next milking, adhered microorganisms can be released into the milk (Vissers and Driehuis, 2008). Thorough cleaning of dairy utensils and equipment is essential.

Anyone handling milk must also pay great attention to hygiene. Lack of hygiene can contaminate milk with other types of bacteria, which turn it sour and reduce its storage life (Pauline and Karin, 2006). The utensils and equipment used during milking should be made of non-absorbent, corrosion-resistant material. The surface should be smooth, have minimal joints or open seams and should be free from dents (Pandey and Voskuil, 2011).

Equipment used on the farm should be kept clean and well maintained, and store rooms and feed stores clean and pest-proof. Vermin should be actively discouraged throughout, and there should be hygienic arrangements for the disposal of waste materials and discarded milk (Buncic, 2006). First wash the utensils with hot water and a detergent. A clean brush with good bristles should be used, which is only designated for the cleaning of the milk equipment. Detergents are necessary to clean milking equipment effectively before disinfection. The effectiveness is increased when warm water is used. This helps to displace milk deposits and to remove dirt, dissolve milk protein and emulsify the fat. Disinfectants are required to destroy the bacteria remaining after washing and to prevent these subsequently from multiplying on the cleaned surfaces. Also their effectiveness is increased with temperature. Sufficient contact time should be allowed with the surfaces to be cleaned and disinfected (Pandey and Voskuil, 2011).

2.8. Common Challenges of Milk Quality and Hygienic Practices in Ethiopia

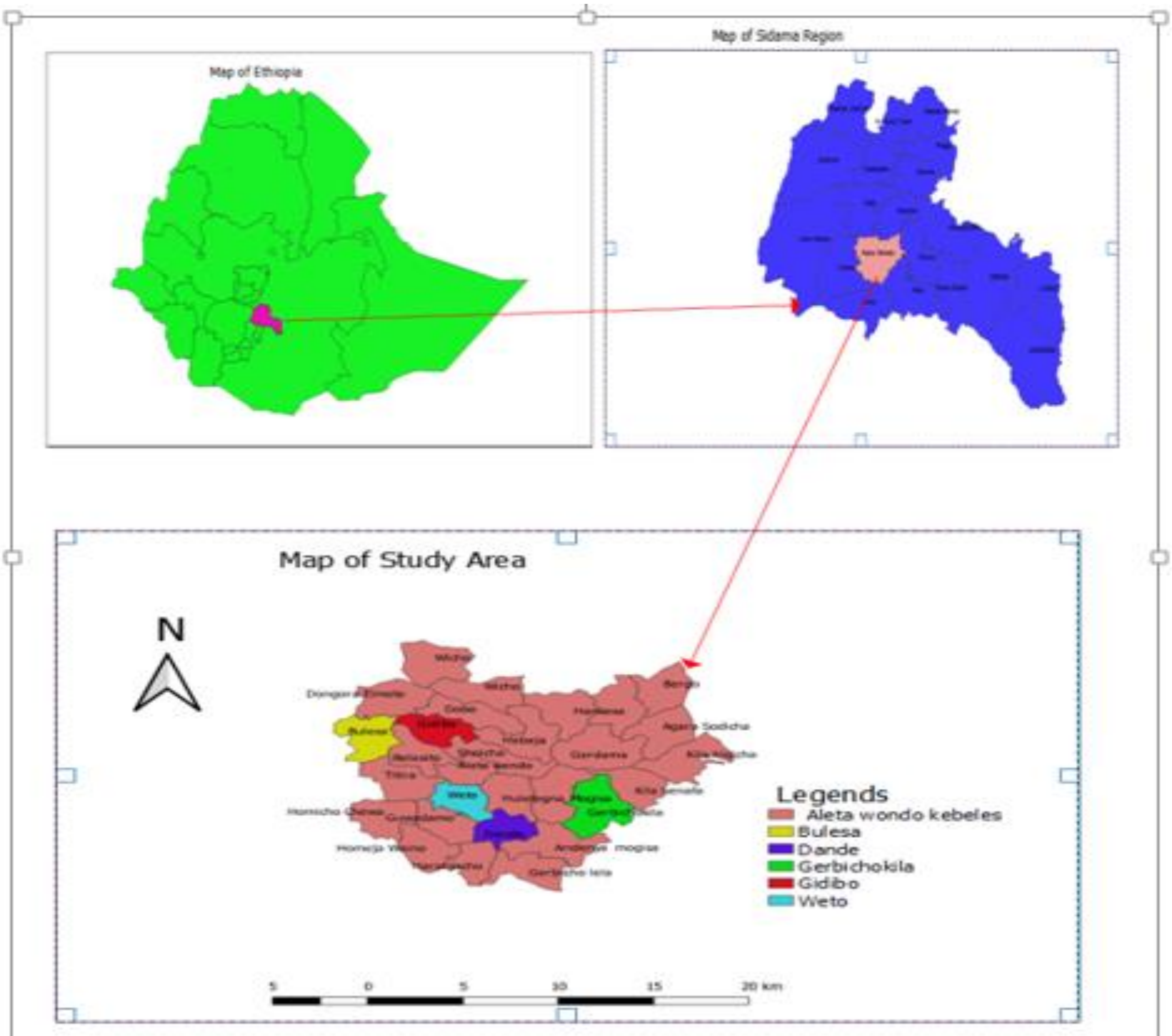
Milk is natural almost a sterile fluid when produced into alveoli of udder. Although microbial contamination might generally occur from three main sources; within the udder, exterior to the udder and from the surface of milk handling and storage equipment, but the surrounding air, feed, soil, faeces and grass are also possible sources of contamination (Mosu *et al.,* 2013). The bacterial contamination in milk emanates from a number of sources including mastitis, external udder surfaces and from the milking plant (Aberra, 2010).

Microorganisms are mainly transferred from the farm environment to milk via dirt (e.g. faeces, bedding and soil) attached to the exterior of teats. Finally, contamination can originate from insufficiently cleaned milking equipment when, during milking, microorganisms adhered to surfaces of the milking equipment are released into the milk (Vissers and Driehuis, 2008). Contamination of bedding material can be very high due to absorption of urine and faeces (Alehegne, 2004). Inadequate cooling of the milk, improper udder preparation methods, unclean milking equipment and the water used for cleaning purposes are considered as the main source of milk contamination (Alehegne, 2004).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Aleta wondo district of Sidama National Regional State of Ethiopia located between 6° 15′ N and 6° 45′ N latitude and between 38° 15′ E and 38° 45′ E longitudes (CSA, 2015/16). The altitude of the district ranges between 1700 to 2500 m.a.s.l. It is located at a distance of 333 km south east of Addis Ababa and at about 67 km from Hawassa, which is the capital city of Sidama Regional State. The district has 640 km^2 area of land with an estimated 288,976 human population (CSA, 2007/8). Annual rainfall in the area ranges from 900 to 1400 mm. whereas; mean minimum and maximum temperature is approximately between 10°c and 24°c (AWDARD report, 2013/14). The district has 27 kebeles with three agro ecologies namely highland (30%), moist midland (52%) and dry midland (18%). Aleta wondo district is bordered on the south by Dara woreda, on the west by Chuko, on the north by Dale and Wonsho, on the east by Bursa and on the south east by Hula. Livestock population is given to be 138,251 Cattle, 39,211 Sheep, 22,421 Goat, 3,918 Horses, 8,586 Donkeys, 168 Mules and 169,256 Poultry (Woreda Livestock and Fishery Office annual report, 2016/17). The main agricultural practices in the area are, coffee plantation, Enset plantations, maize &cereal crop production, cattle fattening, apiculture, vegetables and different fruits.



Source: CSA developed from ARC GIS Soft Ware

Figure 1: Geographical map of Aleta wondo district and the study kebeles

3.2. Study Procedures

The study had two parts namely survey and laboratory work. Survey part was conducted to assess the hygienic milk production practices and the laboratory part, to evaluate microbial quality of milk collected from producers, shops and cafes as well as consumers to further evaluate the quality of milk.

3.3. Sampling Techniques and Sample Size

Multi-stage sampling technique was implemented where combinations of purposive and random sampling technique was employed for selecting the study area and sample households. In the first stage, the study district Aleta wondo was selected purposively based on the potentials of crossbreed and local cattle in the district. The district was stratified as highland and midland based on agro-ecologies. For this study from 27 kebeles of the district, 5 representative kebeles (2 kebeles namely Gerbicho Kila and Dande from highland agro-ecology, and 3 kebeles namely Woto, Gidibo and Bulessa from midland agro ecology) were selected based on the number of kebeles. Kebeles and participating households were selected with the help of development agents (DAs), village leaders and other administrative officials of the district Bureau of Agriculture and Rural Development (Livestock and Fishery Office). Then, 195 households were selected from highland and midland kebeles using proportional sampling method. Households that own at least one local or crossbred milking cow were randomly selected to assess hygienic milk production practices in the district. Systematic random sampling method was used to select respondents from each selected kebele proportionally. An element of randomness is usually introduced in systematic sampling method by using set of random numbers to pick up the unit with which to start. This sampling procedure is useful when sampling frame is available in the form of a list. In such a design the selection process starts by picking some random point in the list and then every n^{th} element is selected until the desired number is secured.

The following simplified formula provided by Yamane (1967) was followed in this study to determine the required sample size at 95% confidence level.

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

Where n is the sample size, N is the population size (total household), and e is the level of precision. The respective numbers of households were allocated for each sampled kebele based on probability proportional to size (PPS) of each selected kebeles. The above formula was widely applied by several survey researchers and up to ±10% precision level (e) is acceptable (Ghimin, 2010; Iwara, 2013). For this study, ±7% precision level was used.

Therefore, the sample size for the socio-economic data was 195 households.

$$\mathbf{n} = \frac{4392}{1 + 4392\,(0.07)^2} = \frac{4392}{1+4392(0.0049)} = \frac{4392}{1+21.5208} = \frac{4392}{22.5208}$$

n = 195

The sample size of each kebeles was calculated as follows.

$\mathrm{nk1} = \frac{\mathrm{Nk1*n}}{\mathrm{N}}, \mathrm{nk2} = \frac{\mathrm{Nk2*n}}{\mathrm{N}}, \mathrm{nk3} = \frac{\mathrm{Nk3*n}}{\mathrm{N}}$, nk4, nk5=1158*195/4392 = 52

Table 2: The sample size of the study kebeles in the Aleta Wondo district

S/No	Name of Kebeles	Agro ecology	Total number of households	Sample size
1	Gerbicho kila	Highland	1158	52
2	Dande	Highland	838	37
3	Woto	Midland	840	37
4	Gidibo	Midland	751	33
5	Bulessa	Midland	805	36
	Total		4392	195

Source: Aleta wondo woreda agricultural office 2016/17

3.4. Data Types and Methods of Collection

The study used primary and secondary data sources. Primary data was collected through household survey, focus group discussions, and key informant interviews. The household survey employs semi-structured questionnaires, while the group discussions and key-informant interviews were used guiding open ended questions. Whereas, Secondary data was collected through reading records of the district, books, journals, research reports and articles, internet sources, various published and un-published sources of the government and non-governmental organization.

3.4.1. Household interview

Structured and semi structured questionnaire was used to gather required information on hygienic milk production practices, and the assessment was focused on the following major areas: household characteristics, hygienic practices (housing and cleaning of barn, frequency of cleaning milk containers, washing of udder and milking equipment, source of water, detergents used for washing of the utensils, milking procedures, methods of milk utilization and identify the major constraints related with quality milk production). The household survey was conducted on 195 sampled households. In order to gain respondents trust, the objectives of the survey and benefits of the study were carefully informed to the respondents.

3.4.2. Focused group discussions (FGDs)

Focused group discussions were employed to refine the questionnaire to be used for household survey and also to validate the data gathered and to get in-depth information on hygienic milk production practices and related constraints in the district. Five focus group discussions 2 (in highland) and 3 (in midland) were conducted with 8 members. At least one focus group discussion was held in each kebele and each group was including eight individuals.

The focus group discussion members included both men and women which were selected based on their past experience in milk production, hygienic practices and handling in the study areas. The discussions were conducted to generate information about milk production practices, hygienic practices and handling of milk and milk products which helped to cross check the data obtained through household survey.

3.4.3. Key informant interviews

The key informant interviews were conducted with people who have sufficient knowledge about the area and be able to memorize well the historical dairy production practice and milk hygienic practice in area. Members of key informants were kebeles residents and dairy model farmers. The interview also extended to value chain actors and service providers such as traders, processors, input suppliers, and others who contribute to dairy value chain in the area.

3.4.4. Milk sample collection

From each of the kebeles, farmers who own at least one local or crossbred milking cow were randomly selected. The total of 40 samples of raw milk were collected in the morning directly from previously sampled surveyed respondents, milk sellers (small shops and cafes) were collected in the afternoon as milk reached the market center around town of the district and samples from consumers were collected during morning until evening across a dairy value chain in the district for the microbiological quality analysis. The sampling was done from the different sampling source (milk producers, small shops and consumers) proportionally based on survey results (Table3). Fresh whole milk samples were collected aseptically after thorough mixing in sterile sample bottles of about 200 ml following standard procedure (Richard, 1985). The samples were transported to Hawassa University Dairy Microbiology Laboratory in an icebox and kept in refrigerator at 4˚C until the time of analysis. Each analysis was made in duplicates. The analysis was performed within 12 hours after sampling (Alganesh *et al.,* 2007).

Table 3: Sampling of raw milk from producers, shops and consumers in the study areas

Milk sources	**Number of samples**
Highland households	
Gerbicho kila	8
Dande	7
Midland households	
Gidibo	6
Woto	4
Bulessa	5
Shops	5
Consumers	5
Total	**40**

3.4.5. Microbial analysis

3.4.5.1. Total bacterial count

For total bacterial count (TBC), appropriate decimal dilutions that would give the expected total number of colonies which is between 30 and 300 colonies were selected (Richard, 1985). The molten standard plate count (SPC) agar was cooled to 45˚C after sterilization before pouring into petridish. One ml of milk sample was added into sterile test tube containing nine ml of peptone water up-to serial dilution of 10^{-7} and mixed thoroughly. Total bacterial count was determined after incubating pour plated duplicate decimal dilutions of milk samples at 32˚C for 48 hours. Finally, colony count was made using colony counter.

