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STUDY ON MILK CHEMICAL COMPOSITION, BACTERIOLOGICAL QUALITY AND HANDLING PRACTICES IN DEBRE LIBANOSE DISTRICT NORTH SHEWA ZONE OROMIA REGION

BY

MEZGEB WORKIYE

JULY 2012

DEBRE ZEIT, ETHIOPIA

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ABBREVIATIONS

ANOVA	Analysis of Variance
CC	Coliform Counts
Cfu	Colony forming unit
cfu/ml	Colony forming unit per milliliter
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration
IDF	International Dairy Federation
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
Km	Kilometer
ISO	International Organization for Standardization
Ml	Milliliter
NAOH	Sodium Hydroxide
NVI	National Vaccine Institute
PIC	Preliminary Incubation Count
SCC	Somatic Cell Count
SE	Standard error
SHO	Soxhilet-Henkel Degree
SNF	Solid non fat
SPC	Standard Plate Count
SPSS	Statistical Package for Social Science
TAC	Total Aerobic Count
TCC	Total Coliform count
TPC	Total Plate Count

ABSTRACT

The present study was under taken on chemical composition, bacteriological quality and handling practices in Debre Libanose district with the aim of investigating hygienic, processing and marketing practices of milk , ownership pattern of dairy animals at their husbandry practices, chemical composition and bacteriological quality of raw milk. Cross sectional study was conducted from September 2011 to March 2012 by way of questionnaire survey, farm visit and laboratory analysis of milk chemical composition and bacteriological quality. A total of 100 households were visited and interviewed. 50 milk samples were examined for specific gravity, alcohol tests, and bacteriological quality and 65 milk samples were also examined for fat, lactose SNF and protein contents at milk collection centers. The households were practicing mixed farming system with an average 6.21 cattle population of which 2.23 were milking cows. The major feeding systems were grazing and stall feeding. All animals were housed at least during night times. Udder and hand washings were practiced by more than 85 and 58 % respectively, of the producers. About sixty three and eighty seven percent of the households process milk to butter, cheese and yoghurt and sold milk to different buyers respectively. The majority (64%) of the milk samples had the specific gravity value of less than 1.026, indicating the existence of adulteration with addition of water. The chemical composition of milk samples for fat, lactose, solid non fat and protein were 3.93, 4.13, 7.54 and 2.73 % respectively. The average total plate counts of milk samples were log 3.61 and 6.28 for udder and bulk milk tank at collection center respectively. The average coliform counts were log 1.76 and 4.17 for udder and bulk milk tank respectively. The two sampling points (udder and bulk milk at collection center) had significant differences ($p \leq 0.001$) in TPC and TCC counts. The average total plate counts and total coliform counts were higher in households that do not have clean barns, which did not wash udder or let calves suckle, not wash hands during milking and not use teat dip and towel. In general milk produced in the study area can be considered as acceptable in its fat and lactose contents and it becomes substandard in its bacteriological quality as it goes from point of production to point of selling. Dairy

producers should be provided with extension service on milk handling practices and Establishing milk processing plants around high milk producing areas, could contribute towards reducing further contamination of milk due to time elapsed during transportation

Keywords: Milk, Chemical composition, TPC, TCC, udder milk, bulk tank milk Smallhoder, Debre Libanos

1. INTRODUCTION

Milk is a very nutritious food that is rich in carbohydrates, proteins, fats, vitamins and minerals, which is a major constituent of the diet and is considered essential to the health and well being of the community (Prejit-Nanu and Latha, 2007). The nutritional as well as economic value of milk is directly associated with its solids content. The higher the solids content, the better its nutritional value and the greater the milk product yields. According to O'Connor (1994), the average total protein, total solids, ash, casein and lactose content of milk ranges between 2.9-5 %, 10.5-14.5 %, 0.6-0.9 %, 2.9-5 % and 3.6-5.5 %, respectively. The constituents may vary with breed, type of feed, stage of lactation, season and age of the cow etc. Milk quality is the sum of physico-chemical, microbial and sensory attributes and these attributes may deteriorate by a number of factors such as adulteration, contamination during and after milking and the presence of udder infections (Esron *et al.*, 2005). Microorganisms could easily contaminate the milk produced and may negatively affect delivery to consumers with its acceptable quality; as, milk is an excellent media for growth and multiplication of spoilage microorganisms.

The various sources of microbial contamination of milk may originate from interior or exterior of the udder, miscellaneous sources and environmental contaminants. Microorganisms may contaminate milk at various stages of procurement, processing and distribution. The health of the cow and its environment and poor handling of milking utensils used for milking could expose the milk to losses through spoilage and contamination. Workers who milk cows and come in contact with milk due to a number of reasons could serve as sources of microbial contamination of milk. Use of non potable water may also cause entry of contaminants into milk.

The hot and humid climatic condition of tropical regions is ideal for quick deterioration of milk because, the temperature is ideal for growth and multiplication of many bacteria (Gilmour, 1999; Godefay and Molla, 2000).

