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ASSESSMENT OF HYGIENIC MILK PRODUCTION AND PREVALENCE OF MASTITIS IN DAIRY COW IN JIKAWO WOREDA OF NUER ZONE, GAMBELLA REGION, ETHIOPIA

MSc Thesis

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ASSESSMENT OF HYGIENIC MILK PRODUCTION AND PREVALENCE OF MASTITIS IN DAIRY COW IN JIKAWO WOREDA OF NUER ZONE, GAMBELLA REGION, ETHIOPIA

A thesis submitted to the college of veterinary medicine and Agriculture of Addis Ababa University in partial fulfillment of the requirements for the degree of Master of Science in Tropical Animal Production and Health

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As members of the Examining Board of the final MSc open defense, we certify that we have read and evaluated the Thesis prepared by **Yien Deng** entitled "**assessment of hygienic milk production and prevalence of mastitis in dairy cow in Jikawo Woreda of Nuer Zone, Gambella region, Ethiopia"** and recommend that it be accepted as fulfilling the thesis requirement for the degree of Masters of Science in **Tropical Animal Production and Health.**

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DEDICATION

This thesis manuscript is dedicated to my mother Nyaduok Reath, for nursing the author with affection and love and for their dedicated partnership in the success of my life.

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LIST OF ABBREVIATION

CAC	Codex Alimentarius Commission
Cfu	Colony forming unit
CMT	California mastitis test
CNS	coagulase negative *Staphylococci*
CSA	Central Statistic authority
CTP	Cow Time Project
ETB	Ethiopian Birr
FSA	Food Standards Agency
GBOA	Gambella Bureau of Agriculture
GDP	Gross domestic products
GRDPPA	Gambella Region Disaster Prevention and Preparedness Agency
GRS	Gambella Regional State
ICAR	Indian council of agricultural research
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Success
LI	livestock improvement
MOA	Minister of Agriculture
MOARD	Minister of agriculture and rural development
SCC	Somatic cell count
SCM	subclinical mastitis
SPC	Standard Plate Count
US$	US Dollar
WBC	White Blood Cell

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ASSESSMENT OF HYGIENIC MILK PRODUCTION AND PREVALENCE OF MASTITIS IN DAIRY COW IN JIKAWO WOREDA OF NUER ZONE, GAMBELLA REGION, ETHIOPIA

ABSTRACT

A cross sectional study was conducted in Jikawo Woreda of Nuer Zone, Gambella Regional State in Southwest Ethiopia, with the objective of assessing hygienic milk production practices, prevalence of mastitis and associated risk factors from December 2013 to April 2014. Data were collected through administering semi-structured questionnaire, group discussion and conducting California Mastitis screening test across the randomly selected households of the three purposively selected kebeles in the Woreda. The questionnaire was administered to 145 households. The results showed that 75.2% (109) of interviewed households were females while the remaining were males who were involved in hygienic milk production responses. Washing udder was not practiced by 95.17% (138) of the households in the area. Only 4.83% (7) practiced washing udder before milking only *after the death of the calf. About 48.3% (70) of the households use cold water to clean milk handling equipments. The California Mastitis Screening Test was performed on 121 lactating dairy cows of these; about 60.33% (73) were showed mastitis cases. The prevalence of clinical and subclinical mastitis was found to be 11.57% (14) and 48.76% (59), respectively. Test of quarter level prevalence of mastitis was done on 484 quarters and it was found that 9.32% (45) and 37.89% (183) of the quarters had clinical and subclinical cases, respectively. The quarter level prevalence of clinical and sub clinical mastitis from the highest to lowest rate of infection was left front teats (LF) 53.72% (65), right rear teats (RR) 50.00% (60), left rear teats (LR) 45.56% (55) and right front teats (RF) 39.65% (48). Those animals which were affected with tick infestation ($\chi 2 = 11.14$, $p < 0.003$),with teat injury ($\chi 2 = 7.14$, $P<0.008$) and with history of mastitis ($P<0.003$, $\chi 2=8.62$) were significantly affected with mastitis compared to their counter parts. The occurrence of mastitis based on age, stage of lactation and parity was significantly higher in adult cow (6-9yrs) ($\chi 2 = 7.87$, $P<0.020$), in mid (5-7month) lactation ($\chi 2 = 6.41$, $P<0.041$), and in cow with moderate (4-7) parity*

($\chi 2=11.79$, $P<0.003$) respectively. In conclusion, the hygienic milk production activity in the area as a whole requires an intervention. Mastitis has been found to be an important disease in the area. This indicates proper mastitis control should be practiced by maintaining an appropriate cow's environment and udder health management program by the farmers including further investigation on the etiological agents associated with prevalence of mastitis to undertake measurable control options of mastitis in the area.

Keywords: Dairy cow, hygienic, milk, mastitis, prevalence, Jikawo, Nuer, Gambella, Ethiopia

1. INTRODUCTION

Ethiopia holds a substantial potential for dairy development mainly due to its large livestock population coupled with the relatively suitable environment for livestock production (Bereda *et al., 2013,* Bereda *et al., 2014)*. The livestock population census showed that Ethiopia has about 52.13 million heads of cattle, 24.2 million sheep, and 22.61 million goats, 1.96 million horses, 6.4 million donkeys, 0.37 million mules, 0.99 million camels and 44.89 million poultry in all the regions of the country excluding the none sedentary population of three zones of Afar & six zones of Somali regions (CSA, 2011). The agricultural sector in Ethiopia, engaging 80% of the population, contributes 52% of the gross domestic product (GDP) and 90% of the foreign exchange (Aynalem *et al,* 2011). The livestock sub-sector alone contributes 12% of the total and over 45% of the agricultural GDP, and over 85% and 90% of the farm and pastoral incomes, respectively, are generated by or from livestock (MOA, 2010).

Dairy cows are biologically the most efficient cattle groups in converting feeds/roughages to milk which is a highly nutritious component for human beings. Milk is universally recognized as a complete diet due to its essential components (Benta and Abtamu, 2011). In Ethiopia, traditionally processed milk products are generally reported to be of substandard quality mainly due to inadequate dairy infrastructure such as refrigeration facility, absence of clean water and limited knowledge of the hygienic handling of milk and milk products (Bereda *et al., 2013)*.

Milk is a complex biological fluid and by its nature, a good growth medium for many microorganisms. Because of the specific production, it is impossible to avoid contamination of milk with micro-organisms. Therefore the microbial content of milk is a major feature in determining its quality (Karmen and Slavica, 2008). The safety of raw cow milk is influenced by a combination of management and control measures along the entire dairy supply chain. Control of animal health, adherence to good milking practices, and control over milking parlour hygiene are important in reducing the microbial load in

raw milk (FSA, 2006). Dairy animals may carry human pathogens which may increase the risk of causing food borne illness. Moreover, the milking procedure, subsequent cooling and storage of milk carry the risks of further contamination from man or the environment or growth of inherent pathogens (CAC**,** 2004).

The safety of dairy products with respect to food-borne diseases is a great concern around the world. This is especially true in developing countries where production of milk and various dairy products take place under rather unsanitary conditions and poor production practices (Zelalem and Faye, 2006). Also, the composition of milk makes it an optimum medium for the growth of microorganisms that may come from the interior of the udder, exterior surfaces of the animal, milk handling equipment and other miscellaneous sources such as the air of the milking environment **(**Worku *et al.,* 2012). Milk has nutrients that make it suitable for the rapid multiplication of bacteria that cause spoilage. Unhygienic production, poor handling and undesirable practices such as addition of water or other substances can introduce bacteria or germs that cause spoilage (Paul *et al*., 2004).

There are several types of diseases which potentially infect and affect the wellbeing of livestock population among which mastitis is the common and costly disease causing loss in milk yield and treatment cost for dairy farmers (Nibret *et al, 2012).* Mastitis is complex disease that generally involves interplay between management practices and infectious agents, having different degrees of intensity and variations in duration and residual effects. There are various infectious agents numbering more than twenty different groups including bacteria, viruses, yeast, fungi and rickettsia (Lidet *et al*., 2013). Gizat (2004) cited that in United States, the economic losses from mastitis have been calculated at approximately 200 dollar per cow per year or 2 billion per year for the nation. In Ethiopia, around urban and peri urban areas of Addis Ababa, Mungube (2001) estimated the economic losses from mastitis to be 210.8 Birr per cow per lactation.

The underlying causes which are responsible for poor productivity of livestock in Ethiopia are so numerous but the prevailing animal diseases; poor management system

and poor genetic potential of the animals are recognized to be among the major constraints (Girma, 2010).

Currently in Ethiopia, there is a national drive to alleviate the existing food deficiency by devising different agricultural strategies including improvements of the productivity of livestock sector by controlling some of the major infectious diseases through regular monitoring. Among the infectious diseases in Ethiopia, mastitis plays a high economic impact in the diary sector yet it has been given little attention, especially the sub clinical form which is mainly caused by a bacterial agent called *Staphylococcus aureus (S. aureus)* (Aberra *et al.,* 2013). The incidence and distribution of mastitis disease in Gambella Peoples National Regional State of Ethiopia has not been studied systematically and information relating to economic loss and the overall prevalence of the disease is not known (GBOA, 2010). Also, studies related to hygienic milk production in Gambella region is generally nil. Among the different woredas in Gambella Regional State, Jikawo Woreda was considered to be a potential area for dairy development. Accordingly, there was no information about the practice of hygienic milk production and prevalence of mastitis in the Region in general and in the study woreda in particular. Therefore the current study was undertaken with the specific objectives of:

- Assessing practices of hygienic milk production,
- Determining the prevalence of dairy cow mastitis and
- Identifying mastitis associated risk factors in Jikawo Woreda of Gambella Regional State, Ethiopia.