3.4.5.2. Coliform count

After vortexing the sample portion, appropriate decimal dilutions were made by transferring 1ml of the sample in to 9 ml of peptone water for initial dilution and by transferring 1 ml of the previous dilution into 9 ml of peptone water. After surface plating the appropriate dilution in duplicates on Violet Red Bile Agar (VRBA), petri dishes were incubated at 32˚C for 24 hours and counts was made on typical dark red colonies normally measuring at least 0.5 mm in diameter on uncrowned plates (Richard, 1985).

After counting and recording bacterial colonies in each petri dish, the number of bacteria in milliliter of milk was calculated by the following formula (FDA, 2003).

$$\mathbf{N} = \frac{\sum c}{((\mathbf{n1} + \mathbf{0.1n}(\mathbf{2})\mathbf{xd}))}$$

N= number of colonies per milliliter of milk

$\sum c$= sum of all colonies on plate counted

n1= number of plate on lower dilution counted

n2=number of plate in the next higher dilution counted

d=dilution of from which the first counts were obtained

3.4.5.3. Total Staphylococcus count

Samples of milk were serially diluted with 0.1% peptone water following similar methods as the other parameters. For each dilution to be plated aseptically 1ml sample were transferred and dilutions were placed on manitol salt agar (MSA, High media) plates. The dried plates were incubated for 48 hrs at 35°C. The plates containing from 20-200 colonies were selected. Typical Staphylococci colonies appeared as golden yellow were counted (Bennett and Lancentte, 2016).

3.4.5.4. Yeast and mould count

Samples of milk were serially diluted following similar methods as for total bacterial count but dilutions were surface plated on Potato Dextrose Agar (PDA, High media). The dried plates were then incubated at 25^{0} C for 3 to 5 days. The plates that contain 10-150 colonies were counted. Colonies with a blue green and white color were counted as yeasts and moulds (Ahmed, 2003).

3.5. Data Analysis

After completion of data collections the result was presented using simple descriptive statistics (i.e. mean, standard errors, frequency and percentage). Statistical Package for Social Science (SPSS) version 20 statistical package and Microsoft-Excel were used to analyse both the quantitative and qualitative variables collected during the individual interview and group discussions. Moreover, ANOVA was employed to compare the various quantitative variables such as socio-demographic characteristics of households (age group and education level), as well as milk hygienic practice, milk production potential and the major milk quality related constraints were ranked based on the frequency of respondents those gave priority for the problems in the questionnaire and also group discussion was considered. Microbial count data was first transformed to logarithmic values (log10) before subjected to statistical analysis. When analysis of variance shows significant differences between means comparisons were done using the Least Significant Difference (LSD) technique. Differences were considered significant at 5% level.

The following model was used for the analysis of microbial quality of milk:

$$\mathbf{Y_{ij} = \mu + \beta_i + e_{ij}}$$

Where, Y_{ij} = individual observation for each test.

μ = the overall mean.

β = the effect of location (Highland and Midland)

e_{ij} = the error term.

4. RESULTS AND DISCUSSION

4.1. Socio Demographic Characteristics of the Households in the Study Area

According to the current study, out of the total interviewed dairy cattle producers in highland agro-ecology 92.1% were male and 7.9% female headed households. In the midland ago-ecology 87.7% were male and 12.3% female headed households (Table 4). The overall sex characteristics indicated few female headed households. Females headed households in dairying can play a significant role for the development of dairy production (Kumar *et al.*, 2011). Generally, dairy production is the very important option for female headed households to ensure and sustain their livelihoods. The current study is in agreement with that of Zewudie, (2010), who reported 86.7 and 13.3% male and female headed households respectively in the highlands and central rift valley of Ethiopia. However, in terms of female headed households, the result is lower than Bekele *et al* (2015), who reported 73.3% and 26.67% and 77.78% and 22.22% male and female headed households in Dangila district, respectively.

The educational status of households in highland and midland included illiterate 16.9% and 14.2%, able to read and write 28.1% and 53.8%, elementary school completed 38.2% and 19.8% and high school and above 16.9% and 12.2% respectively (Table 4). The result indicated that proportionally households in the highland agro ecology were better educated ($P<0.05$) than midland agro ecology. This might be due to the availability of better access to school. However, the households in both highland and midland agro ecologies were mostly able to (read and write) which is useful for further dairy development in the study areas. The result implies the presence of more educated households which can enable producers to easily understand trainings and to accept and implement new ideas/technologies that are important for the development of dairy management and production in the study areas.

The households in the current study were well educated than the findings of Tsadikan (2012), who reported 73.6% and 64% illiterates in trans-human and sedentary production system in Enderta district. Well educated households were reported by Belay and Janssens (2014), in Jimma urban dairy production system, none educated 1.9%, primary school (20.4%), junior secondary school (11.1%), senior secondary school (24.1%), college (35.2%) and university (7.4%) than the current study results. The reason for the variation in educational status may be attributed to the differences in the opportunities and access to the school. Majorities of the respondents 51.8% in the study area were within 41-60 and 29.7% were within 20-40 while only 18.5% of the respondents were in the age group >61years.

Table 4: The household socio demographic characteristics in the study area

	Agro ecology							
Variables	Highland (N=89)		Midland (N=106)		Overall (N=195)		X^2	Sig.
	Freq	%	Freq	%	Freq	%		
Household position							2.19	0.14
Male headed	82	92.1	93	87.7	175	89.7		
Female headed	7	7.9	13	12.3	20	10.3		
Educational status							14.33	0.002
Illiterate	15	16.9	15	14.2	30	15.4		
Read and write	25	28.1	57	53.8	82	42.1		
Elementary	34	38.2	21	19.8	55	28.2		
High school and above	15	16.9	13	12.2	28	14.3		
Age group							1.57	0.46
20-40	30	33.7	28	26.4	58	29.7		
41-60	42	47.2	59	55.7	101	51.8		
>61	17	19.1	19	17.9	36	18.5		

Results are significantly different at P<0.05, N=Number of respondents, Freq=Frequency

4.2. Production System

All of the respondents in the study area, practiced both crop and livestock production system. In this type of production, both production systems, crop cultivation and animal production are complementary and important to farmers' livelihood as outputs from one system are inputs to other system.

Cattle provide power for land preparation and crop transportation after harvest and manure as fertilizer, while crop by-products and residues represent an important source of animal feed. Of the crop residues maize stover, wheat, barley and other cereal crop straw are the major ones. In this production system, different crops predominantly produced include: maize, wheat, enset, barley, sweet potato, potatoes, coffee, banana, mango, and avocado. Of which wheat, barley, Enset are dominantly produced in highland agro-ecology. Others like maize, coffee, avocado and mango are produced in midland areas. Milk and milk products are produced by cattle used for multipurpose; butter and butter milk used as source of income to buy farm inputs and family needs, raw milk and butter milk are used for family consumption, while cattle are an asset securing farmers at the time of emergency and for breeding purpose. The results of current study were similar to Zewdu *et al* (2003) in the mid highlands of Ethiopia and Chewaka (2006) in Yirgachefe area.

4.3. Purpose of Milk Production in the Study Area

Milk producers in the study area produce milk for different purposes such as for home consumption, for sale and for consumption and sale. As presented in figure 2; overall, milk production for home consumption accounts to about 42.4%, for sale 9% and for consumption and sale about 48.6%. In the current study areas about 47.2% of highland farmer's produced milk for home consumption and sale while about 50% of midland household's produced for household consumption and sale. The interviewed households in highland and midland agro ecologies produce milk for different purposes. The highland and midland household with respect to major purpose of milk production was no significantly different (*P>0.05*). The current result is similar to Desalegn (2015) whose report implies production of milk for the purpose of human consumption.

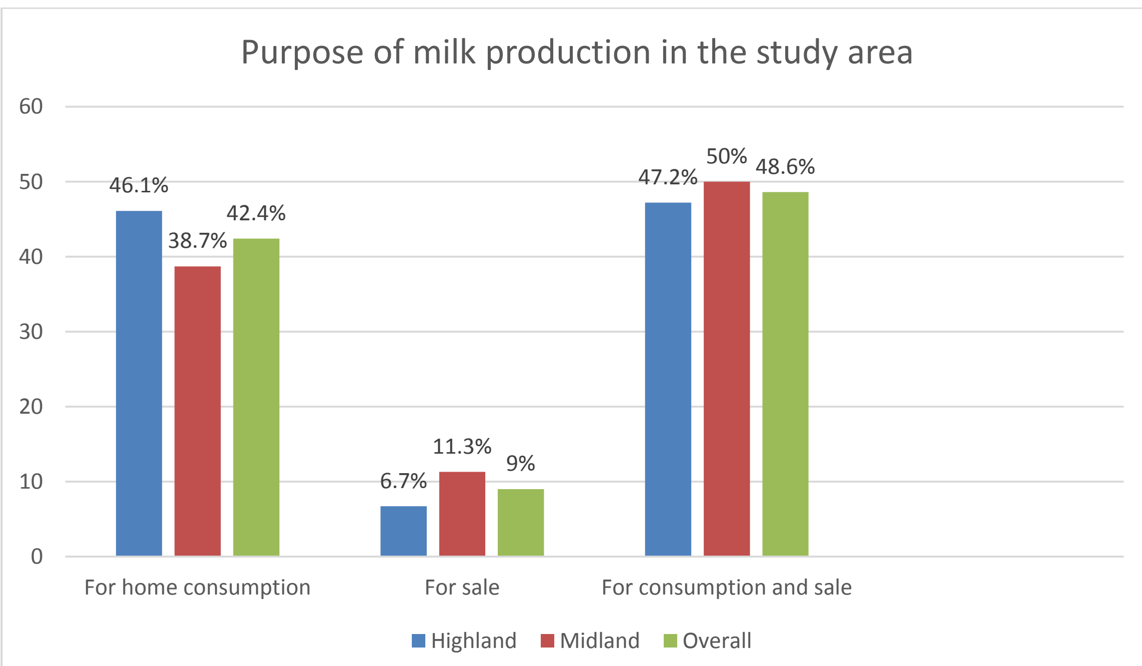


Figure 2: Purpose of milk production in the study area

4.4. Feed Sources and Feeding System

Type of feed sources and feeding system has its own impact on dairy cattle production and reproduction performance. The major feed resources of cattle in the study area were, natural pasture, enset and banana leaves, stem and roots, crop residues from maize, barley and wheat and improved forages (Table5). However, the availability of feed resources varied across agro-ecology. In midland more farmers used natural pasture (52.8%) and crop- residues (28.3%) as major feed to feed their cattle than highland. On contrary, only some farmers had used enset as major feed sources in midland than highland. Mid land and highland are highly populated and they have small land size for cropping and grazing. However, these areas are potential for perennial crop like coffee, enset etc.

The current study was comparable with Nanyeenya *et al* (2008) study in Uganda who reported that crop residues, kitchen wastes like crop peelings, sheaths and haulms, stems and leaves of cereals and bananas left after harvests and crop thinning of mostly cereals like maize are major sources of feed for cattle on crop livestock production systems. Similar study was also conducted by ESAP (2008) which stated that grazing of pastures, fallow lands and crop-residue are major feed resource of livestock. The study also stated that increasing human population and expansion of cropping in to grazing area as a result, the importance of natural pasture is a source of feed is decreasing from time to time. The results from the current study disagreed to Girma *et al* (2014) study in urban and peri-urban dairy production system (Adamitulu, Ethiopia) where due to shortage of grazing land most farmers fed their dairy cattle by cutting green feeds, crop residues, agro-industrial byproducts, brewery byproducts and mill byproduct.

As presented in (Table5) there was a statistical significance difference (*P<0.05*) among the feed sources and feeding system in the study area. About 51.8% of the milk producers obtained feed from grazing on natural pasture 20.5% crop residue, 23.1% enset stem and leaf and 4.6% used improved forage. This was due to the fact that majority of the milk producers have lack of knowledge in how to prepared animals feed and shortage of spaces. The current result is in agreement with the report in the mixed-crop livestock production system where majority (53.7%) of the households use animal feeds from their own crop farm, while 23.7% use a combination of own farm and communal grazing (Sintayehu *et al*., 2008).

The types of feeding systems noted from this study were free grazing and stall feeding. This study also indicated that the major sources of feed for livestock in the study area are natural pasture, crop-residues, and enset. Natural pasture (grazing) and crop residues are the major feed resources used as a basal diet for dairy production in rural and peri-urban dairy systems (Azage *et al*., 2013). Crop residues, natural pasture and aftermath grazing were the major feed resources for dry season, in their descending order. In general crop residues and natural pasture are the major feed resources of the area which agrees with the report of Tolera *et al* (2012) who indicated that natural pasture and crop residue to be the major feed resources for highlands of Ethiopia. Currently with the rapid increase in human population and increasing demand for food, grazing lands are steadily shrinking due to the conversion of grazing lands to crop lands, and are restricted to the areas that have little value of farming potential.