Milk contains both pathogenic and nonpathogenic organisms. Pathogenic organisms, which may come directly from the cow‟s udder, are species of *Staphylococcus*, *Streptococcus*, *Mycobacterium, Brucella, Escherchia*, *Corynebacterium*, etc. Various pathogenic organisms causing diseases like cholera and typhoid may find access to milk from various sources, like water and the persons handling the milk. Other bacterial pathogens such as *Streptococcus agalactae*, S*taphylococcus aureus*, and *Escherchia coli* are pathogens that commonly spread from milk to humans (Hahn, 1996). Non pathogenic microflora may come directly from the udder and may also enter in to milk from milker‟s hands, utensils, cow barn, water, etc. (Hahn, 1996). In most places of Ethiopia, milk is consumed raw; milk products such as yoghurt, butter and buttermilk are also produced using raw milk as a starting material. Hence there exists the possibility of consuming milk, which has been contaminated with disease causing organisms (Mehari, 1988). The high level of bacterial contamination is a matter of concern for food safety. Consumers are entitled to safe and fresh milk of acceptable quality level to safeguard themselves from diseases.

Yet hygienic quality control of milk and milk products in Ethiopia is not usually conducted on routine basis. Apart from this; door-to-door raw milk delivery in the urban and peri-urban areas is commonly practiced with virtually no quality control at all levels (Godefay and Molla, 2000).

However, milk quality is evaluated on the basis of alcohol and lactometer tests such as milk density and studies on aspects of chemical composition, hygienic and bacteriological qualities of milk are scarce in Ethiopia. Therefore, understanding the chemical composition and microbial load of raw milk needs to measure the quality of milk. High population of bacteria in aseptically drawn milk samples or detection of presence of harmful pathogenic microorganisms is an evidence of unhygienic milk production conditions (Abrahamsen *et*

al., 2007). There is limited work so far undertaken regarding assessment of chemical composition, bacteriological quality and handling practices of raw milk in North Shewa in general and in Debre Libannos in particular. The number of bacteria increases considerably between the time of milking and distribution to consumers. As indicated by Chambers (2002) total bacterial and coliform counts are good indicators of the sanitary conditions practiced during production, collection, storage, transportation and handling of raw milk. Therefore, the aims of this study were:

- To assess the hygienic, processing and marketing practices of milk in the study area
- To determine the chemical composition of raw milk in the study area
- To investigate the bacteriological status of raw milk from udder and bulk milk tank
- To examine the effect of some husbandry practices on milk contamination

2. LITERATURE REVIEW

2.1. Milk and its keeping quality

The keeping qualities of milk are influenced by the milk‟s microbial content and the conditions that enhance or inhibit growth of the milk‟s microbial flora. Shelf life of pasteurized milk is influenced by somatic cell concentration in raw milk and is indicative of abnormalities in the cow that is shorter shelf life and adverse milk flavors are the common results of elevated SCC score (Rice and Bodman, 1997). Product temperature is a major factor influencing shelf life. Product temperature must be between 4 ^{0}C to 5 ^{0}C for maximum shelf life. As a general rule, for every 2.8 ^{0}C rise in temperature, shelf life is reduced by about 50 % (Mehari, 1988). Compared to total aerobic plate counts of milk from farms which employed only cold water rinse (8.9 to 11.5×10^6 cfu/ml), the use of an ordinary detergent and tap water did improve the bacteriological quality of milk only slightly (6.4 ×10^6 cfu/ml) and also improve the keeping quality (Kurwijilla *et al*., 1992).

Changes in on farm procedures of milk collection, longer refrigerated storage of raw milk at the farm, and additional storage periods in bulk silos prior to processing may contribute to decreased shelf life of pasteurized milk (Mehari, 1988). Taste defects of pasteurized milks occur when total aerobic bacterial counts reach 10^6 to 10^7 cfu/ml. Maintaining the quality of raw milk to extend the shelf life of milk and milk products is of greater importance. Milk processors wish to extend the shelf life of milk and milk products through the use of higher processing temperatures and also prevent recontamination by bacteria after pasteurization; a reduction in storage temperature increases the keeping quality of milk (Mehari, 1988).

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 (Ashenafi, 1990). According to Mehari (1988), raw milk could be kept for 2 days at refrigeration temperature and 0.9 days at room temperature.

2.1.1. Importance of hygienic quality milk

Milk is an ideal balanced food for human beings. It is not surprising therefore, that it also provides an ideal medium for growth of bacteria. Bacteria finding 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, can all be minimized by starting the manufacturing process with raw milk of good hygienic quality. 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).

2.1.2. Milk quality improvement

Methods of ensuring good-quality milk production

Facilities required ensuring the production, processing and distribution of safe and good quality milk differ from country to country based on factors such as economic condition, access to technology, experience in the venture, and production objective. The methods used in advanced countries for high-quality milk supplies excellent sanitary production, farm refrigeration, and refrigerated transport and pasteurizing are impractical in the early stages of milk collection in developing countries. Sanitation is a universal problem in developing dairy industries because knowledge of hygiene is often not well developed, and facilities to improve milk quality are lacking. Conditions that make it difficult to improve milk quality include very basic equipment that are very difficult to clean; poor quality and inadequate water supplies; no electricity or refrigeration; slow transport; and the heat, dust and mud of tropical environments. One cannot expect a producer to build a cow shed of good material and use sanitary equipment and methods while living in a mud hut himself. However, improving milk quality is still possible.