2. LITERATURE REVIEW

2.1. Overview of Dairy Production Systems in Ethiopia

Ethiopia has recently elaborated a number of agricultural policies and strategies aimed at creating and enabling an environment for investments in the sub-sector, the main thrust of which is to promote labor-based technologies and land capitalization aimed at production for both the domestic and international markets. In this context, it is believed that the development of the agriculture sector will serve as the catalyst for economic growth and could therefore contribute significantly for achieving food security, creating employment and reducing poverty at the national and household levels. In this context, livestock production is of strategic economic importance, not only because of its numbers and diversity, but also because the majority of the rural people either kept livestock as a livelihood or use livestock for various other activities like farming and transportation of people and products (MOARD, 2007).

Dairying in Ethiopia is practiced almost all over the country with the intensity of small or 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).

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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, the 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 litres (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 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. Traditional Milk handling and processing practices in Ethiopia

In Ethiopia the smallholder farmers produce fermented milk by traditional methods. The major fermented milk products produced by smallholder farmers by traditional methods include “Ergo” (fermented sour milk), “Kibe” (traditional butter), “Neterkibe” (ghee or clarified butter), “Ayib” (cottage cheese), “Arerra” (sour defatted milk), and “Aguat” (whey) (Hiwot, 2013). 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).

2.3. Practices of Hygienic Milk Production

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 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 1,000 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. 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-flavours, 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 milkers' 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.

2.4. 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). Follow these rules on the

correct procedures of milking by hand. A good milking technique is essential for the production of safe, raw milk.

The procedure will encompass by cleaning teats, udder and adjacent parts before cluster attachment, 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):

2.5. Factors Affecting Milk Quality

The bacterial contamination in milk emanates from a number of sources including mastitis, external udder surfaces and from the milking plant (Aberra, 2010). Milk is virtually a sterile fluid when secreted into alveoli of udder. However beyond this stage of production, 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 equipments, but the surrounding air, feed, soil, feces and grass are also possible sources of contamination (Mosu *et al.,* 2013). 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. 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).

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.

2.5.1. Interior of the udder

Healthy udders

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. Raw milk as it leaves the udder of healthy cows normally contains very low numbers of microorganisms and generally will contain less than 1000 total bacteria per ml (Murphy, 1996). 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).

Infected udders

Mastitis is an inflammation of the mammary glands in the udder caused by infection with disease-causing bacteria. These bacteria can also end up in the milk and result in illness if the milk is consumed. In case of mastitis counts of *Streptococci*, *Staphylococci* or coliforms will be as high as the total plate count and can be very high up to 10^7 cfu/ml. Bulk milk count may even increase to 10^5cfu/ml under certain circumstances (Alehegne, 2004).

2.5.2. 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).

Housing conditions

In temperate regions, cows are housed in winter and pastured in summer. Differences in teat contamination can be found between housing and pasturing. Both total plate and aerobic spore counts are lower when cows are at pasture. When cows are housed, bedding material and feed stuffs can be contamination sources. In both cases (housing and pasturing) feces and dung are also an important contamination sources. Contamination of bedding material can be very high due to absorption of urine and feces (Alehegne, 2004).

Teat contamination

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 Microcoocci 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).

Udder preparation

Careful cleaning of the cow prior to milking significantly reduces contamination. Clipping the flanks, escutcheon, and udder reduces contamination from hair and adhering debris. A maximum reduction of teat contamination of 90 % can be achieved with good udder preparation (washing with disinfectant and drying with paper towel) before milking. This depends on the initial level of contamination and the way of udder preparation. So with high initial contamination levels this 90 % reduction might not be reached (Alehegne, 2004).

2.5.3. Milking and storage equipment

Contamination of milk via the milking equipment occurs when (a) microorganisms adhere to surfaces of the milking equipment and (b) 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).

Cleaning and disinfections of milk equipment

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). There are various types of cleaning and sanitation agents that have been specially designed to clean and disinfect milk-handling equipment (Lore *et al.,* 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).

Storage of raw milk

Having limited the number of bacteria entering milk during milking, it is essential that contamination from equipment situated between the cow and the refrigerated storage unit is kept to a minimum. Bacteria are present in the air, dust and water, especially any water containing traces of milk residues which may have been left in the milking plant overnight, as such residues provide a very good source of food for bacteria, thereby enabling the bacterial counts to increase rapidly. Cleaning regimes are based on removing visible dirt, removing milk residues (fat, protein, milk stones) which harbour bacteria, then sterilization of the cleaned surfaces using heat or chemical sterilants such as sodium hypochlorite (Nangamso, 2006). In tropical conditions, raw milk, i.e. non-pasteurized milk, goes off within a few hours. It must therefore be kept cool and quickly pasteurized and again cooled to a temperature of 4°C if possible (Pauline and Karin, 2006).

Storage time and temperature

The multiplication of bacteria in milk is dependent on both the temperature and time of storage. After production, milk can be stored in cans and in bulk tanks before collection. The storage temperature influences the types of bacteria which grow and their spoilage characteristics. Spoilage of raw milk is due to streptococci and coliforms, resulting in souring of milk. During storage in bulk tanks and transport, the micro flora of the milk changes from micrococci to psychrotrophic gram-negative rods. There are many different microorganisms (mainly bacteria), which can find access to milk, and there are three broad temperature ranges classifying their optimum growth rates. Organisms with an optimum growth rate at low temperatures (0-15°C) are psychrophiles, at medium temperatures (20-40°C) are called the mesophiles and at high temperatures (45-55°C) the thermophiles ((Nangamso, 2006).

In Ethiopia, smallholder milk processing is based on sour milk mainly due to high ambient temperatures, consumer's preference and increasing keeping quality of sour milk. Raw and pasteurized milk could be kept for 2 and 7.5 days at refrigeration

temperature respectively whereas at room temperature it is only 0.9 and 4.3 days respectively (Alehegne, 2004).

2.6. Cooling of Milk

Effective milk cooling is essential to ensure the quality of the product (CTP, 2006). If the milk is cooled to 4 ˚C within a period of 2 – 3 hours after milking, it maintains nearly its original quality and remains good for processing and consumption. However, in rural areas it is hardly possible to achieve this. Simple alternatives are putting the container with milk in water or placing a moist cloth around the metallic milk containers. Other possibilities are solar powered coolers or a charcoal box which is moistened to reduce the milk temperature (Pandey and Voskuil, 2011). In the tropical countries of Africa with high ambient temperatures, lack of refrigeration facilities at the farm and house hold level imply that raw milk will acidify very fast unless and otherwise protected. Therefore the collection systems must be designed to move the milk to the cooling and/or processing center in shortest possible time. In addition every effort should be made to use available systems such as water cooling, air circulation or shaded areas to reduce milk temperature (Alehegne, 2004).

2.7. Mastitis

2.7.1. Definitions

Mastitis: is an inflammation of the udder. In cows, inflammation of the udder is almost always caused by harmful bacteria, which enter through the teat end and set up infection. Although a bacterial infection is the root cause, and mastitis or inflammation the effect or outcome, we tend to use the words ‘mastitis’ and ‘infection’ interchangeably. This is because preventing mastitis involves preventing bacterial infections (LI, 2001).

Mastitis is defined as an inflammatory reaction of the mammary gland. It is induced when pathogenic microorganisms enter the udder through the teat canal, overcome the

cow's defense mechanisms, begin to multiply in the udder, and produce toxins that are harmful to the mammary gland. Mammary tissue is then damaged, which causes increased vascular permeability. As a result of this, milk composition is altered: there is leakage of blood constituents, serum proteins, enzymes, and salts into the milk; decreased synthesis of caseins and lactose; and decreased fat quality (Christel, 2009). Quinn *et al* (2004) summarizes the main clinical types of mastitis as:

Per-acute mastitis: swelling, pain, heat and abnormal secretion in the mammary gland are accompanied by signs of systematic disturbance such as fever, depression, anorexia, weakness and a rapid, weak pulse. The signs are those of a toxaemia or septicaemia. Gangrenous mastitis is included in this category.

Acute mastitis: changes in the mammary glands are similar to those of per acute mastitis but the systemic signs are less severe.

Sub-acute mastitis: no systemic reaction and the changes in the gland are less marked.

Chronic mastitis: there are no systemic signs and very few external signs of change in the udder, but abnormal secretion in the glands occurs intermittently.

Subclinical mastitis: the infection in the mammary glands is detectable only by bacterial culture or by tests to demonstrate a high leukocyte count in the milk. There is no obvious change in the appearance of the milk. *Staphylococcus aureus* is notorious for causing a high percentage (often 50 percent of the herd) of subclinical infections in a dairy herd with a *staphylococcal* mastitis problem.

Prevalence: is the percentage of the population affected with a specific disease in a given population at a certain point in time (Radostits *et al*., 2006).

Incidence: is a rate, such as the total numbers of new cases of clinical mastitis as a percentage of the animals at risk that occur during a certain period of time. Prevalence is a function of the incidence and the duration of infection (Radostits *et al*., 2006).

2.7.2. Causes of Mastitis

Bovine mastitis is associated with many different infectious agents, commonly divided into those causing contagious mastitis, which are spread from infected quarters to other quarters and cows, those that are normal teat skin inhabitants and cause opportunistic

mastitis, and those causing environmental mastitis, which are usually present in the cow's environment and reach the teat from that source (Radostits *et al*., 2006).

Mastitis is a disease of many mammalian species. At least, 137 infectious causes of bovine mastitis are known to date and in large animals the commonest pathogens are *staphylococcus aureus, streptococcus agalactiae,* other *streptococcus* species and *Coliform* as reported by (Bitew *et al.,* 2010). *Staphylococcus* sp. is the main aetiological agents of clinical and subclinical mastitis in cows while, *S. aureus and Escherichia coli* are most commonly isolated pathogen from the clinical mastitis, coagulase negative *Staphylococci* (CNS) are the most frequently isolated pathogens from the subclinical cows mastitis (Islam *et al*., 2011).