Table 5: Major feed sources and feeding system by respondents in the study area

	Agro ecology							
Variables	Highland (N=89)		Midland (N=106)		Overall (N=195)		X^2	P-value
	Freq	%	Freq	%	Freq	%		
Major sources of feed							17.27	0.001
Grazing on natural pasture	45	50.6	56	52.8	101	51.8		
Crop residue	10	11.2	30	28.3	40	20.5		
Enset and banana	31	34.8	14	13.2	45	23.1		
Improved forages	3	3.4	6	5.7	9	4.6		
Feeding system							0.86	0.353
Free grazing	69	77.5	76	71.7	145	74.4		
Stall feeding	20	22.5	30	28.3	50	25.6		

Results are significantly different at P<0.05, N=Number of respondents, Freq=Frequency

4.5. Water Sources and Watering System

Water is a determining factor for all activities of animals. Water problem in amount and quality and can cause problems like constipation, dry digestive tract, reduce metabolically activities with emaciated body condition (Tsedeke, 2007). In the study area, most of the respondents used pond as major water source for their cattle (55.4%) even though its quality and availability are season dependent (Table 6). As observed during the survey, households that use pond water for their animals do not treat it, or it is not filtered and some farmers used deep well and river water. In closed to current result Asrat *et al* (2013) reported from Bodit, Ethiopia; rivers, tap water and spring were important sources of water for dairy cattle. Dessalegn (2015) also reported similar result where in Bench-Maji Zone, Southwest Ethiopia farmers used rivers, borehole water and dam/pond as main sources of water for their cattle during the dry and wet season. In line with the present study Teshager *et al* (2013) reported similar result from Ilu Aba Bora Zone of Oromia Regional State, South Western Ethiopia that the main sources of water for cattle are river, pond, and well.

Regarding the frequency of watering to dairy animals the study indicated variability between the agro ecologies, which might be affected by different factors, among which season, accessibility (getting easily), performance and/or breed of the animals and type of predominant feed (dry or wet) and feeding systems (indoor or outdoor where some water is available) are important. Most of the respondents have said that they gave water for their cattle only once per day (90.8%); the highest proportion was found in highland (97.8%) through midland (84.9%). In the other way, some famers (9.2%) gave water for their dairy cattle twice per day and most of them were found in midland areas. This might be related to heat effect on the environment (feed type) and animals. According to respondents, this was especially true in dry season due to heat effect at that period. Similar results have been reported by Tsedeke (2007) from Aleba Woreda, Ethiopia and Asrat *et al* (2013) from Bodit, Ethiopia.

Table 6 : Water source and watering frequency in the study area

	Agro ecology							
Variables	Highland (N=89)		Midland (N=106)		Overall (N=195)		X^2	P-value
	Freq	%	Freq	%	Freq	%		
Source of water							48.85	0.000
River	31	34.8	10	9.4	41	21.0		
Pond	56	62.9	52	49.1	108	55.4		
Deep well	2	2.3	44	41.5	46	23.6		
Watering frequency							9.53	0.002
Once a day	87	97.8	90	84.9	177	90.8		
Twice a day	2	2.2	16	15.1	18	9.2		

Results are significantly different at P<0.05, N=Number of respondents, Freq=Frequency

4.6. Milk Production Potential and Lactation Length in the Study Area

The estimated average daily milk yield based on the farmers response varied significantly (*$P<0.05$)* among the agro ecologies (Table7). The variation in daily milk yield could be due to availability of feed and the difference in the practice of keeping selected cows among farmers in different agro ecologies. The present estimated average daily milk yield of local and cross bred dairy cows were 1.55±0.05 and 6.67±0.17 liter/day respectively. The result was in agreement with Zewidie (2010) who reported 1.5±0.3 kg/day for indigenous dairy cows in Ziway area. The result is also comparable with overall average estimated milk yield of 1.45 liter/day reported by Beriso *et al.,* (2015) in Chuko district, Southern Ethiopia and also with that of Demissu *et al* (2014) who reported 1.52±0.86 liter/day at Guduru livestock production and research center and its surroundings for indigenous cows. On the other hand, the result of the current finding was higher than the report by Merha (2006) who noted average daily milk yield of 0.75 liters for Abergele cattle and 1.15 ± 0.386 liters estimated by Ketema (2014) for cows under smallholder farmers in Kersa Malima district. The estimated overall average lactation length in present study of local and cross bred dairy cows were 8.21±0.99 and 9.31±0.04 months respectively and there was no significant difference among agro ecologies *($P>0.05$)*. The lactation length reported in the present study area is comparable with the result of 8.96 month reported by Belay *et al* (2012) for smallholder livestock production system in Dandi district, Oromia Regional State, Central Ethiopia and also with 9.93±0.2 months (Beriso *et al.,* 2015) in Chuko district, Southern Ethiopia. However, it was longer than the national average of 7 months (CSA, 2015) and 203.54 days or 6.78 month for Simada cattle in Tach Gayint district (Assefa *et al.*, 2015).

Table 7: Milk production potential and lactation length in the study area.

Variables	Agro ecology			
	Highland (N=89)	Midland (N=106)	Overall (N=195)	P-value
Local cow milk yield/day/litre	1.49±0.06[b]	1.59±0.07[a]	1.55±0.05	0.002
Crossbred milk yield/day/litre	6.17±0.13[b]	7.15±0.21[a]	6.67±0.17	0.003
Local cow lactation length/months	8.00±1.14	8.3±0.86	8.21±0.99	0.058
Crossbred lactation length/months	9.24±0.04	9.33±0.05	9.31±0.04	0.086

Mean values represented with different superscripts in the same row differs significantly (P<0.05), N = Numbers of respondents.

4.7. Major Constraints of Milk Production in the Study Area

Producers rearing cattle in the study areas face a range of technical, socioeconomic and institutional constraints. Feed shortage, disease, lack of extension support, poor knowledge in animal management and lack of capital are some to mention. As observed in the figure3; 38.2% and 43.4% of the respondents in highland and midland agro ecology respectively, with overall 41% indicated that shortage of animal feed is the most important problem hindering dairy development. Similarly, (42%) of the respondents in western Oromia reported feed shortage as the most single problems responsible for low milk yield and low productivity of the dairy system (Ulfina *et al*., 2013). The same author showed that about 58% of the respondents indicated feed shortage in combination with diseases and poor genetic make-up of indigenous animals as a primary cause for lower productivity. Contrary to this, 18.3% of respondents in Bahir Dar zuria and Mecha districts revealed feed shortage as a constraint for milk production (Asaminew and Eyasu 2009). Similarly (30.8%) and (24%) of respondents respectively in Chencha and kucha districts stated that disease and parasite are their primary problems hindering dairying activities (Minale and Yilkal, 2015).

The primary constraints to increased milk production under existing dairy production system are inadequate feed resources, poor pasture development and the ever increasing feed prices. Farmers tend to keep cattle at stocking rates that far exceed the carrying capacity of their grazing lands. This has resulted in degraded pastures and eroded soils. Stock numbers are not normally reduced in the dry season leading to grazing lands becoming progressively overgrazed. In the dominating crop/livestock production system, producers supplement the feeding of their dairy cows with crop residues and farm by-products from their farms. In some cases, during the dry season, these feedstuffs can be the only feeds available to the animals.

The reasons for feed shortage are indicated in figure3. In this study the main reasons of feed shortage indicated by the respondents were cultivation of grazing lands, declining yields of grazing land and increase of livestock population. Shrinking sizes of the grazing lands driven by the expansion of land cultivation. Declining yield and carrying capacity of the grazing lands was rated as the second important impediment in adequate supply of feeds across the sites. Increases of human and livestock population and drought are also mentioned to cause feed shortage.

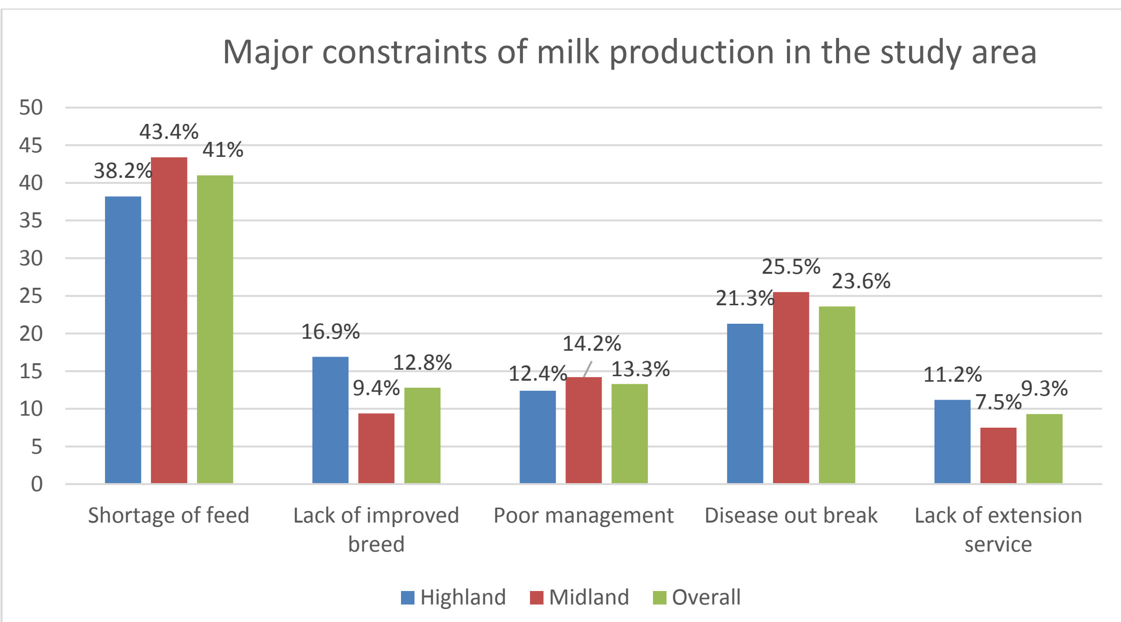


Figure 3: Major constraints of milk production in the study area

4.8. Hygienic Milk Production Practices in the Study Area

4.8.1. Housing and hygienic milk production practices

According to the current study most of the respondents (91.3%) shared the same house with their animals with the intention to protect animals from predators and theft while only 8.7% of the respondents were using separate house for animals (Table8). Similarly, in west Shewa (Saba, 2015) and in Gurage zone (Abebe *et al.,* 2014) about 91% - 100% of the respondents kept their animals in the same house where the family lives. This could probably cause the transmission of disease from animal to human and also from human to animal, and affects the quality of milk. Result of the present study is similar to report from central highland of Ethiopia (Zelalem, 2010) in which 80.4% of the respondents used house type. In contrast with present study, the entire interviewed households used fenced barn for overnight cattle holding in Borana zone of Southern Ethiopia (Garmessa, 2015). Most of the respondents (88.7%) in the study area used earthen floor whereas 7.2% and 4.1% of them used wooded bed and concrete floor house, respectively (Table8). The present results were comparable with reports from Tigray Regional State that the majority of the respondents (87.1%) used earthen type floor and 12.9% of the respondents used concrete (Tsadkan, 2012). The current study showed that about 86.7% of the respondents used poor quality grass and cereal straw as bedding materials for dairy animals. The use of poor quality bedding materials and earthen floor without any bedding materials in the study area might cause udder and/or teat contamination and attribute to poor quality milk production. Reports from different studies support clean, dry and comfortable bedding condition as important factor to minimize the chance of contamination of milk by different microorganism including pathogenic microorganisms (Tassew, 2007; Derese, 2008; Asrat, 2009).

Maintaining the sanitary condition of milking area is an important prerequisite for clean milk production (Zelalem, 2010). In the current study, about 40% of the respondents clean their barns daily, while 30.8% and 29.2% of the respondents clean their barns more than once a week and once a week, respectively. In comparison, 56.2% of the respondents in the highland area were more experienced in daily barn cleaning practice than respondents (26.4%) of midland. This might be the cause of variation in milk quality due to udder contamination with unclean barn. In line with the current finding, about 38.9% of the respondents clean the barn more than once a week in Borana zone of Southern Ethiopia (Garmessa, 2014). However, proper and clean housing environment is a prerequisite to produce milk and milk products of acceptable quality (Tassew, 2007).

Table 8: Housing system and barn cleaning condition in the study area

	Agro ecology							
Variables	Highland (N=89)		Midland (N=106)		Overall (N=195)		X^2	Sig.
	Freq	%	Freq	%	Freq	%		
Housing type							0.02	0.902
Separate/fenced house	8	9.0	9	8.5	17	8.7		
Shared with family	81	91.0	97	91.5	178	91.3		
Barn floor type							0.90	0.639
Earthen type	77	86.5	96	90.5	173	88.7		
Concrete	4	4.5	4	3.8	8	4.1		
Wooded bed	8	9.0	6	5.7	14	7.2		
Type of bedding materials							4.87	0.087
Grass /cereal straw	75	84.3	94	88.7	169	86.7		
No bedding materials	10	11.2	12	11.3	22	11.3		
Saw dust	4	4.5	0	0	4	2.0		
Frequency of barn cleaning							29.03	0.000
Daily	50	56.2	28	26.4	78	40.0		
Once a week	10	11.2	47	44.3	57	29.2		
More than once a week	29	32.6	31	29.3	60	30.8		

Results are significantly different at $P<0.05$, N=*Number of respondents, Freq=Frequency*

4.8.2. Milking practices and procedures in the study area

According to the present findings the entire sample respondents (100%) in the study areas practiced hand milking method. Similarly, reports indicate that all of the households milk their cows by using hand milking either by washing cow teats or letting the calf to suckle to stimulate milk let-down in Shashemene town, Southern Ethiopia (O' Connor, 1995). Another study also indicated that, all of the respondents (100%) were practicing hand milking in Cheha district of Gurage zone, Southern Ethiopia (Kibebew *et al.*, 2020). It has been found out under the current study that almost all of the households (95.9%) milked their cows twice a day, while the remaining 4.1% of them did milking once a day (Table9). This finding agreed with reports from Borana Zone (Garmessa, 2014) and Shashemene town (Teshome, 2013) who reported that all of the respondents milked two times a day.