Farmer‟s attitude to milk quality will depend on the emphasis expressed by authorities. Frequently, quality control measures have been directed more at penalties for adulteration and poor milk composition, than at protecting public health. While people‟s concept of sanitation and facilities gradually improve, milk quality can be improved in several ways. Many countries overcome the problems of time spoilage by delivering raw milk to consumers within hours after production. Other farmers are aware that cream will hold its quality longer than milk, so separate the cream for market and keep the skim milk for home use. Still others produce and market dairy foods based on milk fat like butter and ghee, or fermented products like yoghurt, dahi (Indian fermented milk) or kefir (a type of fermented milk), which will keep much longer than raw milk without refrigeration. In many tropical countries, milk is traditionally boiled in homes before it is used (Zelalem, 2010). The

methods and requirements put in place to ensure good quality milk varies based on level of dairy development and are summarized below.

General rules followed to produce safe milk in dairy developed countries:

Cows should be free of disease, especially tuberculosis, brucellosis and mastitis. Milk from cows that are sick, very late in lactation (milk from late lactation cows may undergo spontaneous lipolysis) or freshly calved (up to five days after calving) should be kept out of the saleable milk supply. Mud and manure should be removed from the udder and teats before milking. Hand-milked cows should also have clean flanks and tails. Housed cows should be given regular clean bedding (Zelalem, 2010).

Milkers should be free of infectious diseases, especially when hand milking. Clothing, hands and forearms should be clean before milking, and cleaned if possible between cows with soap, water and towels. Wet milking (moistening the hands with milk from the teat or pail for hand milking) is discouraged (Zelalem, 2010).

Milk equipment and utensils must also be easy to clean, and be regularly sanitized and maintained and to preserve keeping quality; milk should be cooled immediately after production and be kept in cold storage. Bacterial growth is retarded by cooling and storing milk at 10 ^{0}C or lower, within two hours of milking. Milk should be stored in the coolest possible place, covered and away from any tainting odors. Fresh and aged milk should not be mixed until they are at the same temperature. Milk must be stirred regularly in storage to blend it and to help remove feed taints. Milk being held for collection should be sheltered to keep it cool and to protect it from the direct rays of sun. Delivery to the factory should be as frequently and as early in the day as possible, especially for milk used in the liquid-milk trade. Milk transporters, processors and distributors should follow the same strict sanitary practices; as the farmers, and milk should move as quickly as possible from the farmer to the consumer (Zelalem, 2010).

2.2. Bacteriological quality of raw milk

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

2.2.1. Sources of bacterial contamination

The bacterial contamination in milk emanates from a number of sources including mastitis, external udder surfaces and from the milking plant (Hagstad and Hubbert, 1986; Ashenafi and Beyene, 1994; Slaughuis, 1996). Inadequate cooling of the milk, improper udder preparation methods, unclean milking equipment and the water used for cleaning purpose is considered as the main source of milk contamination (DeGraaf *et al*., 1997). In order to produce milk of good bacteriological quality, dairy farmers should be aware of the sources of contamination and importance of proper milk handling, cooling and storage.

Interior of the udder

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 (Godefay and Molla, 2000). Natural flora within the udder of healthy animals is not considered to contribute significantly to the total numbers of microorganisms in the bulk milk, nor the potential increase in bacterial numbers during refrigerated storage. Natural floras of the cow generally have little influence on standard plate counts (SPC) (Murphy, 1996).

While the healthy udder should contribute very little to the total bacteria count of bulk milk, a cow with mastitis has the potential to shed large numbers of microorganisms into the milk supply. The influence of mastitis on the total bacteria count of bulk milk depends on the strain of infecting microorganisms, the stage of infection, and the percentage of the herd infected. Infected cows have the potential to shed in excess of 10^7 bacteria per ml. If the milk from one cow with 10^7 bacteria per ml comprises 1 percent of the bulk tank milk, the total bulk tank count, disregarding other sources, would be 10^5 per ml (Bramley and McKinnon, 1990).

Table 1. Pathogenic bacteria of public health significance

Pathogenic bacteria	Remark
Anthrax	*Bacillus anthracis*
Brucellosis	*Brucella abortus,B.melitensis*
Campylobacteriosis	*Campylobacter jejuni*
Colibacillosis	*Escherichia coli*
Corynebactriosis	*Corynbacterium spp.*
Listeriosis	*Listeria monocytogenes*
Salmonellosis	*Salmonella spp.*
Shigellosis	*Shigella spp.*
Staphylococcosis	*Staphylococcus aureus*
Streptococcosis	*Streptococcus pyogenes*
Tuberculosis	*Mycobacterium bovis*
Yersiniosis	*Yersinia enterocolitica*

Source: Pal (2007)

Exterior of the udder

The hygienic status of the barn

The production of quality milk begins with good hygienic practices. In the dirty barn, teats and udders of cows inevitably become soiled while they are laying in stalls or when they

are allowed to stay in muddy barnyard. Used bedding has been shown to harbor large numbers of microorganisms (Murphy and Boor, 2000). Dirty milking area and dirty cows can constitute an elevated bacterial level in the bulk tank. Several research results have shown that milk produced and handled under hygienic condition can be expected to have colony counts of less than $2x10^4$/ml before pasteurization while milk produced un hygienically can have bacterial load as large as million and billion of bacteria per milliliter (Godefay and Molla, 2000; Alehegn, 2004).