Major bacteria (pathogens)

These bacteria are capable of causing clinical mastitis, udder tissue damage, and long term or chronic subclinical infections. The major bacteria can be split into two categories, those that are cow associated (or contagious), and those which are environmental in origin (LI, 2001). The cow-associated bacteria are *Staph. aureus* and *Strep. Agalactiae* while the main environmental bacteria are *Strep. uberis, Strep. Dysgalactiae* and coliforms (LI, 2001). The most important major pathogens involved in bovine mastitis worldwide are *Staphylococcus aureus*, *Streptococcus uberis*, *Streptococcus dysgalactiae*, *Streptococcus agalactiae*, *Escherichia coli* and *Klebsiella* spp. (Idriss et al., 2013).

Minor bacteria (pathogen)

These bacteria cause less udder damage but cause slight to moderate increases in SCC. While these infections usually remain subclinical, clinical episodes can occur (LI, 2001). Some organisms, particularly non-hemolytic coagulase negative Staphylococci (CNS) and *Corynebacterium bovis* are almost ubiquitous inhabitants of the bovine mammary gland and are regarded as part of the normal flora (Gizat, 2004). Minor bacteria can be contagious, especially *C. bovis* but can be readily controlled by effective post-milking

teat sanitation. There is growing evidence that subclinical infections by either CNS or *C. bovis* may put the udder more at risk of developing an infection by major bacteria (LI, 2001).

2.7.3. Diagnosis of mastitis using California mastitis test (CMT)

The early detection of disease is very important because in early stages it is amenable to treatment. Physical examination of udder helps in detecting cases where changes have occurred. The California mastitis test is most commonly used and has proved to be very efficient, After mixing milk and the reagent the result is read as traces, 1, 2, 3, and negative depending up on the gel formation in the milk sample (ICAR, 2011).

2.7.4. Control of mastitis

Mastitis in the dairy cow is a disease complex in which bacterial infections, trauma, and faulty managerial practices play important roles. Experiences in attempts to control mastitis indicate that while the occurrence of inflammation in the udder may not be entirely preventable in all cows, the frequency of appearance among cows with in a herd and the intensity of clinical attacks may be lessened significantly through better management (Fincher *et al*., 2001). According to Radostits et *al*., (2006), Components of Mastitis Control Program includes, Use proper milking management methods, Proper installation, function, and maintenance of milking equipment, Dry cow management, Appropriate therapy of mastitis during lactation, Culling chronically infected cows, Maintenance of an appropriate environment, Good record keeping, Monitoring udder health status, Periodic review of the udder health management program and Setting goals for udder health status.

Dry cow therapy

Dry cow therapy is the use of intramammary antimicrobial therapy immediately after the last milking of lactation and is an important component of an effective mastitis control

program (LI, 2001). Prior to 1940, chronic bovine mastitis was considered to be an incurable disease, at least in the United States. Then in quick succession, acriflavine, silver oxide, iodine, sulfanilamide, and tyrothricin were used for intramammary treatment of chronic mastitis caused by streptococcus agalactiae (Fincher et al., 2001).

2.7.5. Epidemiology of bovine mastitis in Ethiopia

Prevalence

Different studies conducted in different parts of Ethiopia showed variable prevalence of mastitis depending on the type of farm and managements systems. Biffa *et al. (2005)* conducted a study on mastitis of 974 lactating dairy cows in Southern Ethiopia as, 34.9% (340) had mastitis; 11.9% (116) clinical, and 23.0% (224) subclinical mastitis respectively. Mastitis prevalence in dairy farms of Holeta town, Central Ethiopia at cow level was 71.0% (76/107), out of which 22.4% (24/107) and 48.6% (52/107) were clinical and subclinical, respectively. The Holeta study also revealed the quarter level prevalence of mastitis as 44.9% (192/428); from this the clinical form was 10.0% (43/428) and the subclinical was 34.8% (149/428) (Mekibib *et al.,* 2010).

Mulugeta and Wassie (2013) also carried out a research on Prevalence of bovine mastitis in and around Wolaita Sodo, Southern Ethiopia. From the total of 349 lactating cows examined, 103 (29.5%) were positive for mastitis. Of these, 9 (2.6%) and 94 (26.9%) were found to be positive for clinical mastitis and subclinical mastitis, respectively. According to Zeryehun *et al.* (2013), a total of 499 cross-bred cows from 38 dairy farms were examined for mastitis detection and out of which 373 (74.7%) cows were found to be affected with clinical and sub clinical mastitis based on the clinical diagnosis and CMT. Likewise, CMT positive for the sub clinical mastitis were found to be 275 (55.1%) (Table1). Out of the 1898 quarter examined 98 (19.6%) quarters which belongs to 73 (14.6%) animals were found to be blind teat. Up on screening of the functional teats (1898) by CMT, a quarter of 909 (42.7%) found to be affected by sub clinical mastitis in

small holder dairy farms in and around Addis Ababa, Ethiopia. This great variation could result from differences in environment and management Gizat (2004).

Economic loss

Economic losses due to mastitis are recognized worldwide as a major problem on dairy farms. Financial loss involved as a result of permanent loss of production in individual cows, discarded milk following antibiotic therapy, early culling of cows, veterinary costs, drug costs, increased labor, death of per acute cases and replacement costs (Sisay et *al*., 2012).

In Ethiopia, the aggregate annual economic losses from animal diseases through direct mortality and reduced productive and reproductive performance were estimated at US$ 150 million (*Belay et al., 2012).* Economic losses from clinical and subclinical mastitis in Addis Ababa milk shed were reported to be approximately 270 Ethiopian birr (ETB) per lactation (Sisay et *al*., 2012).

Gizat (2004) reported the economic loss from mastitis in the urban and peri urban areas of Addis Ababa. The report was based on milk production losses, treatment costs, withdrawal and culling losses as parameters for calculating losses. This loss was found to be 210.8 birr per cow per lactation. In this study, loss due to culling, milk loss, treatment, and withdrawal contributed 49%, 38.4%, 9.3% and 3.3% to the total mastitis losses, respectively. Milk production losses contributed 38.4% of the total losses, sub clinical mastitis contributing 94% and clinical mastitis 6% of the milk losses. Sub clinical mastitis contributed 36.1% of the total losses, which is primarily due to, reduced milk production. In Debre Zeit dairy herds, a quarter with SCM due to S. aureus lost an average of 34.5% of its potential milk production while the total milk yield loss per cow was estimated at 6.8%. Losses were highest in large-scale (13%) farms and lowest (3.7%) in small-scale. Based on the prevalence, the overall financial loss for each cow per lactation was 984.64 Eth Birr (US$78.65) and losses in large farms (1,882.40 Eth Birr or US$150.35) were over 3.5 times the loss in small-size farms. These figures possibly

underestimate the potential benefits of mastitis control program as they do not include other direct and indirect costs (Tesfaye *et al*., 2010).

2.7.6. Risk factors influencing prevalence of mastitis

There are a number of factors that influence the occurrence of mastitis and fewer studies that have investigated cow-level factors associated with the development of Clinical mastitis was carried out. The risk of developing Clinical mastitis is greatest in early lactation and increases with parity and level of milk production (Berry and Meaney, 2005). They have also reported that the risk of a cow developing in the subsequent month of lactation is also a function of number of cases of Clinical mastitis in the previous lactation, number of clinical cases in the previous months of the current lactation, and the occurrence of Clinical mastitis in the current month. The risk of contracting Clinical mastitis was 4.8 times greater if the animal experienced Clinical mastitis in the previous stage of lactation. Clinical mastitis occurred in 38% of cows that experienced Clinical mastitis in the previous lactation, as opposed to 23% of those that had not (Berry and Meaney,2005).

The prevalence of infected quarters increases with age, peaking at 7 years (Radostits *et al*., 2006). It may also be a result of a greater cellular response to infection or of a greater amount of permanent udder damage after infection in older cows. Older cows, especially after four lactations were submitted to more lactation, increasing the risk for mastitis and udder tissue damage (Christa, 2008).

Most new infections occur during the early part of the dry period and in the first 2 months of lactation, especially with the environmental pathogens (Radostits *et al*., 2006). Christa (2008) reported that the first month of lactation is the most sensitive period for risk of mastitis in the cow, even in well managed herds. On the other hand, the SCC of cows late in lactation is higher than the average throughout lactation, but this is due to an increased prevalence of sub-clinical infections late in lactation and a reduced milk flow production.

Predisposing factors such as poor management and hygiene, teat injuries and faulty milking machines are known to hasten the entry of infectious agents and the course of the disease (Islam *et al*., 2010, Islam et *al*., 2011). Where predisposing factors are present the organisms are able to pass along the teat canal and enter udder the set up infection. These factors may be age (the older the animal the greater the likelihood of the infection), stage of lactation (more likely at the beginning of and the end of lactation), milk yield (high yielder), hereditary factors, trauma, hygiene and unknown factors (ICAR, 2011).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Jikawo Woreda of Nuer Zone in the Gambella People's National Regional State located in south-western part of Ethiopia (Fig. 1). The Woreda is located 120 km away from the regional town Gambella. It extends between 7'N to 8.17'N latitude and 33'E to 35.02'E longitude (GBOA, 2010). The altitude of the Woreda town called Nyinenyang is 410 meters above sea level. The study area receives average annual rainfall of 645.3 mm and annual temperature ranges from 33.71-40.32^{O}C (GBOA, 2010). The study area has wet season (May-Oct) and dry season (November-April). The Woreda borders with South Sudan to the North, Jore Woreda to the South, Lare Woreda to the East and Wantawo Woreda to the West. The total land area of the Woreda is about 181.04 km^2.

Animal husbandry is the main economic activity of the Region (GRDPPA, 2006). The major cattle breed is the Nuer cattle (zebu) which is a very good performer in dairying and beef production provided proper management levels are attained (GRS, 2003) and considered to have high tolerance to tsetse challenges (Alemayehu, 2004). According to the CSA (2012) report, the total livestock population of the Nuer Zone in which the Jikawo Woreda is located consists of 183,363 cattle, 40,012 sheep, 5,6705 goats and 10,0952 poultry.