According to the current study, the interviewed smallholder farmers (65.6%) washed their hands before milking. In comparison, interviewed respondents (78.7%) in the highland area had better hand washing experience than midland respondents (54.7%). This might be due to lack of awareness about personnel hygiene related with milk contamination and limited water access in the area (Table9). Similarly, about 30.6% of the farmers did not wash their hands before milking in West Shoa Zone, Ethiopia (Saba, 2015). Moreover, about 82.05% of the milk producers did not wash their hands using detergents prior to milking in Shashemene town, Ethiopia (Teshome, 2014). Cleaning of the udder before milking is one of the most important hygienic practices required to ensure clean milk production. This is important since the udder of the milking cows could have direct contact with the ground, urine, dung and feed refusals (Zelalem, 2010). However, about 52.3% of sample milk producers in the study area did not wash the udder of milking cows (Table9).

It was reported that insufficient cleaning of the udder may result in contamination of milk (Gran *et al.,* 2002). The use of soap and good-quality water for cleaning could be expected to remove milk remains, and microorganisms that affect the microbial quality of milk. In central highlands of Ethiopia (Zelalem and Bernard, 2006) and in Shashemene town (Teshome, 2013) it was reported that around 72% - 79% of the households clean the udder before milking. As opposed to the current study, all respondents from Gurage zone, southern Ethiopia did not wash the udder before milking (Abebe *et al.,* 2012). Milking in dry condition significantly reduces bacterial count. It is because no surplus water remains on 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 (Islam *et al.,* 2009).

However, about 73.3% milking cow owners did not use towel to clean and dry the udder. This might be mainly due to lack of awareness and low level of educational status, absence of training related with hygienic practices in milk production and lack of awareness about the effect of hygiene on milk and milk products quality (Table9). The current study is in agreement with the findings from Shashemene town, southern Ethiopia that indicated about 71.79% of smallholder farmers were not using separate towel to clean and dry the udder of milking cows (Teshome, 2013). The milker can be an important source of milk contamination and hence should keep their personal hygiene and be in good health during milking operation (Zelalem, 2010).

Table 9: Milking practices and procedures in the study area

Variables	Highland (N=89)		Midland (N=106)		Overall (N=195)		X^2	Sig.
	Freq	%	Freq	%	Freq	%		
Milking methods								
Strip hand milking	89	100	106	100	195	100		
Milking frequency per day							1.43	0.23
Once	2	2.2	6	5.7	8	4.1		
Twice	87	97.8	100	94.3	187	95.9		
Hand washing before milking							12.29	0.000
Yes	70	78.7	58	54.7	128	65.6		
No	19	21.3	48	45.3	67	34.4		
Udder washing							0.03	0.87
Udder washing before milking	43	48.3	50	47.2	93	47.7		
No washing	46	51.7	56	52.8	102	52.3		
Use towel to clean the udder							0.54	0.46
Yes	26	29.2	26	24.5	52	26.7		
No	63	70.8	80	75.5	143	73.3		

Results are significantly different at P<0.05, N=Number of respondents, Freq=Frequency

4.8.3. Hygienic conditions of milk utensils in the study area

There was no statistical significant variation *(P>0.05)* in the different parameters among the different agro ecologies in the study area (Table10). About 21% of milk producer households used plastic utensils materials for milking, 26.7% of aluminum/stainless steel and 52.3% used clay pot. About 69.2% used gourd for transportation and 72.3% used clay pot for storage and for churning in the study area. The current study result is in line with Bekele *et al* (2015) who reported all respondents (100%) used clay pot for churning milk. After milking, the milk is transferred into a smoked clay-pot and kept closed at room temperature. Milk from the evening milk is added to the morning milk and kept until the next morning. The quality of curd formed was visually evaluated and readiness of the curd for churning was determined by the woman household.

Most loses of milk and milk products occur as a result of contamination of poor production or handling practices and lack of technical knowledge on clean milk production, use of unclean and un appropriate (milking, transportation, storage and churning) equipment's lack of clean water for cleaning purpose contributed to the poor hygienic quality of dairy products (Zelalem & Faye 2006). As Getachew (2003) indicated milk procedures should follow hygienic practices during milking and handling, before delivery to consumers or processors. Similarly, Gran *et al*. (2002) reported that insufficient cleaning of the udder may result in contamination of milk. The use of detergent and good-quality water for cleaning could be expected to remove milk remains, including microorganisms that affect the microbial quality of milk.

A study conducted by Mosnier (2010) and FAO and IDF (2011) on the hygienic milk production practices includes proper preparation of udder for milking, clean and isolate milking area, use of clean equipment for milking and milk storage, cleaning the milking equipment after every milking using disinfectant, providing clean water for washing purpose, clean house, hygiene of cow, following recommended milking technique, clean milk storage area and milk equipment storage and storing milk in to refrigerator are important to reduce the risk of milk contamination and also protect the health of the animals by reducing the risk of mastitis that result in affecting the quality of milk. According to Nickerson and Oliver (2014) use of incorrect milking technique can cause higher mastitis infections in cow and coliform in milk which leads to low level of milk production and reduce the quality of milk. Research that has been conducted in Kenya and Ethiopian indicated that modern cooling technology contributed to improve milk quality and increasing returns for producers (Florence *et al*., 2014, Lemma, 2018). For instance, solar ice cooling, water cooled charcoal, refrigeration and sand-boxes are used to preserve and cooling milk immediately after milking for reducing microbial load of raw milk and slow composition deterioration, aiding to supply quality milk to market (Makoni *et al*., 2013) and increased economic return.

The churning operation starts after stirring the content and transferring to another smoked clay pot. The clay pot is agitated until butter grains are formed. The developed gas is released every 2-3 minutes by opening the top of the churn during the first 10-15 minutes of the churning operation. The churning operation, a back and forth movement, is manually performed in a traditional way (Tsadkan, 2012). Utensils used for milking, transportation, storage and churning determine the quality of milk and milk products. Traditional milk equipment are reported to be often porous and therefore a reservoir for many organisms and difficult to clean (O'Connor, 1994). Proper metal milk containers are expensive, and hence milk producers use plastic containers which are difficult to clean and disinfect and thus it might contribute to poor quality of the milk (Omore *et al*., 2005). The leftover of milk and other dirt particles within the container may result in the contamination of milk. Omore *et al* (2005) had also reported that lack of formal training and use of plastic containers are the main factors that contribute to the low quality of raw milk sold by producers and informal milk traders. Traditional containers can be a potential source for the contamination of milk by bacteria, because this allows the multiplication of bacteria on milk contact surfaces during the interval between milking. This is mainly due to the difficulty of removing all milk residues from traditional containers that are porous by nature with the common cleaning systems.

Milking and milk storage utensils need to be properly cleaned and dried in an inverted position prior to use. These are important practices to reduce milk contamination raised from the milk utensils (Murphy, 1996). Moreover, producers should pay particular attention to the type of equipment used. In this regard, aluminum or stainless-steel containers are recommended because of easiness to clean and anti-corrosion properties of the materials as compared to plastic containers (Karuga, 2009). Producers need therefore, to pay particular attention for the type as well as cleanliness of milk utensils. Non- food grade plastic cans, buckets and Jerry-cans must not be used (Kurwijila, 2006). Milking utensils should be easy to clean. Aluminum and stainless steel utensils are mostly preferred.

When water from non-tap sources is used for cleaning purpose, it is important that producers should at least filter and heat treat it before use since the quality of water determines the amount of bacterial counts in milk (Zelalem, 2009).

The majority of respondents (70.3%) used cold water for milk utensils cleaning whereas only 29.7% of them used warm water for similar purpose (Table10). This might be due to lack of awareness and training about the effect of untreated water used for cleaning activities on milk quality and safety. Similarly, about 75% - 77% of the respondents washed milk containers with cold water and soap while 23% used hot water and soap in Borana and West Shewa zone of Oromia Regional State, Ethiopia, respectively (Garmessa, 2014, Saba, 2015). In contrary about 85.6% of the producers used hot water and detergents to clean milk utensils in Hawassa town, Ethiopia (Haile *et al.*, 2012). Furthermore, besides to udder infection and water quality, hygienic practices with respect to hand washing, container's cleaning and disinfection are the key areas of milk hygiene intervention (Bonfoh, *et al.*, 2006).

Table 10: Types of milk utensils and milk handling practices in the study areas

Variables	Agro ecology							
	Highland (N=89)		Midland(N=106)		Overall (N=195)		X^2	Sig.
	Freq	%	Freq	%	Freq	%		
Milking utensils							5.76	0.056
Plastic	18	20.2	23	21.7	41	21.0		
Aluminum/stainless steel	17	19.1	35	33.0	52	26.7		
Clay pot	54	60.7	48	45.3	102	52.3		
Utensils used for storage							0.41	0.816
Plastic	20	22.5	23	21.7	43	22.1		
Aluminum/stainless steel	4	4.5	7	6.6	11	5.6		
Clay pot	65	73.0	76	71.7	141	72.3		
Utensils used for transportation							0.57	0.750
Plastic	19	21.3	26	24.5	45	23.1		
Gourd	64	72.0	71	67.0	135	69.2		
Aluminum/stainless steel	6	6.7	9	8.5	15	7.7		
Utensils used for churning								
Clay pot	89	100	106	100	195	100		
Water types for washing utensils							0.03	0.868
Cold water	62	69.7	75	70.8	137	70.3		
Warm water	27	30.3	31	29.2	58	29.7		

Results are significantly different at P<0.05, N=Number of respondents, Freq=Frequency

4.8.4. Source of water and utensils cleaning practices

There was significant differences *(P<0.05)* of the water sources for cleaning purpose of utensils in the study area (Table11). When water from non-tap sources is used for cleaning purpose, it is important that producers should at least filter and heat treat it before use since the quality of water determines the amount of bacterial counts in milk (Zelalem, 2009). Furthermore, besides to udder infection and water quality, hygienic practices with respect to hand washing, container’s cleaning and disinfection are the key areas of milk hygiene intervention (Bonfoh, *et al.*, 2006).

In the current study, about 80% of interviewed households cleaned milk container regularly, whereas the rest 20% of them did not clean regularly (Table11).

In West Shoa Zone, Ethiopia (Saba, 2015) almost all the dairy producers (98%) and milk collectors washed milk utensils immediately after use. Smoking of milk handling equipment is a common practice in many parts of Ethiopia. The milk vessels are usually smoked using wood splinters of "Weyira" (Olea africana) to give desirable aroma and flavor to the milk. Smoking is also found to lower the microbial load of raw milk (Almaz *et al.*, 2005). However, in the present study areas about 51.3% of the respondents cleaned milk container by washing without smoking. On the other hand, around 48.7% of them used both washing and smoking the container with "Weyira" (*Olea africana*) and "Tsid" (*Juniperous procer*). In comparison, respondents in the midland had more equipment smoking practice than highland area (Table11). Similarly, many findings reported that Olea africana is the most frequently used plant for smoking of milk containers in different parts of the country (Zelalem and Bernard, 2006; Fekadu, 1994, Alganesh, 2002, Lemma, 2004).

Table 11: Source of water and handling practices of milk utensils in the study area

	Agro ecology							
Variables	Highland (N=89)		Midland (N=106)		Overall (N=195)		X^2	Sig.
	Freq	%	Freq	%	Freq	%		
Source of water							30.92	0.000
River	31	34.8	10	9.4	41	21.0		
Well	2	2.3	25	23.6	27	13.9		
Pond	6	6.7	4	3.8	10	5.1		
Tap	50	56.2	67	63.2	117	60.0		
Clean the milk container daily							0.19	0.666
Yes	70	78.7	86	81.1	156	80		
No	19	21.3	20	18.9	39	20		
Milk container cleaning practices							2.79	0.094
Washing only	52	58.4	48	45.3	100	51.3		
Washing then smocking	37	41.6	58	54.7	95	48.7		

Results are significantly different at P<0.05, N=Number of respondents, Freq=Frequency

4.8.5. Udder health problems

About 66.7% of the interviewed households in the study areas reported milking cows' udder health problems; which might be due to failure to total removal of milk from the udder during milking, lack of knowledge about prevention and control mechanism of mastitis (Table12). Similarly, higher proportion of the respondents (97.9%) experienced udder health problem among the herds in Nuer zone, Gambella region, Ethiopia (Yien, 2014). With regard to udder health management, about 58.5% of the udder case was treated by health technician, 20.5% treated traditionally and 21% left to cure by itself. Farmers long ago have limited knowledge about mastitis as a disease caused by pathogens and other factors. They believe that the evil eyes were the one who cast a spell on the cow by looking at them, so that udder problem might occur. Eventually they became aware that the udder health problems could occur either as a disease which they locally called "Gadansa" (mastitis). In this case, they were using treatment of healing to cure the disease based on either the disease is clinical (wounded) or subclinical. Boiled water mixed with salt was used dipping the teat to treated cow with clinical mastitis or wounded udder.