Cows

Cleaning the udder of cows before milking is one of the most important hygienic practices required to ensure the clean milk production. This is important since teats and udders of cows inevitably become soiled while they are lying in stalls or when allowed in muddy barnyards. Used bedding has been shown to harbor large numbers of microorganisms. Total counts often exceed 10^8-10^{10} cfu/ml. (Bramley and McKinnon, 1990). Organisms associated with bedding materials that contaminate the surface of teats and udders include streptococci, staphylococci, spore-formers, coliforms, and other Gram-negative bacteria. Both thermoduric (bacteria that survive pasteurization) and psychotropic (bacteria that grow under refrigeration) strains of bacteria are commonly found on teat surfaces (Bramley and McKinnon, 1990).

The influence of dirty cows on total bacteria counts depends on the extent of soiling of the teat surface and the wash procedures used immediately before milking. For example, if one gram of teat soil containing 10^8 cfu/ml bacteria is allowed into the milk of one cow giving approximately 13.5 kg of milk, the total bacteria count for that cow‟s milk, excluding other sources, would be in excess of 7,000 per ml. Milking heavily soiled cows could potentially result in bulk milk counts exceeding 10^4 cfu/ml. Several studies have investigated premilking udder hygiene techniques in relation to the bacteria count of milk (Bramley and McKinnon, 1990).

Milkers

The milkers can be an important source of milk contamination and may contribute various organisms including pathogens especially when they are careless, uninformed, or will fully negligent, directly to milk (Ashenafi and Beyene, 1994). Therefore, milkers, in addition to keeping good personal hygiene, should be in good health during milk operation. Covering hair and dressing gown during milking and handling of milk and milk products are important practices milkers need to obey.

Milking utensils

Equipment used for milking, processing and storage determine the quality of milk and milk products. Therefore, producers should pay particular attention for the type as well as cleanliness of milk equipment. Milking equipment should be easy to clean. Aluminum and stainless steel equipment are mostly preferred.

The degree of cleanliness of the milking system probably influences the total bulk milk bacterial count as much as, if not more than, any other factor (Olson and Mocquat, 1980). Milk residue left on equipment contact surfaces supports the growth of a variety of microorganisms. Organisms considered to be natural inhabitants of the teat canal, apex, and skin are not thought to grow significantly on soiled milk contact surfaces or during refrigerated storage of milk. This generally holds true for organisms associated with contagious mastitis (i.e., *S. agalactiae*) although it is possible that certain strains associated with environmental mastitis (i.e., coliforms) may be able to grow to significant numbers. In general, environmental contaminants (i.e., from bedding, manure, feeds) are more likely to grow on soiled equipment surfaces. Water used on the farm might also be a source of microorganisms, especially psychrotrophs that could seed soiled equipment and/or the milk (Bramley and McKinnon, 1990).

Miscellaneous sources of bacteria in raw milk

Although the air of the milking environment rarely contributes a significant number of the total microbial count of milk, extremely dusty conditions may increase the counts. Polluted water may also cause entry of pathogens into milk (Gudeta, 1987; DeGraaf *et al.,* 1997). The soils, while the cows are in pasture, manure, the animal coats, tails etc. are some of the possible sources of contamination of milk (Teka, 1997).

2.2.2. Cooling of milk

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

2.2.3. Bacteriological quality tests

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

classified into grades designated as A, B, and C (Volk and Wheeler, 1980). Tests commonly employed to determine the quality of milk include: Alcohol test, Standard plate count, Coliform count, Somatic cell count, and titrable acidity.

Alcohol test

When milk contains more than 0.21% acid, or when calcium or magnesium compound are present in greater than normal compounds, it coagulates on the addition of alcohol. This fact is the basis of alcohol test, which furnishes a means of judging the quality of milk (O'Mahony, 1988; Ombui *et al*., 1995).

Standard plate count (SPC)

The standard plate count of raw milk gives an indication of the total number of aerobic bacteria present in the milk at the time of pick up. Obviously, very clean milk will have lower bacterial counts than milk collected or handled under unsanitary conditions. The standard plate count is a basis for grading milk (Volk and Wheeler, 1980). Milk samples are plated on standard plate count agar media and then incubated for 48 hrs at 32^0C to encourage bacterial growth. Single bacteria or clusters grow to become visible colonies that are then counted. All plate counts are expressed as the number of colony forming units (cfu) per milliliter (Murphy, 1996). This method is used mainly to estimate the bacterial population of raw milk prior to heat treatment. It has a limited value in that it does not indicate the quality of microbial populations in terms of pathogens and non pathogens (Teka, 1997). The standard plate count is generally accepted as the most accurate and informative method of testing bacteriological quality of milk (Kurwijilla *et al*., 1992; Godefay and Molla, 2000). It is sensitive but also labor intensive and is inaccurate for high count milks (Slaughuis, 1996). Plate count standards have been developed to ensure satisfactory production hygiene and that the product is safe (Table 2). The plate count method has been conducted as a valuable adjunct to guide sanitarians in correcting sanitation failures and improving milk quality (IDF, 1990).