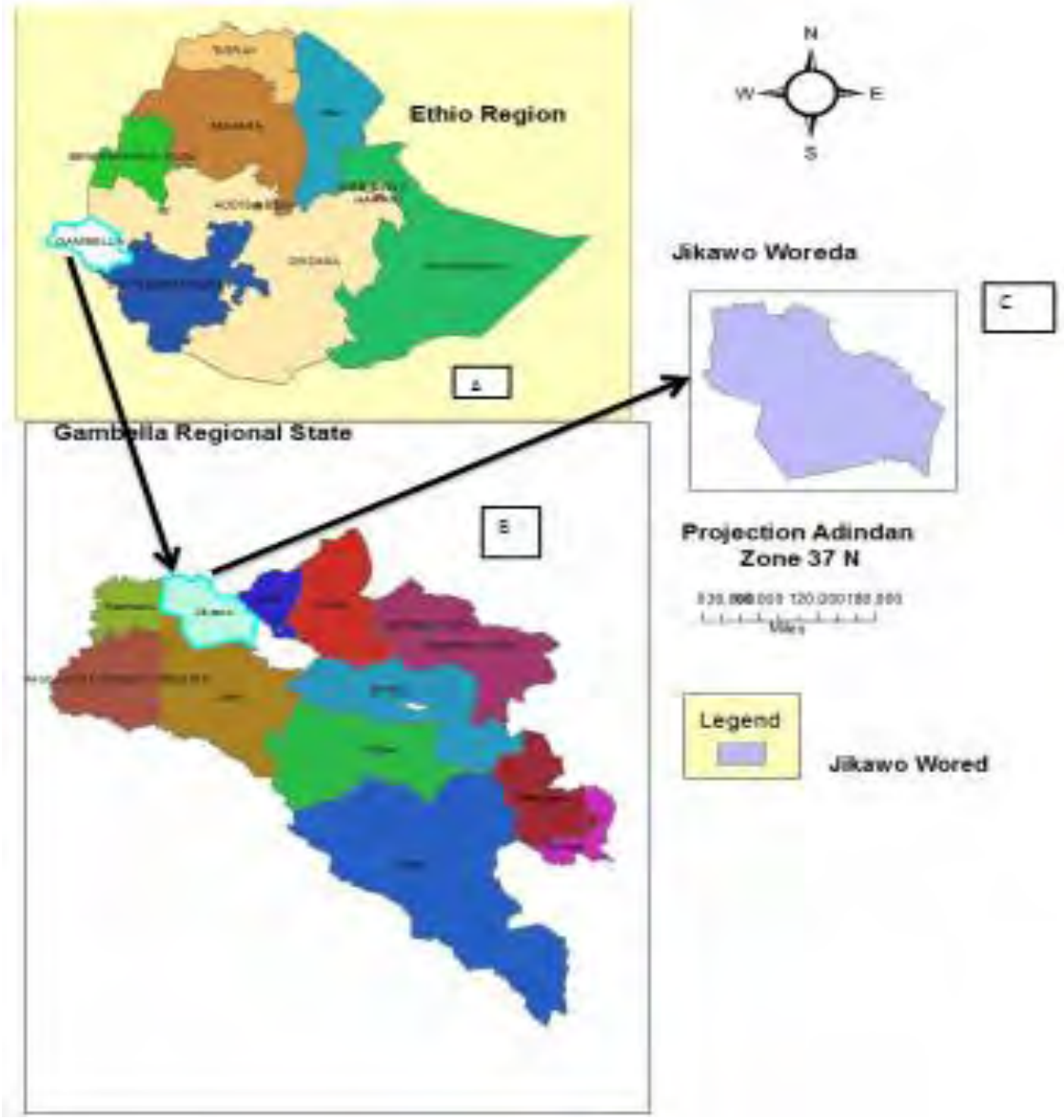

Figure 1: Map of the study area

3.2. Target population

The target populations which were included in this study included all lactating cattle and dairy farmers in Jikawo Woreda.

3.3. Study Design

A cross-sectional study was conducted from December 2013 to April 2014 to assess the prevalence of sub-clinical and clinical mastitis and the associated factors in dairy cows from purposively selected three kebeles of the Jikawo Woreda. Prevalence of mastitis was determined at cow and quarter levels using California Mastitis Test (CMT) from randomly taken cows of the three kebeles. A semi-structured questionnaire survey was also conducted on the randomly selected households.

3.4. Sampling procedure and Sample size determination

Prior to performing sampling, the background of the study area was assessed with regard to the potential of cattle production in the study woreda. The rapid exploratory field visit was carried out with extension agents.

The sampling procedure used here was purposive type by considering the population of cows, accessibility and security of the kebeles. Based on the obtained information from rapid exploratory field visit together with available secondary information, 3 kebeles (namely, Puokueth, Nyinenyang and Bildak) were purposively identified.

The sample size was determined based on the formula described in Thrusfield (2007). Given that information on the prevalence of mastitis in dairy cattle in Gambella Regional State was not available at the time of the study, a prevalence rate of 50% was assumed, a precision of 9`% and a confidence interval (CI) of 95% was decided upon. The calculated sample size was 121 cows with 5 % contingency.

$$n = \frac{1.96^2 \, p_{exp}(1 - p_{exp})}{d^2}$$

where $n = \text{required sample size}, p_{exp} = \exp ected \;\; prevalence, d = desired \; absoulteprecision$

Accordingly, 50 households each from Puokueth and Nyinenyang kebeles, and 45 from Bildak kebele were selected and subjected for a semi-structured questionnaire, making a

total of 145 households for the study woreda. Also, 121 lactating cows of which 41 cows from Puokueth, 40 from Nyinenyang and 40 from Bildak kebeles of the Jikawo Woreda were selected and tested for mastitis using California mastitis test (CMT) method.

3.5. Methods of Data Collection

Both qualitative and quantitative data were collected by employing the following data collection methods.

3.5.1. Questionnaire survey

Semi-structured questionnaire was used to assess the hygienic status of milk production (Appendix 1). About 145 farmer households and/or milking personnel were interviewed from purposively selected 3 kebeles in the study area. Consequently, the milk production, handling and hygienic practices employed, and others conditions thought to affect the hygienic quality of milk were assessed. In addition, group discussion about constraints affecting production system, ownership of cattle and farmer perception for the cause of mastitis and way of management was done.

Similarly, a questionnaire was used to evaluate the effect of potentially selected risk factors on the occurrence of mastitis (appendix 2). The selected risk factors considered were, age, stage of lactation, parity, body condition, presence of udder and teat injuries, presence/absence of ticks, and previous history of mastitis. The stage of lactation was categorized as early (<4 months), mid (5-7 months) and late (>8 months). Age of the study animals was categorized as young adult (3-5years), adult (6-9years) and old (>9 years). Parity was also categorized as cows with few (1-3 calving), cows with moderate (4-6) calving and cows with many parties (≥ 7 calving) (Appendix 2).

3.5.2. Secondary data collection

Previous studies and literatures were reviewed to assess current cattle and hygienic milk production in the study area. The secondary data relevant to the investigation with respect to study district were collected from government organizations and other stakeholders.

3.5.3. Field observation

During the questionnaire administration period, cattle housing, feeding, milking and other routine husbandry practices were observed by the researcher to fortify the information obtained. In addition, close assessment concerning cleanliness and design of the barn, kind of materials used for washing or cleaning milk utensils, hygienic practices used by the milk handlers were assessed.

3.5.4. Physical observation of udder and cow

The udder was first examined visually and then by palpation to detect fibrosis, inflammatory swellings, visible injury, tick infestation, atrophy of the tissue, and swelling of supra mammary lymph nodes. The size and consistency of mammary quarters were inspected for the presence of any abnormalities, such as swelling, firmness, and blindness by the help of veterinarian and animal health technicians. Information relating to the previous health history of the mammary quarters was obtained from interviews with owners of the cows. The cows were also inspected for the presence of tick's infestation and body condition.

3.5.5. California mastitis test (CMT)

The California Mastitis Test was carried out at the side of cows to diagnose the presence of subclinical mastitis based on the method described by Quinn *et al.,* (2004). Accordingly, udder and teat were washed with water and dried before milk sample collection; first few strips of milk were removed and discarded, then the right teats was

sampled first followed by the left ones. A squirt of milk from each quarters of the udder is placed in each of four shallow cups in the CMT paddle. Mixture of 2ml of milk with an equal amount of the commercial reagent was added to each cup. A gentle circular motion was applied to the mixtures in a horizontal plane and a positive gelling reaction occurred in a few second with positive samples. The result was scored from negative without gelling to positive from slight gelling to viscous form.

3.6. Statistical Analyses

The collected data were checked for any inconvenience and inconsistence and entered to Excel spread sheet, coded, and transferred to SPSS version 20. Both the questionnaire and CMT data were analyzed on the given statistical package software. For descriptive statistics presentation of categorical data Chi- square was used to compare the different groups of age, sex, and various risk factors, with the outcome variable (mastitis). A p-value less than 0.05 were considered statistically significant.

4. RESULTS

4.1. Socio-economic characteristics of the respondents

A total of 145 dairy farmers were interviewed in this cross sectional study in the three selected kebeles of the Jikawo Woreda. Females comprised 75.2% (109) of the respondents while the remaining 24.8% (36) were males of different age and educational levels. Regarding the educational level, 60.7% (88) were illiterate, 14.5% (21) read and write, 7.6% (12) attended 1-5 grade, and 17.2% (25) were >6 grade, respectively. Mixed farming or agro pastoral production system is predominantly practiced in the area 89.0% (129) (Table 1). In case of religion, 80% (116) of the respondents were Christians (Protestants) and the rest 20% (29) were either have traditional beliefs (paganism) or none religion.

The mean and the standard deviation of the family size in the study areas was 5.17± 0.154. Regarding farming, 89% (129) of the dairy cattle owners practiced crop production and livestock rearing as their main occupation. About 5.5% (8) of the elder people participated in some off farm activities such as black smith and weaving as an income source. Regard with age category, 44.8% (65) falls within the age group of 21-45 years (Table 1). This indicates that majority of the respondents were in potential productive age.