Table 12: Udder health problem and treatment in the study area

	Agro ecology							
Variables	Highland (N=89)		Midland (N=106)		Overall (N=195)		X^2	Sig.
	Freq	%	Freq	%	Freq	%		
Udder health problem							8.69	0.003
Yes	69	77.5	61	57.5	130	66.7		
No	20	22.5	45	42.5	65	33.3		
Udder health treatment							4.49	1.106
Treated veterinarian	45	50.6	69	65.1	114	58.5		
Treated traditionally	21	23.6	19	17.9	40	20.5		
Left to cure by itself	23	25.8	18	17.0	41	21.0		

Results are significantly different at P<0.05, N=Number of respondents, Freq=Frequency

4.9. Microbial Quality of Raw Cow's Milk

4.9.1. Total bacterial count

Milk Bacterial counts in milk reflect the level of hygiene practiced during milking, milk collection, milk storage temperature, and the time elapsed since milking (Soler *et al.,* 1995). The current results on total bacterial count (TBC) of milk samples collected from smallholder farmers from the two agro-ecologies, small shops and cafe and final consumers is indicated in (Table 13). The mean TBC was not significantly different *(P>0.05)* among the milk samples collected from smallholder farmers in the two agro ecologies. However, there was a significant difference *(P<0.05)* among the milk samples obtained from farm, cafe and consumers. There was also marked difference *(P<0.05)* between milk samples collected from shops and café serving the final consumers (Table13). The average TBC(5.699 log cfu/mL) found in milk samples collected in this study was unsuccessful to comply with the standard set for raw milk intended for direct human consumption (4.6 log cfu/mL) (Bodman and Rice, 1996). The current study in lined with the findings from Cheha district of Gurage zone, Southern Ethiopia reported TBC (5.675 ± 0.016) (Kibebew *et al.*, 2020). Similarly, high results of TBC (6.36 - 9.82 log cfu/mL) were also reported in different parts of the country (Abebe *et al.*, 2012; Zelalem, 2010, Saba, 2015; Haile *et al.*, 2012; Godefay and Molla; 2000 Debebe, 2010; Asaminew and Eyassu, 2011). Generally the high counts of bacteria observed in the present study were attributed to lack of awareness related with milk hygiene, low level of educational status, absence of training on clean milk production, udder or teat contamination with unclean barn and bedding materials, lack of cooling facilities at farm and selling points, poor transportation conditions, lack of good hygiene during milking, poor hygiene of milking utensils and milkers hands as well as lack of good hygiene in and around milking environments. Therefore, in order to reduce contamination of milk utensils used for milking should be thoroughly washed, cleaned using detergent and disinfected immediately after use (Dodd and Phipps, 1994).

4.9.2. Coliform count

High numbers of coliform bacteria in the milk generally reflect fecal contamination due to poor hygiene during milking and subsequent handlings, as unclean udder and teats can contribute to the presence of coliform from various sources such as manure, soil, feed, personnel and water (CDC, 2006). The average coliform count (CC) was significantly different *($P<0.05$)* among milk samples collected from milk producers of the two agro ecologies and that of milk samples collected from small shops and cafes. Milk samples from West Shewa Zone of Oromia region were reported to have 4.49 log cfu/ml (Tassew, 2007) and 4.84 log cfu/mL from cows kept under traditional condition in the Wolayita zone, southern Ethiopia (Rahel, 2008). Moreover, about 4.18 ± 0.01 log cfu/ml was reported for raw milk samples collected from Bahir Dar milk shed in Amahara region, Ethiopia (Derese, 2008) and 4.10 log cfu/ml for milk samples collected in and around Addis Ababa (Godefay and Molla, 2000). On the other hand, higher coliform count of 6.57 log cfu/ml was reported for raw cow's milk collected from different producers in the central highland of Ethiopia. In general, the average values of CC observed in the current study were much higher when compared with the permissible values set by the American Public Health Service : <100 cfu/mL for Grade A milk and 101 - 200 cfu/mL for Grade B milk(WHO,1997). This higher CC in the present study might be due to lack of awareness related with hygiene, udder or teat contamination with unclean barn and bedding materials, lack of good hygiene during milking, poor hygiene of milking utensils and milker's hands (possible contamination of milk with fecal materials) unclean udder and teats of cow's, mastitis, improper and low frequency of barn cleaning, and others related factors.

4.9.3. Yeast and mould count

Significant variation was observed in yeast and mould count among the milk samples collected from milk producers of the two agro ecologies and that of milk samples collected from small shops and consumers. The overall average YMC was 5.36$\log_{10}$ cfu/ml for milk samples collected from small holder raw milk producers from the two agro ecologies, small shops and consumers. Average value of yeast and mould counts were significantly different *(P<0.05)* among milk samples collected from the study area (Table13). The present value of YMC was lower than Haile *et al* (2012) and Teshome *et al* (2014) who reported higher Yeast and mould counts of 7.13$\log_{10}$ cfu/ml for milk samples collected from distribution containers in Hawassa, Southern Ethiopia and greater than 4.206 $\log_{10}$ cfu/ml for raw milk sample collected from different critical points of milk sources in Shashemene town, Ethiopia respectively. The YMC observed in raw milk obtained from milk might be attributed to contamination from air, storage containers or poor personal hygiene of milker. Yeast and mould are considered to be spoilage organisms. Some yeast and moulds, however, are public health concerns due to their production of mycotoxins, which are not destroyed during food processing or cooking (McLandsbrough and Ann, 2005).

4.9.4. *Staphylococcus count*

There was no statistical significance variation*(P>0.05)* in *staphylococcus* count among the milk samples from different milk samples collected from smallholder farmers in the two agro ecologies, shops and consumers. *Staphylococcus* is an important pathogenic bacterium that can affect quality and safety of milk and milk products. It is naturally present in udder environment and often associated with milk born disease due to the ability of some strains to produce heat stable toxins. *Staphylococcus spp.* is among pathogenic microbes that cause minor skin infections and life threatening diseases.

Dairy cows with mastitis may be the source of enterotoxigenic *staphylococcus* in raw milk, which may subsequently be coming led with other milk while collecting from cows (Sintayehu and Haile, 2015).

In the present study the average value of *Staphylococcus count* was 5.625±0.027 for raw milk collected from the study area. This result was lower than the value 6.13 log_{10} cfu/ml for raw milk reported by Sintayehu and Haile (2015). It is contagious pathogenic infection of udder, cause of foodborne diseases of human throughout the world. The milk and milk products can be contaminated by *Staphylococcus spp.* due to absence of mastitis control methods, inappropriate milking procedure and use of poor hygienic condition practice in the farm (Nickerson, 2014 and Dufour *et al*., 2011). Use of good hygienic condition of milk production, use of mastitis control and pasteurizing the milk can prevent the contamination of *Staphylococcus*. The *staphylococcus* has been cause of mastitis in dairy animal leading to food borne intoxication in milk and milk products.

Table 13: The mean (±S.E) microbial counts (log10cfu/ml) of raw milk samples

Variables		**(Mean±SE)**		
Milk sources	TBC	CC	YMC	SC
Highland HHs	$5.156±0.022^{c}$	$4.145±0.032^{b}$	$4.921±0.019^{b}$	$5.418±0.012^{a}$
Midland HHs	$5.173±0.016^{c}$	$4.141±0.029^{b}$	$5.282±0.015^{a}$	$5.582±0.010^{a}$
Shop and cafe	$6.165±0.013^{b}$	$5.181±0.019^{a}$	$5.392±0.002^{a}$	$5.661±0.061^{a}$
Consumer	$6.303±0.016^{a}$	$5.291±0.013^{a}$	$5.881±0.061^{a}$	$5.841±0.025^{a}$
Overall mean	5.699±0.017	4.689±0.023	5.366±0.024	5.625±0.027
P-value	0.001	0.003	0.002	0.086

All of the Means followed by different superscripts within columns are significantly different (P<0.05), HHs=Households, TBC=Total bacterial count, CC=Coliform count, YMC=Yeast and mould count, SC= Staphylococcus count, SE= Standard error.

4.10. Major Constraints Related to Milk Quality

The major milk quality related problems ranked based on the current assessment of the study areas of the sampled respondents and group discussions with key informants from two agro-ecologies were limited knowledge of milk handling, shortage of clean water, lack of appropriate milking equipment and cooling facilities (Table14). Other constraints such as poor barn conditions and poor market access were also ranked as milk quality related problems of the study areas. In consent with the present finding, limited awareness on hygienic handling of milk, lack of cooling facility, shortage of clean water, lack of effective quality control system and absence of quality based payment system were the major milk quality related constraints in Borana and west Shewa zone of Oromia Regional State, Ethiopia (Garmessa, 2014; Saba, 2015). The present results were also comparable with the findings from Cheha district of Gurage zone, Southern Ethiopia (Kibebew *et al.*, 2020).

Table 14: Major challenges related with milk hygiene and quality ranked by respondents in the study area

Constraints	Priority level							
	1	2	3	4	5	Score	Index	Rank
Highland (N=89)								
Shortage of clean water	15	74	0	0	0	371	0.28	2nd
Limited awareness on hygienic practices	89	0	0	0	0	445	0.34	1st
Lack of appropriate milking utensils	0	0	0	28	61	117	0.09	4th
Poor barn condition	7	19	45	12	6	276	0.21	3rd
Poor market access	0	0	0	17	72	106	0.08	5th
Midland (N=106)								
Shortage of clean water	18	88	0	0	0	442	0.26	2nd
Limited awareness on hygienic practices	76	5	25	0	0	475	0.27	1st
Lack of appropriate milking utensils	34	23	20	29	0	358	0.21	3rd
Poor barn condition	16	27	30	33	0	344	0.2	4th
Poor market access	0	0	0	8	98	114	0.06	5th

Index = the sum of (5 times first order + 4 times second order +3 times third order + 2 times fourth order + 1 times fifth order) for individual variables divided by the sum of (5 times first order + 4 times second order +3 times third order + 2 times fourth order + 1 times fifth order) for all variables.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The purpose of this study was to assess milk production practices and microbial quality of cow milk produced in Aleta Wondo district. Based on the microbial analysis of milk sampled from the study area the quality of the milk was below international and national standards. This is mainly due to lack of good hygienic practices starting from the point of production up until consumption, including materials used for milking, transportation and storage. This high level of contamination of milk might be due to initial contamination of milk originating from the udder surface, source of cleaning water, milkier hygienic condition and milking utensils. High amount of milk contamination could be associated with milking of cows in the same barn and hygienic practices implemented while milking. This practice might have led to soil, dung and urine contamination of milk and failure to milk quality production at producers. This could lead to consumer health problem and loss of income from milk and milk products to households.

The unhygienic conditions of milking, unclean milk handling equipment and the use of contaminated cleaning water were among the main sources of milk contamination. The problems of milk handling practices were scarcity of material resources, untargeted training and extension services and lack of access to new technology adoption. Generally, the high bacteria count leads to early spoilage of the products before the expected shelf life, which makes it unfit for human consumption. The producers should also strengthen their capacity of quality control to deliver safe and quality products to consumers. Therefore, good milk production and handling practices need to be practiced by both the milk producers and stakeholders involved in milk transportation and marketing. Moreover, pertinent tailor-made trainings and awareness creations need to be made to the farming community.

5.2. Recommendations

Based on the findings of this study, the following recommendations were forwarded:

- Promoting farm level adaptation need to emphasize on the crucial role of providing information on better production techniques and improving producers awareness on milk production to enable farmers adapt to production.
- Introducing and disseminating appropriate dairy technologies to smallholder farmers with a continuous follow up could be a means through which their livelihoods and income can be improved.
- Strict hygienic measures should be applied during milking and milk handling practices, achievable by educating communities on good animal husbandry practices.
- The milk used for consumption as well as the water used for udder washing and cleaning of dairy products handling equipment should be heat treated.
- Routine assessment of milk quality produced in the area and consumed by the general public has to be mandatory in order to protect the public from milk borne infections.
- Further study with wider area coverage is needed to identify the different species of microorganisms that might cause public health hazards.

6. REFERENCES

Abebe, B., Zelalem, Y. and Ajebu, N. 2012. Hygienic and Microbial Quality of Raw Whole Cow's Milk Produced in Ezha District of the Gurage Zone, Southern Ethiopia. Wud pecker Journal of Agricultural Research, 1, 459-465.

Abebe, B., Zelalem, Y. and Ajebu, N. 2013. Handling, Processing and Utilization of Milk and Milk Products in Ezha District of the Gurage Zone, Southern Ethiopia. *Journal Agriculture, Biotechnology and Sustainable Development, 591*-98. https://doi.org/10.5897/JABSD2013.0206

Abebe, B., Zelalem, Y. and Ajebu, N. 2014. Dairy Production Systems and Constraints in Ezha District of the Gurage Zone, Southern Ethiopia. Global Veterinaria, 12, 181-186.

Aberra, A. 2010. Microbiological safety of pasteurized and raw milk from processing plants in and around Addis Ababa. M.Sc. Thesis submitted to School of Graduate Studies Addis Ababa University, in partial fulfilment of the requirements for the degree of Masters of Science in Environmental Science.

Adugna Tolera and Aster Abebe. 2007. Livestock production in pastoral and agro-pastoral production systems of southern Ethiopia. Livestock Research for Rural Development.19: 4-7.

Ahmed, M., Ehui, S. and Yemesrach Assefa. 2003. Milk development in Ethiopia. Socioeconomics and policy research. Working paper 58. ILRI (International Livestock Research Institute), Nairobi, Kenya. p.47.

Alehegne, W. 2004. Bacteriological quality of bovine milk in small holder dairy farms in Debre zeit, Ethiopia, an M.Sc. Thesis Submitted to the Faculty of Veterinary Medicine, Addis Ababa University in partial fulfilment of the requirement of the degree of Master of Science in *Tropical Veterinary Medicine* pp. 2-13.

Aleta wondo district agricultural and rural development office .2013/14. Aleta wondo district agricultural and rural development office. Unpublished report.

Aleta wondo district livestock and fishery office .2016/17. Aleta wondo district livestock and fishery office. Unpublished report.

Alganesh, T. 2002. Traditional Milk and Milk Products Handling Practices and Raw Milk Quality in Eastern Wollega. M.Sc. Thesis, Alemaya University, Dire Dawa.

Alganesh, T., Ofodile, L.N. and Fekadu, B. 2007. Microbial Quality and Chemical Composition of Raw Whole Milk from Horro Cattle in East Wollega, Ethiopia.

Alganesh, T. 2017. Status and Challenges in Safety and Quality of Dairy Products in Ethiopia. A Review, Holeta Agricultural Research Center, Addis Ababa, Ethiopia.

Ali, A., M.S. Mahmood Iftikhar, H. and Masood, A. 2011. Adulteration and Microbiological Quality of Milk (A Review). Institute of Microbiology, Department of Parasitology, Faculty of Veterinary Science, University of Agriculture, Faisalabad, 38040, *Pakistan Journal Nutrition.* 10 (12): 1195-1202.