Table 2. Grade of raw milk based on SPC

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

Source: Kurwijilla *et al.* (1992)

Coliform count

Coliforms are group of bacteria, which inhabit the intestinal tracts of human and animals. They are excreted in large number with human excreta and animal droppings. They may be found in the soil, on vegetables and in untreated water (Teka, 1997). It includes all aerobic and facultative anaerobic, Gram-negative, non-spore forming rods able to ferment lactose with the production of acid and gas at 35^0C within 48 hours. Most of them belong to the genera *Escherichia, Enterobacter* and *Klebsiella* (Godefay and Molla, 2000). The presence of coliform organisms in milk indicates unsanitary conditions of production, processing or storage. Hence, their presence in large number in dairy products is an indication that the products are potentially hazardous to the consumers‟ health (Volk and Wheeler, 1980; Godefay and Molla, 2000). Coliform organisms contaminate raw milk from unclean milker‟s hands, improperly cleaned and un sanitized or faulty sterilization of raw milk utensils especially churns, milking machines, improper preparation of the cows‟ flecks or dirt, manure, hair dropping into milk during milking, udder washed with unclean water, dirty towels and udder not dried before milking (Ombui *et al.,* 1995).

Somatic cell counts (SCC)

The somatic cell count (SCC) is internationally recognized as a parameter for assessing milk quality and udder heath (Degraaf *et al*., 1997). EU standards require that the milk should not contain more than 400,000 somatic cells/ml. Milk market routinely rely on

somatic cell counts, to ensure a quality product. Somatic cell counts levels are monitored to ensure compliance with set milk quality standards. Today, most markets in developed countries pay a premium for low SCC, good quality milk. One can appreciate the reasons, for paying a bonus for quality milk when the relationship between mastitis (high SCC) and milk composition is understood. Chemical changes in milk composition due to mastitis reduce milk quality (Rice and Bodman, 1997).

Titrable acidity test

In order to determine the sourness of milk, we use titration using sodium hydroxide (NaOH) and Soxhilet-Henkel Degree (SH0) gives the degree of sourness. Generally, the sourness of normal milk is 6 to 7 SH0. If the milk sourness is 4 to 5 SH0, it indicates that either the milk is adulterated or there is mastitis (Kurwijilla *et al.,* 1992).

Other milk quality tests

Organoleptic tests

Microorganisms cause various undesirable and detectable organoleptic and physical changes in raw milk. Generally, when actively growing types of organisms capable of causing changes in flavor and physical appearance reach population levels of 5-20 millions per ml; organoleptic and physical changes are evident or imminent (Ashenafi and Beyene, 1994). The general appearance, cleanliness, colour and smell of the fresh milk should checked at collection before it blended with milk from other suppliers since the volume and value at risk increases down the chain (Harding, 1999).

Sedimentation test

Performed by leaving milk in flask or any container kept for 15-30 minutes and observing if there is any sedimentation of dirt, the sediment can be examined bacteriological for the presence of bacteria (Warner, 1975).

Clot on boiling test

Acidity decreases the stability of milk, if the concentration of hydrogen ion is more than the normal amount, then casein will get precipitated on heating immediately. The clot on boiling test is used to determine whether milk is suitable for processing, as it indicates whether the milk is likely to coagulate during processing (usually pasteurization). It is performed when milk is brought to the processing plant. If the milk fails the test, it is rejected (O"Mahony**,** 1988).

Catalase test

This measures the activity of the enzyme catalase. The catalase content of milk primarily depends up on the number of cells in milk. Hence, the increased activity of this enzyme indicates mastitis (Cheesbrough, 1984).

Specific gravity

To test adulteration, specific gravity is measured and calculated. The specific gravity of milk will be measured using lactometer. The specific gravity of normal unadulterated cow"s milk is between 1.026 and 1.032 at 20^0C (Ombui *et al*., 1995).

Freezing test

The normal freezing point of milk is between -0.50 and -0.61^{0}C. The soluble constituents, lactose and ash determine the freezing point of milk and are responsible for its being lower than that of water. This fact makes it possible to determine whether or not milk has been watered. It had been shown that with addition of 1% of water to milk, the freezing point is raised approximately by 0.0055^{0}C (Hansen, 1994).

2.3. Milk handling and processing practices in Ethiopia

Dairy processing in the country is basically limited to smallholder level and hygienic qualities of products are generally poor. Cows are the main source of milk, and it is cows‟ milk that is the focus of processing in Ethiopia. Dairy processing in Ethiopia is generally based on *ergo*(fermented milk in Ethiopia), without any defined starter culture, with natural starter culture. The milk is kept for fermentation prior to processing at ambient temperature or kept in a warm place (Mogessie, 2002).

Because of the generally prevailing unorganized processing, transport and marketing facilities, the people of the tropical countries have mastered the art of conserving or processing the limited quantity of the milk they produce. In small-scale milk production and for those many rural dairy producers rarely practice living in rural areas, pasteurization of milk except smoking of containers (Taye, 1998). In addition, Mogessie and Fekadu (1993) in their study reported that smoking of milking vessels found to lower the microbial load as compared to unsmoked containers.

Traditional milk containers smoked with “Ejersa” (*Olea africana*) splinters together with the leaves into which the raw milk added every day and let to undergo natural fermentation at ambient temperature. The coagulated (curdled) milk called “Ergo” and “Ititu” with their

characteristic aromas and flavors would be commonly relished alone, as part of the meal or might also be churned for butter production (Hellen and Eyassu, 2007).