Table 1. Socioeconomic profile of the respondents in Jikawo Woreda

Variables	Parameters	N	Proportion (%)		
Sex	Male	36	24.8		
	Female	109	75.2		
Educational level	Illiterate	88	60.2		
	Read and write	21	14.5		
	Grade 1-5	11	7.6		
	Above grade 6	15	17.2		
Religion	Christians	116	80.0		
	Muslim	-	-		
	Others	29	20.0		
Occupation	Mixed farming	129	89.0		
	Livestock rearing only	8	5.5		
	Off farm business	8	5.5		
Age category	<20 years	23	15.9		
	21-35years	65	44.8		
	36-45years	48	33.1		
	>46years	9	6.2		
Family size by kebele		Puokueth	Nyinenyang	Bildak	Total
	Mean±S.E	5.46±0.279	5.28±0.218	4.71±0.294	5.17± 0.154

N=number

4.2. Production System

Livestock rearing and rarely crop cultivation were the major farming systems practiced by 100% (145) of the respondents as the main production system in the study areas. in the group discussion on the production system practiced in the study area, most of the discussants replied that their livelihood depends mainly on the livestock and crop production. They also rarely practice fishing, hunting and wild food collection. Commonly reared livestock are cattle, goats, sheep and rarely poultry. The major food crops of the area are cereals, vegetables, tubers and fruits. From the cereals maize and sorghum, which are both rain fed and recessional cultivation, are very essential. Majority of the respondents agreed dairying is the main income source. The contribution of crop products as the sources of income comes next to dairying because farmers cultivate only a small piece of land making the products to be consumed in a short period of time.

Different factors were observed to have negative impacts on production system, which includes flood, conflict over cattle raiding, diseases and pest infestation based on their group agreement. Flood causes seasonal form of movement of their herds and related to the rise and fall of the Baro River which affect livestock grazing lands. Generally, the farming system of the districts is a mixed subsistent farming where the majority of farmers live on livestock and crop production.

4.3. Cattle inventory in the study kebeles

Cattle compositions of the randomly sampled households in Jikawo Woreda are presented in Table 2. The study showed that the overall average size of lactating dairy cattle and standard error per household in the study area was 7.97±0.496 heads. From the overall interviewed households, cattle were composed of calves (male (54.67%, 54.45% and 51.22%) and female (45.33%, 45.55% and 48.78%)), cows (dry (24.74%, 38.32% and 34.48%) and lactating (75.26%, 61.68% 65.52%)) and oxen (castrated (34.38%, 38.78% and 40.74%) and bull 65.62%, 61.22% and 59.26%)) in Nyinenyang, Bildak and

Puokueth kebeles respectively. Lactating cow were the most dominant among other cattle totaling up to 47.90% (2297) of the population and castrated oxen covering the less proportion 1.48% (71). The result of this study showed that 100% (145) of the respondents explained that household head (husband) is the owner of cattle in the family and wife owns the cattle only when the husband dies. The study also revealed that, in case of polygamy the household head (husband) may declare the ownership of the cattle to his wives, leaving some of the cattle with him and his last wife and distribute the rest to the older wives with their children but any decision to the use of cattle either selling of cow or marriage or other activity was the responsibility of husband. The responsibilities of wives were residing on the management and dairying activities.

Table 2. Cattle inventory in three kebeles of Jikawo woreda.

		Kebeles		
Cattles		Nyinenyang N (%)	Bildak N (%)	Puokueth N (%)
Calves	Male	117 (54.67%)	269 (54.45%)	231 (51.22%)
	Female	97 (45.33%)	225 (45.55%)	220 (48.78%)
	Total	214(100%)	494(100%)	451(100%)
Cow	Lactating	651 (75.26%)	787 (61.68%)	859 (65.52%)
	Dry	214(24.74%)	489 (38.32%)	452 (34.48%)
	Total	865(100%)	1276(100%)	1311(100%)
Oxen	Castrated	11(34.38%)	38 (38.78%)	22 (40.74%)
	Bull	21 (65.62%)	60 (61.22%)	32(59.26%)
	Total	32(100%)	98(100%)	54(100)

4.4. Livestock holding Preference

Livestock species kept in the area included cattle, sheep, goats and poultry. Cattle are the dominant livestock type in the study area and most preferred (ranked 1st) by all of the respondents than other livestock. From the total respondents 52.41% (76) ranked goat 2nd and 46.89% (68) of the respondent ranked sheep 2nd according to their preference. The

reverse is true that 52.41% (76) of the respondent ranked sheep 3rd and 46.89% (68) of the respondent ranked goat 3rd. This indicates that there was variation in preferring sheep or goat among farmers depending on individual interest in the study area. Majority of the farmers (93.3%) (140) put poultry as the last choice (4th) than other livestock, indicating that poultry are less preferred (Table 3). The present study showed that farmers who do not have either of the livestock (sheep, goat and poultry) had not given the rank, rather only those animals they hold.

Table 3. Livestock preference by farmers in three kebeles of Jikawo districts

Rank	Livestock	Frequency of respondents (N=145)	Percentage (%)
1st	Cattle	145	100
2nd	Goat	76	52.41
	Sheep	68	46.89
3rd	Goats	68	46.89
	Sheep	76	52.41
4th	Poultry	140	93.3

4.5. Purpose of keeping cattle

In the study area, the survey result indicated that farmers kept cattle mostly for milk (ranked 1st), ritual ceremony (marriage) (ranked 2nd), cash earning (ranked 3rd) by selling live animals and their products and/or both, and social prestige (wealth measurement) (ranked 4th) respectively (Table 4). Based on the key respondents during the group discussion meat, draught power and manure were not important in the study area as a purpose for keeping cattle.

Table 4. Purpose of keeping cattle in Jikawo Woreda

Purpose	Frequency(N=145)	Percentage (%)	Rank
Milk	100	68.96	1st
Ritual ceremony	100	68.96	2nd
Cash earnings	96	66.20	3rd
Social prestige	56	38.62	4th

4.6. Feed and Feeding system

The main source of feed of cattle in the study area was natural pasture as all the respondents indicated (Table 5). From the total respondents 34.48% (50) ranked crop residues/stover of maize and sorghum as the second major sources of feed for cattle. Salt provision and local brewery byproducts were ranked 3rd by 14.48% (21) of respondents. During the group discussion respondents agreed that salt solution and local wine by products were used as feed during dry seasons preferably given to nursing cattle for calves and consumption. The feeding system practiced was commonly free grazing system in communal land where cattle could graze freely in the rangeland but herder were active to prevent mixing of herds and entrance of cattle raiders in to cattle grazing area.

Table 5. The main feed sources for cattle in Jikawo Woreda

Type of animal feed	Number of respondents	Rank given by the farmers
Natural pasture	145	1st
Stover	50	2nd
Salt provision and local brewery by products	21	3rd

4.7. Milk Production

4.7.1. Milk yield

Survey result showed that milk yield in the study area varied from 1 liter to 5 liters, while the average milk yield per day in the study area was 2.85 liter, with the minimum and maximum yields being 2 and 5, 1 and 5 liters, and 1 and 4 liters in the three kebeles (Nyinenyang kebele, Bildak and Puokueth) respectively. The maximum milk yield was found to be 5 liter in Nyinenyang and Bil nyoak kebeles which is very rare, and the maximum average milk yield was found in Bil nyoak kebele recorded as 3.1 liter (Table 6).

Table 6. Milk yield across three kebele in Jikawo district

Location /kebele	Minimum milk yield (liter)	Maximum yield(liter)	Average milk yield (liter)	Total (liter)
Puokueth	1	4	2.76	138
Nyinenyang	2	5	2.66	120
Bildak	1	5	3.1	155

4.7.2. Milking Practices

Almost 100% (145) of the respondents were practicing hand milking (Table 7). Regarding cow stimulating before milking, 98.6% (143) of the respondents milk their cows by letting few suckling before and after milking, while only 2 (1.4%) milk without suckling. All the respondents practice complete milking in order to get maximum milk from a lactating cow. From the total respondents 96.6% (140) were practicing milking in

the absence of calf or when calve dies which is common in all the three kebeles of the Jikawo Woreda. They stimulated the milk let down by inserting air pressure inside the cow via reproductive organs, so that milk would easily come out (Appendix Fig 4). Traditional hand milking and using traditional milking storage equipment locally called “diaar" (gourd) practiced in all the respondents in the three kebeles (Appendix Fig 5). Group discussion revealed that farmers milk their cows twice a day during the morning 9-10 AM and 7-8 PM evening. Hours of milking may vary from season to season, for example in summer the evening milking time was found to range from 6-7 PM due to the harsh environment that could disturb milking activities. Culturally the utilization of hired labor for milking and related farm practices was not common due to large size of family members resulting from polygamy. Whenever the family size was small they used to bring one of the nearest relatives to help them in farm activities whenever there was work load. It is also found that females were highly involved in milking operation with the proportion of housewife 71.0% (103) and daughter 29.0% (42) involvement.

Table 7. Milking practices by dairy farmers in Jikawo districts

Variable	Frequency	Percent
Milking practice		
Milking without suckling	2	1.4
suckling before and after milking	143	98.6
Total	145	100.0
Complete milking		
Yes	145	100.0
No	-	-
Milking in the absence of calf		
Yes	140	96.6
No	5	3.4
Person who is engaged in milking operation		
Housewife	103	71.0
Housewife's and daughter	42	29.0

4.8. Milk Hygienic Practices

Washing of udder before milking was not a common practice in the study area, as there is a belief that calve could wash it with saliva when they are allowed to have few suckling before and after milking. It is found that, 34.1% (48), 31.2% (43) and 34.1% (47) of respondents in Puokueth, Nyinenyang and Bildak kebeles do not wash udder at all before milking and after milking (Table 8). Similarly, 28.6% (2), 28.6% (2) and 42.9% (3) of respondents in Puokueth, Nyinenyang and Bildak kebeles, respectively, practices washing of udder before milking and this happened only in the absence (death) of calf with the intention of removing dirt from udder. Boiling of milk was not commonly practiced in the study area, except for milk from first to two week of lactating cow, goat

and sheep. All of the respondents store milk at room temperature since there was no refrigeration facility. Milk requires different time to reach to the consumer/home/storage as shown in (Table 9). Most of the respondents (35.6%) (31) in Puokueth, 35.6% (31) in Nyinenyang and (28.7%) (25) in Bildak respectively replied as milk would require between 15 minute and 30 minutes reaching the consumer/home/storage site.