Almaz, G., Foster, H.A. and Holzapfel, W.H. 2005. Field Survey and Literature Review on Traditional Fermented Milk Products of Ethiopia. *International Journal of Food Microbiology*, 68, 173-186. https://doi.org/10.1016/S0168-1605(01)00492-5

Amistu, K., Melese, A. and Degefa, T. 2015. Evaluation of Hygienic Status and Marketing System of Raw Cow Milk in Different Critical Points of Oromia Special Zone. Global Journal of Science Frontier Research: Biological Science, 15, 21-30.

Amistu, K., T. Degefa and A. Melese. 2015. Assessment of raw milk microbial quality at different critical points of Oromia to milk retail centers in Addis Ababa. Food Science and Quality Management 38:1-9.

Anteneh Belete, 2006. Studies on cattle milk and meat production in Fogera district: Production systems, constraints and opportunities for development. M.Sc. Thesis. University of Hawassa, Ethiopia.

Asaminew, T. 2007. Production, handling, traditional processing practices and quality of milk in Bahir dar milk shed area, Ethiopia, Haramaya University of agriculture, diredawa, Ethiopia.

Asaminew, T., Eyassu, S. 2009. Smallholder dairy production system and emergence of dairy cooperatives in Bahir Dar Zuria and Mecha Woreda, Northwestern Ethiopia. Dairy and Food Sciences, No 4, pp. 185-192.

Asaminew, T. and S. Eyassu. 2011. Microbial quality of raw cow's milk collected from farmers and dairy cooperatives in Bahir dar zuria and Mecha district, Ethiopia. *Agriculture and Biology Journal of North America* 2:29-33.

Assefa, G., Mussie, H., Mengistie, T., Zewdu, W., Assemu, T. 2015. A survey on breeding practice, and productive performance of Simada cattle in Tach Gayint District, Ethiopia. J. Life Sci. Biomed. 5(6):171- 180.

Asrat, G. 2009. Evaluation of Traditional Practices and Effects of Lacto peroxidase System on Keeping Quality of Cottage Cheese, M.Sc. Thesis. Hawassa University, Ethiopia.

Asrat, A., Yilma, Z. and Nurfeta, A. 2013. Characterization of milk production systems in and around Boditti, South Ethiopia. Livestock Research for Rural Development. Volume 25, Article #183. Retrieved June 9, 2015, from http://www.lrrd.org/lrrd25/10/ayza25183.htm

Aysheshim Bekele, Fekadu Beyene, Mitiku Eshetu, 2015. Handling, processing and marketing of cow milk in urban and peri-urban areas of Dangila town Western Amhara region. Global Journal of Food Science and Technology. pp 159-174.

Azage Tegegne, Gebremedhin, B., Hoekstra, D., Belay, B. and Mekasha, Y. 2013. Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market oriented development. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 31. Nairobi: ILRI.

Barbuddhe, S. B. and Swain, B. K., 2008. Hygienic Production of Milk. Technical Bulletin No: 11, ICAR Research Complex for Goa (Indian Council of Agricultural Research), Ela, Old Goa-403 402, Goa, India, pp. 1-4.

Belay D, Yisehak K, Janssens GPJ .2012. Productive and reproductive performance of Zebu X Holstein-Friesian crossbred dairy cows in Ethiopia. 23. Jimma Town, Oromia, Ethiopia. Glob. Vet. 8(1):67-72.

Belay Duguma and Janssens J. 2014. Smallholder milk processing and marketing characteristics at urban dairy farms in Jimma town Oromia Regional state. Global veterinarian. ISSN 1992-6197

Bennett, R.W. and Lancette G.A. 2016. Studies on Enterotoxins and Antimicrobial Resistance in *Staphylococcus aureus* Isolated from Various Sources

Bereda, A., 2013. Handling, processing and utilization of milk and milk products in Ezha district of the Gurage zone, Southern Ethiopia. Addis Ababa Ethiopia

Beriso K, Tamir B, Feyera T. 2015. Characterization of smallholder cattle milk production system in Aleta Chukko District, Southern Ethiopia. J. Adv. Dairy Res. 3:132.

Bille, P.G., B.R. Haradoeb and N. Shigwedha. 2009. Evaluation of chemical and bacteriological quality of raw milk from Neudamm dairy farm in Namibia. 9: 7.

Biruk Hailu, Samson Weldemichael and ZelalemYilma. 2009. Review Microbial Properties of Milk and Traditionally Produced Ethiopian Fermented Milk Products. In: 17thed Annual conference of the Ethiopian Society of Animal Production (ESAP).Proceedings, held in Addis Ababa, Ethiopia. pp. 137- 148.

Blowey, R and P.Edmondson. 2010. Mastitis Control in Dairy Herds. 2nded. CABI (Centre for Agriculture and Biosciences International) Publishing.

Bodman, G.R. and Rice, D.N. 1996. Bacteria in Milk Source and Control. University of Nebraska and United State Department of Agriculture, Lincoln.

Bonfoh, B., A. Wasem, A.N. Traore, A. Fane, H. Spillmann, C.F. Simbe, I.O Alfaroukh, J. Nicolet, Z. Farah and J. Zinsstag. 2003. Microbiological Quality of Cow Milk Taken at Different Intervals from the Udder to the Selling Point in Bamako and Mali. *Food control* 14:495-500.

Bonfoh, B.C., Roth, A.N., Traore, A., Fane and Farah, Z. 2006. Effect of Washing and Disinfecting Containers on the Microbiological Quality of Fresh Milk Sold in Bamako (Mali).Food Control, 17,153-161.

Buncic, S., 2006. Integrated food safety and veterinary public health. School of Veterinary Science University of Bristol, UK, pp. 283-287.

CDC (Center of Disease Control). 2006. Emerging Infectious Diseases.

CDFA (California Development of Food and Agriculture. 2008. New Coliform Bacteria Standard for California Raw Milk Producers

Chewaka, T. 2006. The current status of dairy production in Yirgachefe area of southern Ethiopia. MSc. thesis. Hawassa University, Hawassa, Ethiopia. pp. 38-74.

Codex Alimentarius Commission (CAC). 2004. Code of hygienic practices for milk and milk products. pp. 4

Coorevits A., V. De Jonghe, J .Vandroemme, R. Reekmans, J .Heyrman, W. Messens, P .DeVos and M. Heyndrickx. 2008. Comparative analysis of the diversity of aerobic spore-forming bacteria in raw milk from organic and conventional dairy farms. *Application of Microbiology* 31 (2):126-140.

CSA (Central Statistical Agency). 2007/8. Federal Democratic Republic of Ethiopia Agricultural sample survey. Livestock and livestock characteristics bulletin, Volume II. Addis Ababa, Ethiopia.

CSA (Central Statistics Agency). 2015/16. Livestock and Livestock characteristics, (private peasant holdings).Agricultural Sample survey. Statistical bulletin volume II, Central Statistics Agency. Addis Ababa. Ethiopia.

CTP (Cow Time Project). 2006. Cow Time Project Version National Milk Harvesting Centre, Australia.

Debebe, W. 2010. Physicochemical Properties and Safety of Street-Vended Milk in and around Addis Ababa City (Kotebe, Bishoftu and Chancho). M.Sc. Thesis, Haramaya University, Haramaya.

Debuyser, M. L, Dufour, B., Maire, M. 2011. Implication of milk and milk products in food-borne diseases in France and in different industrialized countries

Demissu, H .2014. Assessment on Peri-Urban Dairy Production System and Evaluation of Quality of Cows' Raw Milk: A Case of Shambu, Fincha and Kombolcha Towns of Horro Guduru Wollega Zone, Ethiopia. *Science of Technology and Articles Research of Journal* 3(3):37-43.

Derese Teressa. 2008. Present situation of urban and peri-urban milk production and quality of raw milk produced in West Shoa Zone, Oromia Region, Ethiopia. MSc Thesis. Haromaya University, Ethiopia.

Dessalegn, G. 2015. Assessment of Production and Reproductive Performances of Cattle and Husbandry Practices in Bench-Maji Zone, Southwest Ethiopia. *Global Journal of Animal Scientific Research.* 3(2): 441-452 2015

Dodd, F.H. and Phipps, R.H. 1994. Dairy Management and Health. In: Smith, A.J, Eds., Milk Production in Developing Countries, Centre for Tropical Veterinary Medicine, University of Edinburgh, Scotland, UK, 258-271.

Douglas, J.R. 2003. Bulk Tank Cultures are the Dairy Man best Friend. University of Wisconsin Milking Res. Inst. Lab., (Report) No. 2223.

Dufour, S., A. Frechette, H. W. Barkema, A. Mussell and D. T. Scholl. 2011. Effect of udder health management practices on herd somatic cell count. *Journal of Dairy Science* 94 (2): 563-579.

Edward, K.C. and Inya, I.M., 2013. The Microbial Quality of Raw Milk from four locations in Abia State, Nigeria. IOSR *Journal of Pharmacy and Biological Sciences*, (5), 30

ESAP (Ethiopian Society of Animal Production). 2008. Commercialization of the livestock center of agriculture in Ethiopia. In: proceeding of 16th annual conference of ESAP held in Addis Ababa, Ethiopia .October 8-10, 2008.

FAO and IDF. 2011. Guide to good dairy farming practice. Animal Production and Health Guidelines. Rome. 8no.

FDA (Food and Drug Administration). 2003. Food Sampling and Preparation of Sample Homogenate. In: Andrews, W.H. and Hammack, T.S., Eds., Bacteriological Analytical Manual, 8th Edition, Revision A, AOAC, Gaithersburg, Chapter 1.

Fernandes, R., 2009. Microbiology Handbook Dairy Products.pp100.

Fekadu, B. 1994. Present Situation and Future Aspects of Milk Production, Milk Handling and Processing of Dairy Products in Southern Ethiopia. Food Production Strategies and Limitations: The Case of Aneno, Bulbula and Dongora in Southern Ethiopia. PhD Dissertation, Agricultural University of Norway, University Student.

Fikirneh, N., Tadesse E., Aseffa E., Yimamu, C., Hundessa, F. 2012. Production, handling, processing, utilization and marketing of milk in the Mid Rift Valley of Ethiopia. Livestock Research for Rural Development. 24. pp 75-76

Florence Suma, Asna Urooj, Asha MR and Jyotsna Rajiv. 2014. Sensory, Physical and Nutritional Qualities of Cookies Prepared from Pearl Millet (Pennisetum Typhoideum)

Food Standards Agency (FSA). 2006. Milk hygiene on the dairy farm a practical guide for milk producers to the food hygiene (England) and to food hygiene (whale), pp. 1-10.

Gandiya, F. 2001. Where quality begins: Cow management factors affecting the quality of milk. Bulletin of International Dairy Federation (IDF) 361: 6-8.

Gebrewold, A., Alemayhu, M., Demeke, S., Bediye, S., and Tadessie, A. 2000. Status of dairy development in Ethiopia. In: The role of village dairy cooperatives in dairy development. SDDP (Smallholder Dairy Development Project) Proceedings, MOA (Ministry of Agriculture). Addis Ababa, Ethiopia.

Getachew, F., Medhin W. and Getnet H. 2014. Inventory of dairy policy-Ethiopia. pp. 13-21

Ghimin, Y.N, Shivakoti, G.P. and Perette, S.R. 2010. Household-level vulnerability to drought in hill agriculture of Nepal: Implication for adaptation planning, international journal of sustainable development and world ecology, vol.17, no.3, pp.25-230.

Girma, C., Yoseph, M. and Mengistu, U. 2014. Feed resources quality and feeding practices in urban and peri-urban dairy production of southern Ethiopia. Tropical and Subtropical Agro ecosystems, 17 (2014): 539 – 546.

Godefay, B and B. Molla. 2000. Bacteriological Quality of Raw Milk from Four Dairy Farms and Milk Collection Center in and around Addis Ababa. Munich. Tierarzil wschr 113: 1-3.

Gran, H.M., Mutukumira, A.N., Wetlesen, A. and Narvhus, J.A. 2002. Smallholder Dairy Processing in Zimbabwe: Hygienic Practices during Milking and the Microbiological Quality of the Milk at the Farm and on Delivery. Food Control, 13, 41-47. https://doi.org/10.1016/S0956-7135(01)00082-2

Gurmessa, T. 2014. Physicochemical Properties and Microbial Quality of Raw Cow's Milk in Yabello District, Borana Zone, Southern Ethiopia. MSc Thesis, Haramaya University, Haramaya.

Gumersa, T. 2015. Microbiological quality and impact of hygienic practices on raw cow's milk obtained from pastoralists and market. The case of Yabello District Borana Zone, Ethiopia. ISSN: 2408-5472 Vol. 3 (2), pp. 153-158, May, 2015.

Haile, W., Zelalem, Y. and Yosef, T.G. 2012. Hygienic Practices and Microbiological Quality of Raw Milk Produced under Different Farm Size in Hawassa, Southern Ethiopia. Agricultural Research and Reviews, 1, 132-142.

Harding, F. 1999. Milk Quality. 2nd.ed. Gaiters burg, Maryland: Aspen. pp. 25-38, 104-105.

Hiwot, D. 2013. Hygienic practices during milking and bacteriological quality of the milk in raw bovine bulk milk in the selected milk collection centers: small holder dairy processing Ethiopia. Doctoral Program in Animal Nutrition and Food, Safety University Degli Studi di Milano pp.23-24

Holloway, G. and Ehui, S. 2002. Expanding Market Participation among Smallholder Livestock Producers: A Collection of Studies Employing Gibbs Sampling and Data from the Ethiopian Highlands. Socio-Economic and Policy Research Working Paper 48. ILRI, Nairobi.

Islam, M.A., Islam, M.N., Khan, M.A.S., Rashid, M.H. and Obaidullah, S.M. 2009. Effect of Different Hygienic Condition during Milking on Bacterial Count of Cows' Milk.

Karmen, G.T. and Slavica, G.T. 2008. The Microbiological Quality of Raw Milk after Introducing the Two Day's Milk Collecting System. Acta Agriculturae Slovenica, 92, 61-74.