2.3.1. Fermented/sour milk (Ergo)

In Ethiopia, milk is either consumed fresh or allowed to ferment naturally. The product typically is semi-solid and in smallholder dairy farms, it is produced from whole milk, while in milk cooperatives or other producer groups it is produced from skim milk. On average, milk is accumulated in a clay pot or a gourd over a period of 1 to 4 days and allowed to develop acidity. The mean shelf life of fermented milk is 3.8 days. Fermented milk is the main product used as basis for further processing of various fermented milk products such as traditional butter, ghee, cottage cheese, butter milk and whey (Figure1) (Yitaye *et al*., 2009).

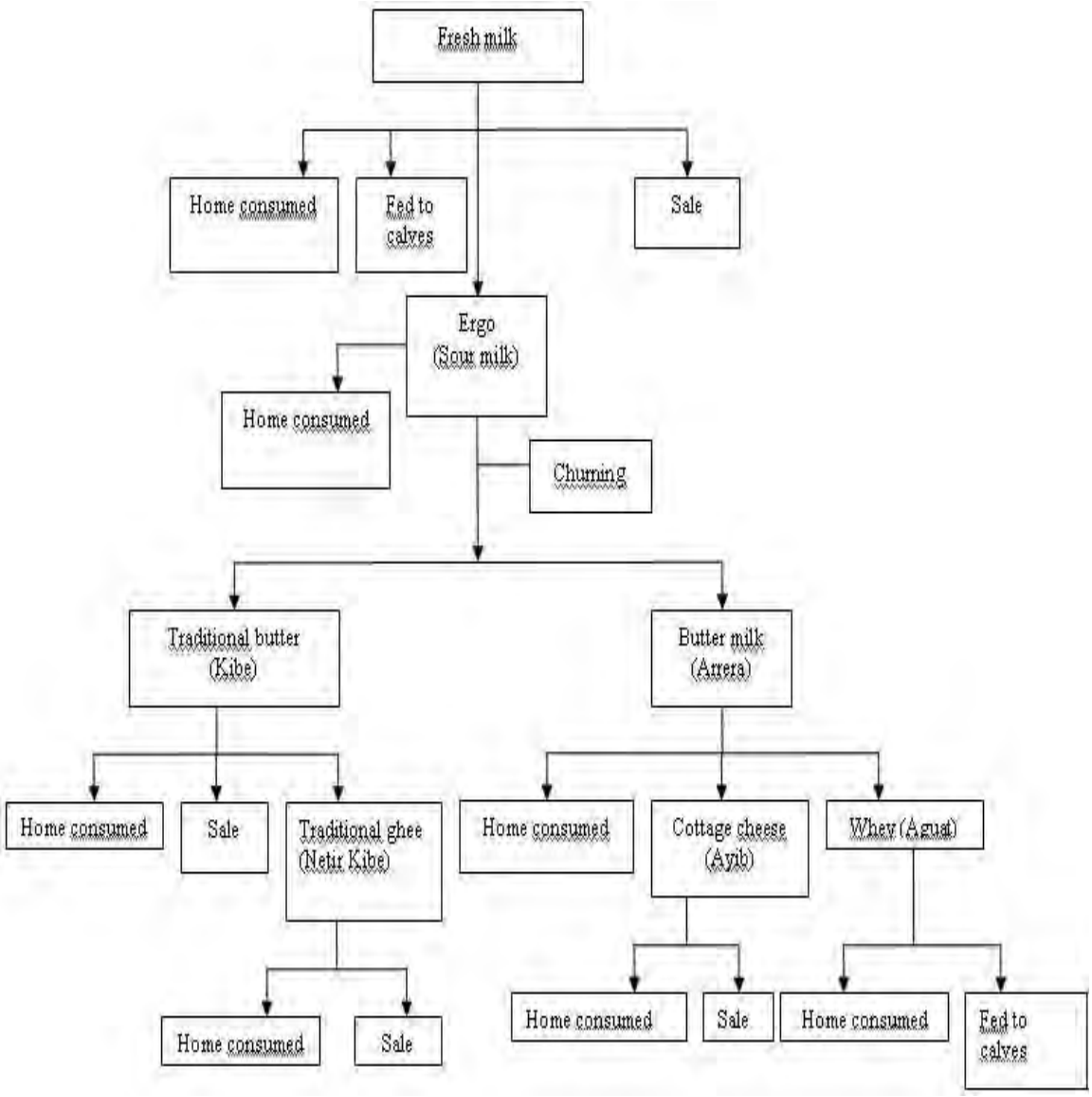

Figure1. Flow scheme for milk utilization by smallholder dairy farmers in Ethiopia

Source: Yitaye *et al*. (2009)

2.3.2. Butter making

Some of the traditional smallholder butter-making methods and improved processing method developed by International Livestock Research Institute (ILRI) are present as follows. 1) Sour milk is agitated by placing the churn (clay pot) on a mat on the floor and rolling it back and forth, 2) Sour milk is stirred with "Mesbekia" (a stick with three to five finger like projections at one end) by inserting it in the sour milk inside the clay pot and using the palms of both hands to rotate the stick. In this case, the clay pot is not moved, 3) Sour milk is initially stirred for about three minutes with "Mesbekia" as in 2 and then agitated by rolling the sour milk in the clay pot back and forth until milk fat is recovered in the form of butter as in 1 and 4) internal wooden agitator fitted to the traditional clay pot (Zelalem *et al.*, 2007).