Table 8. Hygienic and milk consumption practices followed by dairy farmers in Jikawo Woreda

Variables regarding hygienic practices	Kebele		
	Puokueth N (%)	Nyinenyang N (%)	Bildak N (%)
Producers followed during milking			
Washing udder before milking only	2 (4%)	3(6%)	2 (4.4%)
No washing at all	48(96%)	47(94%))	43(95.6%)
Total	50(100%)	50(100%)	45(100%)
Consumption of milk			
Raw only	9(18%)	16(32%)	18(40%)
By processing only	0(.0%)	3(6%)	1(2.2%)
All	9(18%)	1(2%)	11(24.5%)
Raw and processing	32(64%)	30(60%)	15(33.5%)
Total	50(100%)	50(100%)	45(100%)

Table 9. Time required for milk to reach to the consumer/home/storage.

Distance raw milk travel	Kebele		
	Puokueth	Nyinenyang	Bildak
Below 10 minutes	19(38%)	23(46%)	14(31.1%)
Between 15 min and 30 min	31(62%)	25(50%)	31(68.9%)
≥1 hour	0(.0%)	2(4%)	0(00.0%)
Total	50(100%)	50(100%)	45(100%)

4.9. Sanitary practices of milk and milk products

4.9.1. Hygiene of milk handling equipment

The current survey result showed that, cleaning of milk handling equipments is common among most of the respondents. Cleaning frequency of milk handling containers using either cold or warm water depend up on the cleanliness of containers and types of dairy products that was kept on the containers. The farmers responded with 48.3% (70) 43.4% (63) and 8.3% (12) proportions that they used cold water, both cold and warm water and warm water, respectively for cleaning milk handling equipments. In the study area, farmers usually use sponge, ashes, grass leaves, and any locally available materials that may remove the dirt to clean milk handling equipments. From the total participants 34.48% (50) and 25.50% (37) use ashes and other locally available materials, respectively, for cleaning purposes (Table 10).

Regarding sources of water for cleaning purposes, 44.8% (65), 11.7% (17) and 43.4% (63) of the respondents used hand pump water; hand dug well water and river water respectively (Table 10). Survey result showed that, the majority of the respondents use either of the water sources for cleaning purposes whenever the others are not available. Uses of clean water for washing purposes varies depending on seasonal movement from river bank to upstream with their herd, clustering policy to settle in one village and some

people who are away from the source of water. Scattering of people are also a factor, for example those who are away from village uses hand dug well both for cleaning and drinking purposes. They use different types of milk handling equipment for milking and storage such as traditional milking equipment (gourd) with different types and size for churning, milking and storing of milk and milk product, plastic jar, jug and nickel. Based on the observation during assessment, the levels of sanitizing milk handling equipments vary from household to household, person to person with in household.

Table 10. Milk sanitary practices in Jikawo Woreda

Sanitary practices	Frequency	%
Cleaning frequency of milk handling containers		
Using cold water	70	48.3
Using both cold and warm water	63	43.4
After each usage using warm water	12	8.3
Materials used to wash milk handling equipment		
Sponge	27	18.62
Ashes	50	34.48
Grass leaves(any)	31	21.38
Other locally available materials	37	25.50
Sources of water for washing purpose		
Hand pump water	65	44.8
Hand dug well water	17	11.7
River water	63	43.4

4.10. Housing system and barn cleaning

Current study revealed that 100% (145) of the interviewed households live in separate house from their cows. Cows are housed in closed barn constructed with woods and grass, the wall is built with mud and the roof with grass (Appendix Fig 6). This type of

house is locally known as “Luak”. Most commonly in summer season, the house protects cattle from environmental factors, theft and predators. Regarding barn cleaning all of respondents said, they clean barn once per day in morning time immediately after cows left the barn to yard. Boys are more engaged in barn cleaning activities than other family members. According to present study all of the respondents used dried manure and dried barn waste as bedding material, they used to mix barn waste with some manure and dry it every day. Dried manure was also used to smoke the barn to avoid wetness and prevention of some vectors that may enter in to the barn.

4.11. Animal health delivery

Animal losses due to diseases were very high compared to other factors in the study area. In the three kebeles of the study area, majority (73.1 %) (106) of the respondents replied as they do not have animal health service in their area, while only 26.9% (39) have an access for animal health services (Table 11). Majority of the respondents (97.9%) (142) experienced udder health problem among the herds. In regard to udder health management, only 24.1% (35) of the udder case was treated by health technician, 49.7% (72) treated traditionally and 26.2 % (38) left to cure by itself. Based on survey results farmers long ago have no 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 could occur. Eventually they became aware that the udder health problems could occur either as a disease which they locally called “Tak” (mastitis) or from evil eye. In this case, they were using two type of healing to cure the disease based on either the disease is clinical (wounded) or subclinical. Boiled water mixed with salt was used to treated cow with clinical mastitis or wounded udder. Traditional they use stone and touched each quarters with it and put the stone under small piece of wood (peg) where the cow was stalled (tethered) on, so that udder problems may be healed. From the respondents 93.8% (136) milked sick animals but it depends on severity and the types of disease. Basically drug withdrawal period were very essential to avoid public hazards resulting from residual of drugs. The present study indicates that 115(79.3%) of the farmers experienced milking of drug treated animal immediately.

Milking of sick animals and milking of drug treated animal immediately was due to lack of awareness about its effects on consumers. There were only three animal health clinics established in the districts but only one of the clinics was functional with limited materials and facilities which could not provide enough services throughout the entire woreda due to shortage of budget. In addition, the locations of functional clinics was in the main town of the district which are not easily accessible to most community requiring most of cattle owners in the Woreda to walk two to three hours to get access of drugs for the treatment of their animals.

Table 11. Animal Health Service delivery system, udder health management and drug withdrawal practices in the study area.

Variables	Frequency	%
Animal Health service		
Get animal health serves	39	26.9
Do not get animal health serves	106	73.1
Udder Health problem		
Yes	142	97.9
No	3	2.1
Udder health management		
Treated by veterinarian (health tech.)	35	24.1
Treated traditionally	72	49.7
Left to cure by itself	38	26.2
Milking of sick animals		
Yes	136	93.8
No	9	6.2
Milking of drug treated animal immediately		
Yes	115	79.3
No	30	20.7

4.12. Prevalence of mastitis

Out of total examined cows, 60.33% (73) were found to be affected with clinical and subclinical mastitis. The study similarly showed, cows with CMT positive for the clinical and subclinical mastitis were found to be 11.57% (14) and 48.76% (59) respectively (Table12).

Out of the 484 quarters examined only one teat was found to be blind. During the screening of quarters, 9.32% (45) and 37.89% (183) were found to be both affected by clinical and subclinical mastitis respectively (Table 12). The quarter level prevalence of clinical and sub clinical mastitis from the highest to lowest rate of infection were left front teats (LF) 53.72% (65), right rear teats (RR) 50.00% (60), left rear teats (LR) 45.56% (55) and right front teats (RF) 39.65% (48) respectively(table 13). The overall quarters prevalence of clinical and sub clinical mastitis was 47.21% (228) (Table 13).

Table 12. Prevalence of clinical and sub clinical mastitis at cow and quarter levels

Form of mastitis	Total examined (Cows)	Total No. affected N (%)	Total examined quarter	Total No. affected (%)
Clinical	121	14(11.57)	483	45 (9.32)
Subclinical	121	59(48.76)	483	183 (37.89)
Total		73(60.33)		228(47.21)

Table 13. Prevalence and distribution of udder infection across the four quarters in dairy cows based on their clinical stages

Variable	Total nº. of examined quarter	No. of quarters affected	Clinical mastitis	Subclinical mastitis
			Prevalence N (%)	Prevalence N (%)
LF	121	65(53.72)	12(26.67)	53(28.96)
LR	121	55(45.56)	8(17.78)	47(25.68)
RF	121	48(39.67)	11(24.44)	37(20.22)
RR	120	60(50.00)	14(31.11)	46(25.14)
Total	483	228(47.21)	45(100)	183(100)

4.13. Risk factors associated with dairy cow mastitis

The association of the different potential host risk factors and the occurrence of mastitis in Jikawo Woreda are shown in (Table 14). Accordingly, the occurrence of mastitis based on age, stage of lactation and parity was significantly higher in adult cow (6-9yrs) ($\chi 2$ =7.87, P=0.020), in mid (5-7m) lactation cows ($\chi 2$ =6.41, P=0.041), and in cow with moderate (4-7) parity ($\chi 2$=11.79, P=0.003) respectively.

Table 14. The prevalence of dairy mastitis based on intrinsic risk factors

Risk factors	Total number of animal Examined	Number of animals Affected	Prevalence (%)	$\chi 2$	P- value
Age					
Young adult(3-5)	22	9	40.91	7.87	0.020
Adult(6-9)	27	17	62.96		
Old(>9)	72	47	65.23		
Stage of lactation					
Early(<4m)	37	21	56.76	6.41	0.041
Mid(5-7m)	74	41	55.41		
Late(>7m)	10	8	80.00		
Parity					
Few(1-3)	23	13	56.52	11.79	0.003
Moderate(4-7)	51	33	64.71		
Many(>8)	47	27	57.45		

Similarly, Table 15 summarized the result of association between the occurrence of mastitis and some of the environmental risk factors. The occurrence of mastitis based on body condition, tick infestation, teat injury and history of previous mastitis was significantly higher in cow with good body condition ($\chi 2=6.69$, $p<0.010$), in moderately tick infested cows ($\chi 2 =11.14$, $p< 0.003$), in cows with teat injury ($\chi 2 =7.14$, $P<0.008$) and in cows with previous mastitis history ($P<0.003$, $\chi 2=8.62$) respectively.