Karuga, S. 2009. Draft Report on Dairy Chain Analysis, Timau Milk Shed. Micro Enterprise Support Program Trust.

Kedija Hussien. 2007. Characterization of milk production system and opportunity for market orientation: A Case Study of Mieso District, Oromia Region, Ethiopia: Haramaya University. pp. 56-58

Ketema, Y. 2013. Zonal diagnosis and intervention plan Sidama zone, SNNP Region: Livestock and irrigation value chains Ethiopian smallholder.

Ketema, W. 2014. Assessment of dairy cattle feed resources and milk yields under smallholder farmers in Kersa Malima woreda. Department of Animal Production Studies M.Sc. program in Tropical Animal Production and Health, Bishofitu, Ethiopia.

Kibebew, B., Mitiku, E. and Firew, K. 2020. Hygienic Production Practices and Microbial Quality of Cow Milk in Cheha District of Gurage Zone, Southern Ethiopia.

Kumar P. Nikam.T and Landge S. 2011. Participation of women in dairy farming. Indian Res. J. Ext.Edu.112.2011. pp. 76

Kurwijila, L.R. 2006. Hygienic Milk Handling, Processing and Marketing: Reference Guide for Training and Certification of Small-Scale Milk Traders in Eastern Africa. ILRI (International Livestock Research Institute), Nairobi, Kenya, pp.11-26.

Lemma, F. 2004. Assessment of Butter Quality and Butter Making Efficiency of New Churns Compared to Smallholders' Butter Making Techniques in East Shoa Zone of Oromia, Ethiopia. MSc. Thesis, Alemaya University of Agriculture, Dire Dawa, 113 p.

Lemma F, 2005a Fekadu B. Rural smallholder milk and dairy products production, utilization and marketing systems in East Showa zone of Oromia. 17-28 pp. In: Participatory innovation and research: Lesson for livestock development. Proceedings of the 12th Annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa Ethiopia. August 12-14. ESAP, Addis Ababa volume 2: technical papers.

Lemma, H. 2018. Analysis of intensification of dairy production systems, bovine milk quality and consumption in the smallholder dairying of ada'a district of Ethiopia. M.Sc. Thesis. Addis Ababa University, Ethiopia.

Lore, T.A., Kurwijila, L.R. and Omore, A. 2006. Hygienic milk production: a training guide for farm-level workers and milk handlers in Eastern Africa. ILRI (International Livestock Research Institute), Nairobi, Kenya, pp. 1-12.

Makoni N., Mwai R., Redda T., Zijpp A. van der. and Lee, J. van der. 2013. White gold; opportunities for dairy sector development collaboration in East Africa. Centre for Development Innovation, Wageningen UR (University & Research center). CDI report CDI-14-006. Wageningen.

Mclands brough and Ann, 2005. The Risk of Mycotoxins Contamination of Dairy Feed and Milk on Smallholder Dairy Farms in Kenya

Merha, Z. 2006. Genetic Diversity in Northern Ethiopian Cattle Breed: An on-farm and molecular characterization. Doctoral Dissertation, Agricultural University, Wageningen, Netherlands.

Mesfin, Z. 2015. Hygienic practices, bacteriological quality of cow milk and its public health importance along the dairy value chain in sidama high lands of southern Ethiopia.M.Sc. Thesis, Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Microbiology, Immunology and Veterinary Public Health.

Minale, G. and Yilkal, T. 2015. Constraints and Opportunities of Dairy Cattle Production in Chencha and Kucha Districts, Southern Ethiopia

MOARD, 2007. Livestock development master plan study phase I Report – data collection and analysis volume I – Dairy, Addis Ababa, Ethiopia pp.2.

Mosnier, W. 2010. Dairy Farming and Climate Change.

Mosu, S. 2013. Bacteriological quality of bovine raw milk at selected dairy farms in Debre Zeit town, Ethiopia Company. *Journal of Food Science Technology*.

Murphy, S.C. 1996. Source& causes of High Bacteria count in raw milk: an Abbreviated Review corneu University, Ithaca, and N.Y.pp 1-4.

Murphy, S. 2008. Raw Milk Bacteria Tests–Standard Plate Count, Preliminary Incubation Count, Lab Pasteurization Count and Coliform Bacteria Counts. Dairy Foods Science Notes: p.7.

Nangamso, B. 2006. General hygiene of commercially available milk in the Bloemfontein area. MSc Thesis submitted in fulfilment of the requirements for the degree of Master of Science, In the Faculty of Natural and Agricultural Sciences, Department of Microbial, Biochemical and Food Biotechnology at the University of the Free State, Bloemfontein, South Africa, pp. 23-24.

Nanyeenya, W.N., Mugisha, J., Staal, S.J., Baltenweck Romney, D.I and Halberg, N. 2008. Dairy Performance and Intensification under Traditional and Economic Efficiency Farm Plans in Uganda. Middle-East *Journal of Scientific Research 3 (2): 82-89, 2008 ISSN 1990-9233. © IDOSI Publications,* 2008

Nickerson, S.C. 2014. Choosing the best teat dip for mastitis control and milk quality. In; conference on milk quality of the National Mastitis Council Professional Dairy Producers. Proceeding. Wisconsin. p. 43.

O'Connor, C.B. 1994. Rural Dairy Technology. ILRI training manual Number 1. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.pp.133

O'Connor, C.B. 1995. Rural Dairy Technology ILRI Training Manual I. International Livestock Research Institute, Addis Ababa.

Oliver S P., Jayarao B M., Almedia R A. 2005. Food borne pathogens in milk and the dairy environment food safety and public health implications. Foodborne Pathoenic Disease 2:115-1129.

Oliver, S. P. 2010. How Milk Quality is Assessed. The University of Tennessee.

Omore, A., S. Arimi, E. Kaugethe, J. McDermott, S. Staal, E. Ouma, J. Odhiambo, A. Mwangi, G. Aboge, E. Koroti and R. Koech, 2001. Assessing and Managing Milk-born Health Risks for the Benefit of Consumers in Kenya. Smallholder Dairy (Research and Development) Project, Nairobi, Kenya. 46p.

Omore, A. T. Lore, S., Staal, J., Kutwa, R. Ouma, S., Arimi and E., Kangethe. 2005. Addressing the public health and quality concerns towards marketed milk in Kenya. Smallholder Dairy (R&D) Project Research and Development Report. No. 3.

Pandey, G. S. and G.C.J., Voskuil, 2011. Manual on milk safety, quality and hygiene for dairy extension workers and dairy farmers, Lusaka, Zambia. pp. 7-26.

Pauline, E. and Karin, R. 2006. Preparation of dairy products. Agro book 36.printed by pigigrafi, wageningen and the Netherlands.

Rahel, N. 2008. Traditional and Improved Milk and Milk Products Handling Practices and Compositional and Microbial Quality of Milk and Buttermilk in Delbo Watershed of Wolayta Zone. MSc Thesis, Hawassa University, Hawassa.

Richardson, G.H. 1985. Standard Method for the Examination of Dairy Products. 15th Edition, American Public Health Association, Washington DC.

Ruegg, P.L. 2003. Practical Food Safety Interventions for Dairy Production. *Journal of Dairy Science.*86p.

Saba, H. 2015. Quality Assessment of Cattle Milk in Adea Berga and Ejerie Districts of West Shoa Zone, Ethiopia, MSc Thesis, Haramaya University, Ethiopia.

Shunda, D., Habtamu, T., and Endale, B., 2013. Assessment of Bacteriological Quality of Raw Cow Milk at Different Critical Points in Mekelle, Ethiopia. *International Journal of Livestock Research* ISSN 2277-1964 Volume 3(3b).

Sintayehu, Y., Beyene, F., &Tegegn, A. 2008. Dairy production, processing and marketing systems of Shashemene-Dilla area, South Ethiopia, IPMS Working Paper 09. ILRI (International Livestock Research Institute), Nairobi, Kenya.

Sintayehu, Y. and Haile, G. 2015. Assessment of Microbial Quality and Safety of a Traditional Fermented Milk- ‘Ergo’, Collected from Hawassa City, South Ethiopia.

Soler, A., Ponsell, C., DePaz, M. and Nunez, M. 1995. The Microbiological Quality of Milk Produced in the Balearic Islands. International Dairy Journal, 5, 69-74. https://doi.org/10.1016/0958-6946(94)P1599-9

Spreer, E. 1998. Milk and dairy product technology. Mixa, A (translator). Marcel Dekker, INC.ISBN: 0-8247-0094-5. New York, pp. 39-58.

SPSS (*Statistical Package for the Social Sciences)*, 2012. Vision 20. IBM Corporation, SPSS Inc., Chicago IL.

Tassew, A. 2007. Production, Handling, Traditional Processing Practices and Quality of Milk in Bahir Dar Milk Shed Area, Ethiopia. M.Sc. Thesis, Haramaya University, Haramaya.

Tegegne, A., Gebremedhin, B., Hoekstra, D., Belay, B. and Mekasha, Y. 2013. Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market oriented development. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 31. Nairobi: ILRI.

Teshager, A., Belay, D. and Taye, T. 2013. Smallholder Cattle Production Systems in Three Districts of Ilu Aba Bora Zone of Oromia Regional State, South Western Ethiopia. American-Eurasian Journal of Scientific Research 8 (1): 38-46, 2013 ISSN 1818-6785 © IDOSI Publications, 2013.

Teshome, G. 2013. Physicochemical Properties and Microbial Quality of Raw Cow's Milk Produced and Marketed in Shashemene Town, Southern Ethiopia. MSc Thesis, Haramaya University, Haramaya.

Teshome, G., Fekadu, B. and Mitiku, E. 2014. Handling Practices and Microbial Quality of Raw Cow's Milk Produced and Marketed in Shashemene Town, Southern Ethiopia. *International Invention Journal*, Volume.2 (9): pp. 153-162.

Tolera, A., Yami, A., and Alemu, D. 2012. Livestock feed resources in Ethiopia: Challenges, Opportunities and the need for transformation. Ethiopia Animal Feed Industry Association, Addis Ababa, Ethiopia.

Tournas Valerie, Michael E. Stack, Philip B. Mislivec, Herbert A. Koch and Ruth Bandler. 2011. Bacteriological Analytical Manual (BAM) Main Page

Tsadikan, Z., 2012. Study on Cattle Milk Production, Processing and Marketing System in Enderta District, Tigray Regional State. Thesis of Graduate Studies of Addis Ababa University, Ethiopia.

Tsedey.A and Asrat.T, 2015. Safety and Quality of Raw Cow Milk Collected from Producersand Consumers in Hawassa and Yirgalem areas, Southern Ethiopia. Southern Agricultural Research Institute, Hawassa Agricultural Research, Center, Ethiopia: volume. 44

Tsedeke, k. 2007. Production and marketing system of dairy cattle in Ethiopia international livestock institute, Addis Ababa.

Ulfina Galmessa, Jiregna Dessalegn, Alganesh Tola, Shiv Prasad and Mulugeta Kebede. 2013. Dairy Production Potential and Challenges in Western Oromia Milk Value Chain, Oromia, Ethiopia. *Journal of Agriculture and Sustainability. Volume. 2 (1).*

Vissers, M.M.M. and Driehuis, F, 2008. On-Farm Hygienic Milk Production, BLBK061 Tamime pp.1-3.

WHO (World Health Organization). 1997. Global Estimation of Food-Borne Disease. World Health Statistics in Raw Milk, International Dairy Federation, Brussels, 8-11.

Worku, T., Negera, E., Nurfeta, A. and Welearegay, H. 2012. Microbiological quality and safety of raw milk collected from Borena pastoral community. Oromia Regional State, *African Journal of Food Science and Technology.* 3(9) pp. 213-222.

Yamane, T. 1967. Statistics, an Introductory Analysis 2nd Edition. New York

Yien, D., 2014. Assessment of Hygienic Milk Production and Prevalence of Mastitis in Dairy Cow in Jikawo Woreda of Nuer Zone, Gambella Region, Ethiopia. MSc Thesis Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Animal Production Studies Bishoftu, Ethiopia.

Yigrem, S., Beyene, F., Tegegne, A., and Gebremedhin, B., 2008. Dairy production, processing and marketing systems of Shashemene-Dilla area, South Ethiopia. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 9, ILRI (International Livestock Research Institute), Nairobi, Kenya 62 pp.

Yitaye Alemayehu. 2008. Characterization and analysis of the urban and peri-urban dairy production systems in the North western Ethiopian highlands. PhD thesis, University of Natural resources and applied sciences, Vienna, Austria, 103 pp.

Yitaye A, Maria W, Azage T, Zollitsch, W. 2009. Performance and limitation of two dairy productions System in the North western Ethiopian highlands. *Tropical Animal Health Production* 41(7): 1143-1150.

Yohannes Urgessa, 2015. Status of Dairy Cattle Production in Borena and Guji Zone, Ethiopia ISSN 2278 – 0211

Zelalem, Y. and Bernard, F. 2006. Handling and Microbial Load of Cow's Milk and Irgo Fermented Milk Collected from Different Shops and Producers in Central Highlands of Ethiopia. Ethiopian Journal of Animal Production, 6, 67-82.

Zelalem, Y., and Faye, B. 2006. Handling and microbial load of cow's milk and ergo fermented milk collected from different shops and producers in central highlands of Ethiopia, *Ethiopian Journal Animal Productions* 6(2)-2006:67-82.

Zelalem, Y. 2009. Sanitary Conditions and Microbial Qualities of Dairy Products in Urban and Peri-Urban Dairy Shed of the Central Ethiopia. DEA, Lyon.

Zelalem, Y. 2010. Microbial Properties of Ethiopian Marketed Milk and Milk Products and Associated Critical Points of Contamination: An Epidemiological Perspective. Addis Ababa.