2.3.3. Buttermilk

Buttermilk („ƒarera‟‟‟), a by-product of traditional butter making is either directly consumed within the family or converted into a cottage cheese known as "ayib" to be sold for family consumption. The consumption of buttermilk depends on the living standard of the family. Buttermilk is rich in protein, lactose, minerals and vitamins. The fat content of this product generally ranges from 1 to 3 percent depending up on the churning temperature (FAO, 1990).

Large proportion of fat remains in the buttermilk if the churning temperature is high and it affects the percentage of butter fat recovery. The poor quality buttermilk arises from poor handling of the milk. Under conditions of hygienic milk production, handling and properly controlled processing, churning of fermented milk or cream can produce good quality buttermilk. The pleasant milk flavour and taste of buttermilk is a result of the comparatively low acidity, together with the better flavour and the low concentration of fat (Vandenberg, 1988).

2.3.4. “Ayib” making

In Ethiopia, smallholder milk processing is based on sour milk resulting from high ambient temperatures, while meeting consumers' preferences and improving keeping quality. “Ayib”, a traditional Ethiopian cottage cheese, is a popular milk product consumed by the various ethnic groups of the country. It is made from sour milk after the butter is removed by churning. Traditional “ayib” making has been described by FAO (1990) as follows. Milk for churning is accumulated in a clay pot over several days. This is kept in a warm place (about 30^0C) for 24 to 48 hours to sour spontaneously. Churning of the sour milk is carried out by slowly shaking the contents of the pot until the butter is separated. The butter is then removed from the churn and kneaded with water. The casein and some of the unrecovered fat in skim milk can be heat precipitated to a cottage cheese known as “ayib”. The defatted milk is heated to about 50^0C until a distinct curd forms. It is then allowed to cool gradually, and the curd is ladled out or filtered through a muslin cloth. The temperature varied between 40^0C and 70^0C without markedly affecting product composition and yield. Heat treatment does not appear to affect yield but gives the product a cooked flavor (Mogessie, 2006).

“Ayib” making time and temperature differences might have occurred because of the variation on cooking temperatures used for “Ayib”-making and on the decision made on the break point of adequate coagulation of casein. Some farmers used a higher intensity of fire that resulted in fast coagulation of casein, while others used a lower intensity that resulted in slow coagulation of casein (Fekadu and Abrahamsen, 1994). However, these differences may not have apparent effects on yield. Higher “Ayib”-making temperatures between 70^0C and 90^0C for instance were reported not to affect “Ayib” yield, but gave the product a cooked flavor (Mogessie, 1990). The speculation for the increased “Ayib” yield with time “Ayib” stay in the whey (TASW) could be that by letting the “Ayib” stay in the whey longer before separation, the temperature decreases and small particles of “Ayib” that were intermingled in the whey, will have enough time to precipitate and merge together increasing the yield.”Ayib” produced in different parts of Ethiopia generally has high

moisture content contributing to its poor keeping quality. Percent fat and protein contents are 1.9 and 14.6, respectively (ILCA, 1992).

2.3.5. Ghee making

Traditional ghee is made by evaporation of the water from butter by heating and melting of butter in an iron or clay container until bubbling ceases. The ghee is decanted into another container leaving the curd material in the pan. The consistence of this product is described as semisolid at room temperature. It could be stored for about 2.8 years without losing the quality desired by the local consumers (Yitaye *et al*., 2009).

3. MATERIAL AND METHODS

3.1. Description of study area

The study was carried out in Debre Libanos district North Shewa zone of the Oromia National Regional states. The district is located at 89 km North of Addis Ababa at an altitude ranging from 1500 to 2635 meters above sea level and has area coverage of 250 square kms with 46850 thousand human populations. The area is characterized by two rainy seasons, from February-May (short rainy season) and from June up to October (long rainy season) (Tittarelli, 1990). The average annual rainfall ranges between 800 mm and 1200 mm. Daily temperature ranges between 19^0C up to 23^0C (Debre Libanos District communication Bureau, 1999). The area is considered as high potential crop-livestock zones where dairy activities play a significant role in the livelihood of farmers in the area. Considering the potential of the area and the economic significance of dairy production to the local community, there have been repeated efforts by governmental and non-governmental aid organizations to improve the dairy productivity. This area has also better access to livestock development services (governmental and non-governmental) and milk

markets than other rural areas. Due to the above mentioned reasons and the economic capacity of the peasant‟s small-holder dairy production with crossbred dairy cattle is a common practice in the area. From a total of eleven “kebeles” of Debre Libanos district four “Kebeles”, namely Debre Tsige, Wakenne, Selle and Tumano were selected purposively for this study.