Table 15. The prevalence of bovine mastitis based on some of the extrinsic risk factors

Risk factors	Total number of animal Examined	Number of animals Affected	Prevalence (%)	$\chi 2$	P-value
Body condition					
Poor	85	40	47.06	6.69	0.010
Good	36	33	91.67		
Tick infestation					
Highly	14	10	71.43	11.41	0.003
Moderately	47	44	93.62		
Low	60	19	31.67		
Teat injury					
Present	65	45	69.23	7.14	0.008
Absent	56	28	50.00		
History of previous mastitis					
Yes	26	23	88.46	8.62	0.003
No	95	50	52.63		

5. DISCUSSION

Majority (75.2%) of respondents in the study area who were engaging in hygienic milk production were females than Males which is similar to Bereda *et al.,* (2012) report, that dairying offers more opportunities for females to be closely involved in the daily management than males. The present study indicated that most of the respondent's educational levels were found between illiterate and primary school. This is also in agreement with report from Illu Aba Bora Zone, Southwest Ethiopia (Bereda *et al.,* 2014), where the educational level attained by the majority of the household heads falls between illiterate and primary school. This indicates that more intervention is needed to aware farmers in order to improve their hygienic dairy production and husbandry practices.

The overall mean of family size in the study area was lower than the report by Teshager, *et al.* (2013[a]) that the overall means of family size was (7.09$\pm$ 0.15) in Ilu Aba Bora Zone of Oromia Region. Most of the respondents were in the productive ages which agreed with Teshager, *et al.,* (2013[b]) report.

The survey result showed that, production system was predominantly crop- livestock production system in which dairy cows were kept under an extensive management. Similar finding was reported by Abebaw *et al.*, (2011) in Jimma town.

Majority of the respondents hold more lactating cows than other types of cattle which is in agreement with study from Ezha Districts, Gurage Zone of South West of Ethiopia (Bereda *et al.,* 2014). The reason for holding large proportion of cows than other cattle was for milk production and to produce replacing heifers for future dairy cattle replacement. In contrary to this finding, Teshager *et al., (*2013b) reported that the reason for large proportion of cows was that they are maintained for producing replacement oxen which are very important for draught power.

Females involved in milking activity in higher proportion compared to other family members that is in line with the report from different parts of Ethiopia (Bereda *et al.,* 2012, Asrat *et al.,* 2013). This indicates that female have the responsibility to determine the production of hygienic and quality milk and milk products. Similar to the report of Tesfaye, (2007), milking was completely done by hand and respondent's practices complete milking of the cow to increase milk yield using calf as stimulator in the study districts. However, even though producers wash their hand before milking, it is rough and not to the required standards so that contamination of milk is obvious.

In this study, all of the interviewees were not practicing pre milking udder preparation which may lead to possible contamination of udder with microorganism present in the environment which agreed with the report by Bereda *et al.* (2012). Different reports confirm that milk pathogens primarily originate from poor sanitation, animal stress, and animal sickness (Martin. and Terry, 2007).

Milking of cow after the death of her calf was somewhat difficult because cow is likely to be docile when seeing their calf nearest to it. Survey result showed that, milking of cow after the death of her calf was a tradition among Nuer agro pastoral community in the study district in particular and in the Gambella Region in general. They continue milking the cow starting from the death of the calf up to the end of normal lactation period by pushing air pressure inside the cow via reproductive tract to stimulate milk let down.

They use cold and warm water to clean milk handling equipments without detergents which was insufficient to remove all the dirt on the milking equipment which is also similar to the finding of Alehegne, (2004). Hence, the possibility of consuming contaminated milk resulting from unsanitary cleaning practices is high.

Washing of equipment with grass leave, ashes and locally available materials to remove visible and dried dirt that attached to milking equipments was practiced by the majority of the respondents. They use this practice whenever there were accumulation of dirt's which cannot be removed by water alone.

Sources of water available to dairy producers used for cleaning purposes vary based on their temporal settlement of the farmers. The sources of water used for cleaning were river, pump, and hand dug well water. The quality of both river and hand dug well waters used for cleaning may not of the required standard thus can contribute to the poor quality of milk in the area (Bereda *et al*., 2012).

In the present study, the overall prevalence of mastitis in local Nuer breed cows was 60.33% and 47.21% at cow and quarter levels respectively. This result is in agreement with finding of Birhanu *et al*., (2013), who reported that the overall mastitis prevalence in the farm was 66.6% and 42% at cow and quarter level, respectively in Assella Dairy Farm in Oromia Region, Ethiopia. The present findings were found to be higher than previous findings in some parts of the country (Girma, 2010, Tigre 2011 and Aberra, 2013), which could be due to lack of awareness, housing and milking practices they are accustomed.

The host risk factor considered for this study was, age, stage of lactation and parity. In The present study from selected potential risk factors age ($P<0.020$, $\chi 2 = 7.87$), stage of lactation ($P<0.041$, $\chi 2 = 6.41$), and parity ($P<0.003$, $\chi 2 = 11.79$) had statistically significant effect on the occurrence of mastitis which agree with the report by Zeryehun et al., (2013). Similarly, the environment risk factors considered for this study were body condition, tick infestation, teat injury and previous history of mastitis. The occurrence of mastitis based on these risk factors like body condition, tick infestation, teat injury and history of previous mastitis showed statistically significant effect with the occurrence of mastitis. This was also reported by several investigators to have association with the occurrence of mastitis (Biffa et al., 2005; Mekibib, 2010; Benta, 2011; *Nibret, 2012*).

6. CONCLUSION AND RECOMMENDATION

In the study area, majority of farmers who were participating in hygienic milk practices was females. There are various factors that were observed to affect practices of hygienic milk production such as herd management, milking practices and diseases like mastitis and its associated risk factors. The presence of poor milk handling practices and absence of hygienic milk processing system was a common problem observed in the study area. The unhygienic conditions of milking, unclean milk handling equipment and the use of contaminated cleaning water were among the important determinant factors of milk contamination in the study area. The study also revealed poor involvement of males in the milking practices. Udder washing in the presence of calf is not practiced, which indicates a poor milk hygienic practice. It is also found that more than 15 minutes are required until the milk reaches the storage site and has no means such as refrigerator to preserve milk for further uses, which can lead for fast spoilage of the product due to the hot climate of the area. Moreover, all the farmers' replied as they used jug, plastic jars and traditional milking equipments as containers for milking, which can be a potential source for the contamination of milk by bacteria. Apparently the housing systems of the cows could also predispose factor for mastitis. The California mastitis test (CMT) method also indicated that mastitis of both clinical and subclinical types were major health problems of the dairy cows, which cause huge loss of milk production that assure serious attention in creating awareness and prevention strategy. The study also showed various environmental risk factors such as tick infestations, teat injury and previous history of mastitis which are statistically significant and required intervention. Based on the above conclusions the following points are recommended:

- Farmers in the study area need be aware about the importance of hygienic milk production and hygienic milk handling practices.
- Awareness creation need to be given to farmers in order to avoid immediate milking of drug treated cow and milking of sick cow
- Further investigation and diagnosis on mastitis causative agents should be done in order to apply the proper prevention and treatment scheme.

- External parasites especially tick prevention program should be applied
- Keeping the hygiene of the cow and housing area are important to ensure reduced exposure to mastitis pathogens.

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8. APPENDICES

Appendix 1: Questionnaire format for hygienic milk production survey

1. Socio economic characters of the respondents

1.1.Code				
1.2..Date of interview	1.3.Peasant Association (PA)			
1.4..Kebele	1.5.Name of village			
1.6.Name of the farmer				
1.7.Owner's sex	Male [ ]		Female [ ]	
1.8.Owners educational level	No [ ]	Reading and writing [ ]	grades [ ]	>6 grade [ ]
1.9. Religious	Christian[ ]	Muslim [ ]	Others[ ]	
1.10.Number of family members	<15 years [ ]	>15 years [ ]		
1.11. main occupation	Farming [ ]	Livestock production [ ]	Off-farm business [ ]	
	Formal employment [ ]		Informal employment [ ]	

2. Production system

2.1.Major production systems exercised by the smallholder/farmers	Livestock rearing [ ]	livestock rearing and crop farming (mixed farming) **[ ]**	Crop farming [ ]	others (specify) [ ]
2.2. What is your main source of household revenue?	Crop cultivation **[ ]**	livestock production **[ ]**	mixed crop-livestock farming [ ]	fishing [ ]
	other (specify)			

3. Livestock inventory

Species	Calves		Cow		Oxen		Total		
Cattle	Male	Female	Dry	Lactating	Castrated	Bull			
	Kid /Lamb		Yearling						total
	Male	Female	Male	Female	Doe	Ewe	castr	Buck/ram	
Goat									
Sheep									

Species	Young	Mature female	Mature male	Total	Species	
Donkey					Poultry	Bees
Horse						

3.1. Rank the most preferred livestock species in the area in order of importance (1, for most preferred and 2, 3…)	Cattle [ ]	Sheep [ ]	Goats [ ]
	Poultry [ ]	Equines [ ]	Camel [ ]

4. Purpose of keeping cattle (√)

Services	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7
Milk							
Meat							
Draft power							
Cash earnings							
Soil fertility mgt							
Social prestige							
Ritual ceremony							
Others							

5. Feeding practice (prioritize according to order)

5.1.Type feeds	Rank
Natural pasture	
Cultivated pasture	
Cereal straws (‘teff’, barley, wheat…)	

Stover (sorghum and maize)	
Salt and minerals	
Other	

6. Milk production

6.1. Where do you milk the cow?	In barn [ ]	In milking room [ ]	Others (specify)	
6.2.Milk yield per day (liter)	1lit [ ]	1.5lit [ ]	2lit [ ]	3lit [ ]
	>3lit [ ]			
6.3.Type of milking practices	Milking without suckling [ ]	Few suckle before and after milking [ ]	Suckling before milking only [ ]	others(specify
6.4. Do you practice complete milking practice?	Yes [ ]	No [ ]		
6.5. If yes, why?	To get more milk [ ]	prevention of mastitis [ ]		
6.6. Do you milk your animals in the absence (death) of their calves?	Yes [ ]	No [ ]		
If the above question is Yes, how?				