Zelalem, Y. 2011. Guernebleich E, Sebseba A. A .Review of the Ethiopian Dairy Sector pp. 88-90.

Zewudie Wondatir, 2010. Livestock production systems in relation with feed availability in the highlands and central rift valley of Ethiopia. pp. 64

7. APPENDICES

Appendix 1: Household Questionnaires

Dear Participant, first of all, I appreciate your willingness to participate in this study questionnaire. This questionnaire designed with the purpose of investigating milk handling, hygienic practice and milk production practice which is part of my M.Sc. Thesis research entitled with Assessment of hygienic milk production practices and microbial quality of raw cow milk produced in Aleta wondo district of Sidama Region, Ethiopia. I assure you that all the information gathered during this interview is purely for research purpose and any sensitive or confidential maters will be kept closed and will not be transferred to other in a personal base. Thank you for your valuable time.

I. Socio demographic profile of the respondents

1. Region: _________ Zone __________ Woreda ______________ Kebele ______________

2. Study Site Highland _______________ Midland ________________

3. Name of Enumerator: _______________________Date_____________ Signature _________

4. Name of the respondent _________________________

5. Sex of the respondent A) Male B) Female

6. Educational status: A) Unable to read and write. B) Read and write.

C) Elementary D) High school and above

7. Age of the respondent. A) 20-40 B) 41-60 C) >61

II. Cattle husbandry and management

1. What are the purposes of milk production?

A) For household consumption B) For sale C) For consumption and sale

D) Other (Specify)

2. What are the major feed resources you use for dairy animal feeding?

A) Natural pasture B) Crop residues C) Improved forage D) Enset leaves E) Other (Specify)

3. What type of feeding do you practices for dairy cattle?

A) Free grazing B) Stall feeding C) Based on grazing and stall feeding

4. Do you provide supplementary additional feeds for your dairy animals? A) Yes B) No

5. What type of water sources you use for dairy animals?

S/N	Water Source	Season of availability(indicate in months	Frequency of watering
1	Supplied tank/pipe		
2	Hand dug well		
3	River		
4	Spring water		
5	Pond and holes		

III. Milk Production potential and lactation length

1. Which cattle breed do you used to produce milk? A) Local B) Cross breed C) Both

2. What is the average milk production in liter per day?

For local breeds yield /cow/day/liter__________ For cross breeds/cow/day/liter_________

3. How many times do you milking your cows/day?

A) One times B) Two times) C) Three times

4. What is the average lactation length of your cow?

A) For local breeds ______________ months/year.

B) For cross breeds ______________ months/year.

5. How do you use the amount of milk produced (in liter)?

A) Consumed at home___________ B) selling ___________C) others (specified)

6. What are the main constraints for your dairy cattle production?

Major Constraints	Rank	1st	2nd	3rd	4th	5th
Shortage of feed						
Lack of improved breed						
Lack of extension services						
Poor management						
Disease out break						

7. How do you house your dairy cattle?

A) Separate house from house hold B) shared with household

C) Separately in barn D) Other (specify) ______________________

Type of your barn	Barn Floor type	Bedding materials
1.Closed	1.Concrate floor	1.Grass
2.Open fenced	2.Natural earth	2.No bedding materials
3.Grass covered	3.Wooden bedded	3.Saw dust
Other(specify)		

8. How often do you clean the barn? A) Once a day B) Twice a day C) Once in two days

D) Once a week E) Others __________________________

IV. Hygienic practices and handling of milk and milk products

I. Hygienic practices during milking

1. Do you wash your hands before and after milking? A) Yes B) No

2. Do you wash your cow's udder before and after milking? A) Yes B) No

3. If your response to Q2. Yes, when do you wash it?

A) before milking B) after milking only C) before and after milking

4. Do you use separate towel for drying teat? A) Yes--- B) No

5. Do you use shared towel for drying teat? A) Yes--- B) No

6. Do you practice milking mastitis cow last? A) Yes--- B) No

7. Do you clean the milk equipment before milking? A) Yes--- B) No

8. How frequently do you clean your milking equipment's?

A) Once per day B) Twice per day C)3 times per day D) Others (specify) ________________

9. Describe washing technique of milking equipment? ______________________________

10. Water source used to washing udder and milking utensils?

11. What type of milk equipment's do you use? A) Plastic B) Clay pot

C) Aluminium D) Gourd E) Other

12. How often do you wash the utensils? A) Before every use B) After every use

C) Before and after every use

13. How do you clean the equipment's? A) Cold water B) Warm water

C) Cold water and soap D) Warm water and soap

14. Dou you milking after drying teats?

A) Yes B) No

II.Types of milk utensils and milk handling practices

1. What type of utensils do you use for milking?

A) Plastic B) Aluminium/ stainless steel/ C) Clay pot

2. What type of utensils used for milk transportation?

A) Plastic/ Jeri cans B) Aluminium /stainless steel/ C. clay pot

3. What type of utensils used for milk storage?

A. Plastic B) Aluminium/stainless steel/ C) Clay pot

4. What type of utensils used for milk churning?

A) Gourd B) Aluminium C) Clay pot

V: Check list for group discussion

1. Types of Production system in the area?
2. What are the general hygienic conditions of farm activities?
3. Constraints that affecting production system?
4. Who has the ownership of cattle in household?

Appendix 2: Materials and equipment used for samples

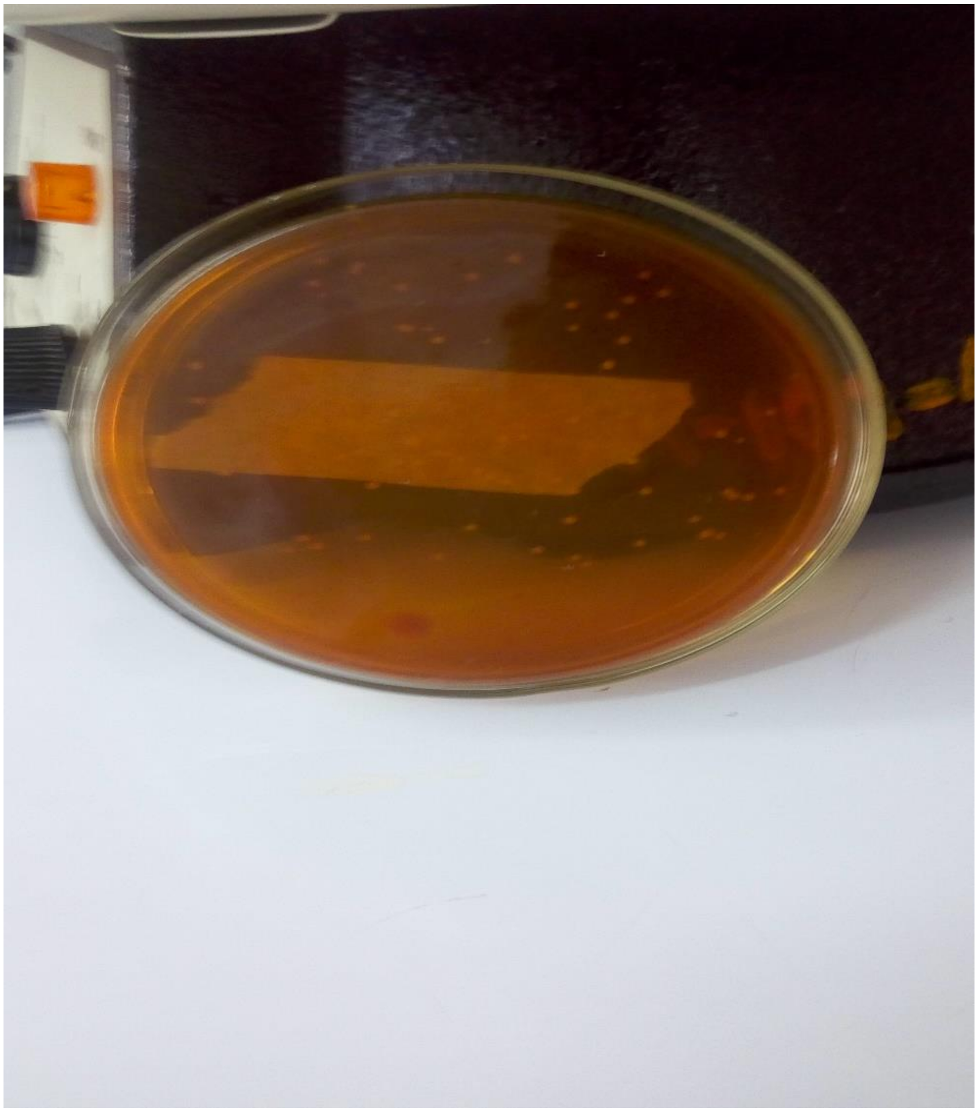
Iceboxes

Appendix 3: Different Medias used for bacteria count

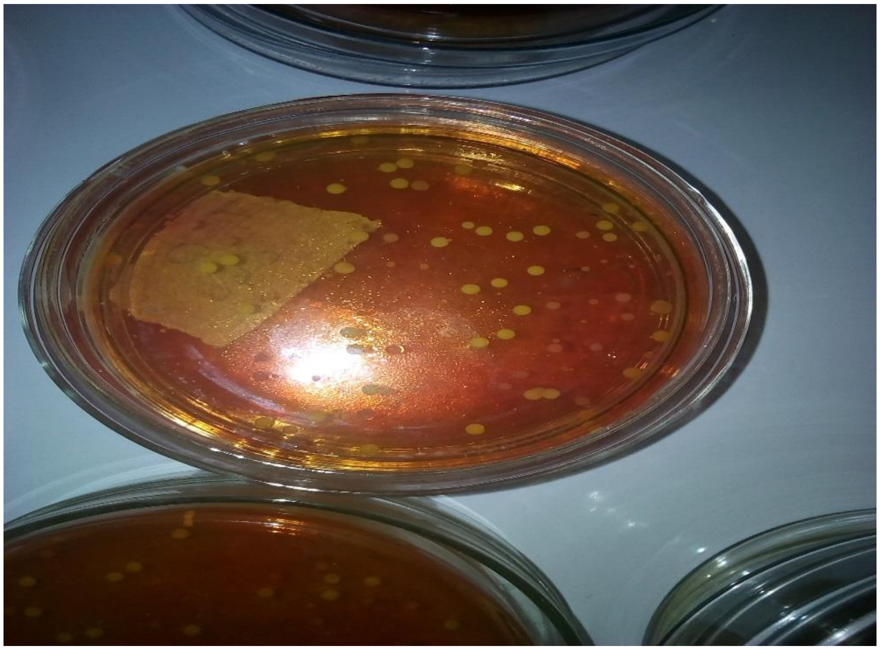
Media preparation

Appendix 4: Duplicated milk sample prepared dilution factor

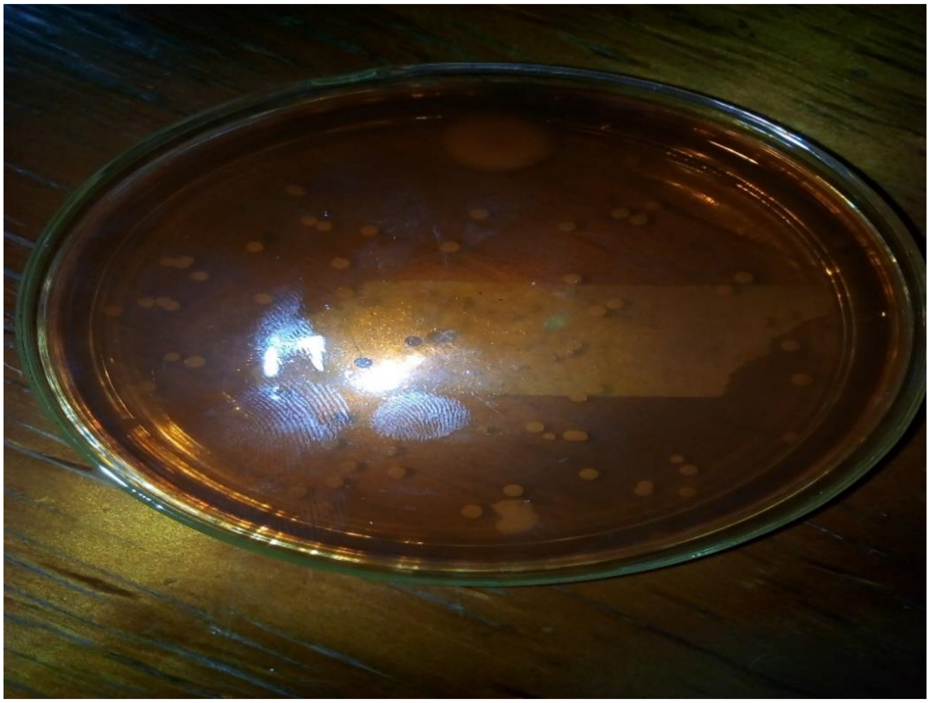
Appendix 5: Different bacteria's examined in the laboratory



Total bacteria count



Staphylococcus spp.



Yeast and mould

BIOGRAPHICAL SKETCH

The author of this thesis was born from his father Sharo Shalamo and his mother Godantu Gatamo in Hoko woreda of Sidama Region Ethiopia in 1995 G.C. He attended his primary and junior secondary school in Hoko Woreda at Odi-boko elementary school (1-8) from 2001-2008 G.C. He had also attended his secondary School from Secondary and Preparatory education in Bensa district at Kebena Gata Secondary and Preparatory School (9-12) from 2009-2012 G.C. After completion of secondary school education he joined Wolaita Sodo University of Agriculture in 2013 G.C and graduated with BSc degree in Animal and Range Science in 2015 G.C. After graduation he was employed by Aroresa Woreda of Environment Protection and Forest Development Office where he worked for 3 year as Biodiversity Protection expert. Finally, after three years of working experience he joined Hawassa University in 2019 G.C to pursue his graduate studies in Dairy Science and Technology.