7. Hygienic and sanitary practices

7.1. How often do you clean milking room or Barn?	once a day [ ]	Twice a day [ ]	Three times a day [ ]	Others
7.2. What kind of milker's clothing do you use?				
7.3. What kind of milking				

equipment's do you use?				
7.4. How long it will take to reach the milk from farm to the consumer/home/storage site?	Below 10 minutes [ ]	Between 15 & 30 minutes [ ]	Around 1 hour [ ]	
7.5. Where do you store the milk after milking?	In refrigerator [ ]	At room temperature [ ]		
7.6. How do you consume the milk?	Raw milk [ ]	After boiling [ ]	By processing the milk [ ]	Other

8. Hygienic practices, housing and bedding used by the smallholder dairy farmers in Jikawo woreda

8.1.Hygienic practices during milking	
Washing udder before and after milking [ ]	Washing udder before milking only [ ]
No washing at all [ ]	
8.2. Types of housing	
The same house with family [ ]	Separate housing [ ]
8.3. Bedding used	
Grass [ ]	Cereal straw [ ]
Dry manure and dry barn waste [ ]	Others [ ]

9. Milking operation in Jikawo woreda

Variable	
9.1.Who is frequently engaged in milking practices	
Mother [ ]	Father [ ]
Daughter [ ]	Son [ ]
Hired laborer [ ]	

10. Sanitary practices for milk handling equipment used by dairy farmers and animal health condition in Jikawo woreda

Variables	
10.1. Cleaning frequency of milk handling containers	
After each usage using cold water [ ]	Both [ ]
After each usage using warm water [ ]	None [ ]
10.2. Materials used for Washing of milk handling equipment.	a)
	b)
	c)
	d)
	e)
10.3. Animal health	
Get animal health serves [ ]	Do not get animal health serves [ ]
10.4. Have you encountered udder health problem?	Yes [ ] No [ ]
10.5. If yes, What did you done to it?	
treated by veterinarian [ ]	left to cure by itself [ ]
treated traditionally [ ]	
10.6. Do you milk a sick animal?	Yes [ ] No [ ]
10.7. If yes, why?	
10.8. Do you milk a drug treated animal immediately?	Yes [ ] No [ ]

Appendix 2: Milk sample collecting format (CMT test result format)

Kebele _____

Name of owner _____

Sample taken _____

1. Risk Factors associated with mastitis

	1.1.Intrinsic factors			
	Breed	Local [ ]	Cross [ ]	Exotic [ ]
	Age	Young adult (3-6 year) [ ]	Adult(6<x<10years [ ]	Old =10 years [ ]
	Stage of lactation	Early (< 4 month) [ ]	Mid (5-7 month) [ ]	Late [ ]
	Parity number	Cow with 1-3 calves[ ]	Cows with 4-7 calves[ ]	Cows with > 7 calves [ ]

	1.2.Extrinsic factor				
	Body condition	Poor [ ]	Good[ ]		

	Tick infestation	Highly infested [ ]	Moderately infested[ ]	Low infestation[ ]	
	Teat Lesion (injury)	Present[ ]	Absent[ ]		
	Udder hygiene	Washing/drying[ ]	Washing only [ ]	Not at all[ ]	
	Floor type	Good concrete[ ]	Bad concrete[ ]	Muddy soil[ ]	
	Do you wash your hands during milking?	Yes [ ]	No [ ]		
	If yes	Before milking [ ]	After milking [ ]	After each cows [ ]	
	Do you use teat dips and towel?	Yes[ ]	No [ ]		
	If yes when?	Before milking [ ]	After milking [ ]	Both before and after [ ]	
	Do you wash milking cow's udder?	Yes [ ]	No [ ]		
	If yes, the type of water	Cold [ ]	Warm [ ]	Both [ ]	
	Source of water used for washing purpose	Pipe water [ ]	Lake water [ ]	River [ ]	
	Frequency of milking	Once [ ]	Two times [ ]	Three times [ ]	I do not have regular schedule [ ]
	History of previous mastitis	Yes	No		

2. distribution of udder infection across the four quarters in dairy cows

	Quarters examined	Clinical case		Sub-clinical case		
		CMT positive	CMT negative	CMT positive	CMT negative	
	Left Front					
	Left rear					
	Right Front					
	Right Rear					

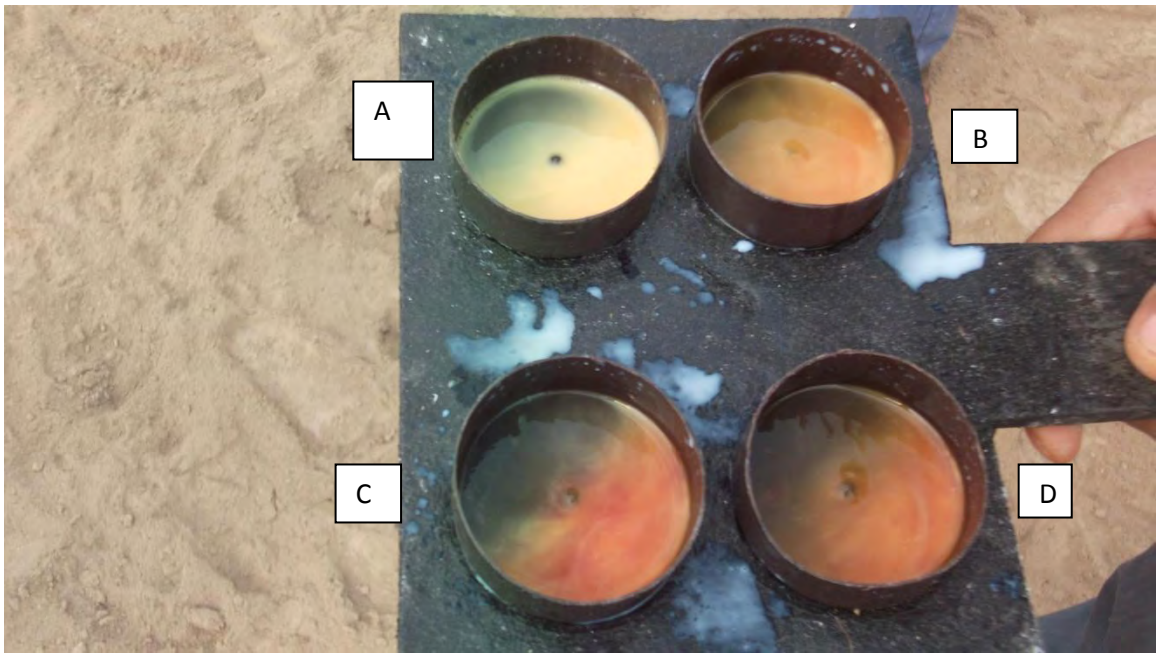
Appendix 3: Check list for group discussion

1. Types of Production system commonly and rarely practice?
2. What kind of off farm business are practicing by farmers and by whom they are handled?
3. What are the general hygienic conditions of farm activities?
4. Constraints affecting production system?
5. Who has the ownership of cattle in household?
6. Purpose of keeping cattle (meat, drought, soil mgt, etc?
7. Farmer Perception for the cause of mastitis and way of mgt?

Appendix table 1. Interpretation of CMT scores

CMT Score	Somatic Cell Range	Interpretation
N (Negative)	0 – 200,000	Healthy Quarter
T (Trace)	200,000 – 400,000	Subclinical Mastitis
1	400,000 – 1,200,000	Subclinical Mastitis
2	1,200,000 – 5,000,000	Serious Mastitis Infection
3	Over 5,000,000	Serious Mastitis Infection

Sources: Pamela L. R., (2005)



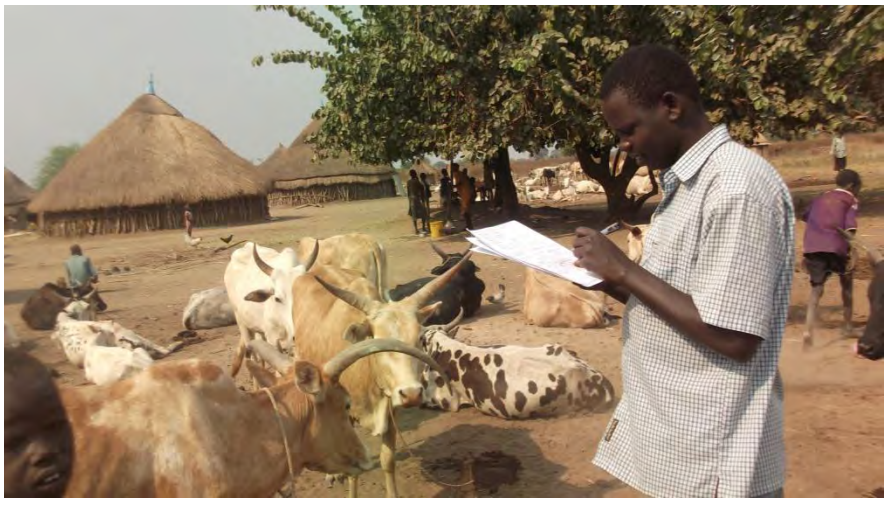
Appendix figure 1. CMT tested milk samples taken from a cow at Jikawo woreda, Puokueth kebele. A (LR) indicates negative, B (LF) slightly positive, C (RR) and D (RF), strongly positive milk samples.

Appendix figure 2. CMT paddle (left) and CMT reagent (right)

Appendix figure 3. Tethering of cattle in the yard in winter

Appendix figure 4. Boy inserting pressure on cow to stimulate milk letdown after the death of the calf

Appendix figure 5. Woman handling traditional milking equipment (diaar)



Appendix figure 6. Cow house "Luak" near the tree