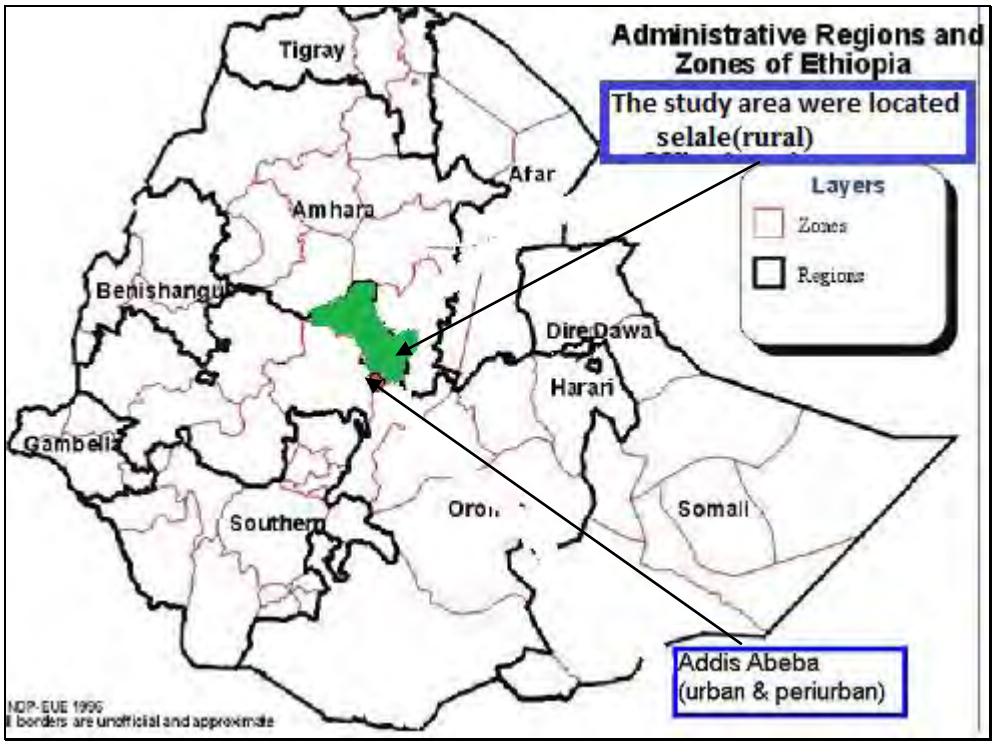

Figure 2. The map of Ethiopia showing the locations of the study areas

3.2. Study population

All smallholder farmers owning dairy cattle in the selected four “Kebeles” of Debre Libanos district constituted the study population. There are one dairy cooperative and five private milk collectors in the district. Dairy owners delivered milk to their nearest milk collection centers either to cooperative or to private milk collectors.

3.3. Study design

Cross sectional study was conducted from September, 2011 to March, 2012 by way of questionnaire survey and laboratory analysis of milk chemical composition and bacteriological quality.

3.3.1. Sample size determination and sampling method

The sample size was determined using the formula given by Arsham (2007).
$N=0.025/SE^2=100$

The Standard Error was computed at 10% confidence interval and at 95% confidence level that gave SE value of 0.05.

The total calculated sample size was 100. The number of smallholders owning milking cows in Debre Tsige, Wakenne, Selle and Tumano "Kebeles" were 150, 490, 260 and 250 respectively. Hence, using proportional sampling procedure 13, 42, 23 and 22 households were randomly selected from the four "Kebeles", respectively.

3.4. Data collection

Data were collected by using questionnaire survey, farm visit and laboratory analysis of milk samples.

3.4.1. Questionnaire survey

A structured questionnaire that has a type of mixed questions (i.e. technical and opinion pools) with open ended and closed types was prepared. The questionnaire was pretested and adjusted before full administration. The focus areas of the questionnaire was milking

and milk handling practices, milk handling utensils, hygienic quality and preservation method etc.

3.4.2. Farm visit

A one time farm inspection was carried out at the same time with the questionnaire interview. Activities carried out during the farm inspection encompass inspecting housing conditions, milking practices, and utensils in use, milk storage equipments, milker‟s sanitation and other activities regarding milk handling.

3.4.3. Milk sampling

Sixty five raw milk samples were taken for chemical composition tests from individual smallholders at the time of delivery to collection center at the morning time. Forty five and five milk samples were collected from four “Kebeles” individual farmers and milk tankers, at collection center respectively. All together, 115 milk samples were collected separately and aseptically. During sampling of raw milk from the udder, the surface of the teat end was cleaned by wiping it with clean cotton dipped in 70 % alcohol. Before sampling from bulk milk tank the milk was thoroughly mixed after which 25 ml of milk was transferred into sterile sampling bottles. All milk sample bottles were capped, labeled with a permanent marker and stored in an ice packed cool box and transported to Debre Zeit National Vaccine Institute (NVI) for bacteriological analysis. All the analyses were performed within 9 hours of sampling.

3.4.4. Laboratory Analysis

The milk quality assessment including preliminary quality tests, determination of major milk chemical composition, and analysis of bacterial loads of milk were conducted.

Preliminary quality test:

In order to evaluate the quality of milk, preliminary quality tests were undertaken. These include: milk specific gravity or milk density and alcohol tests.

Specific gravity: The specific gravity of milk samples from individual dairy owner‟s cans were taken while supplying milk to the milk collection centers. 50 ml milk sample was put in glass cylinder and the milk was mixed thoroughly and gently to avoid formation of air bubbles. The lactometer was read after it was inserted into the milk and left to float freely until it is at rest. Milk temperature was also read immediately. The milk density was calculated based on the results of the lactometer reading and milk temperature according to the formula described by O‟Connor (1994).

Specific gravity=(L/1000) + 1
Where, L: corrected lactometer reading at a given temperature. i.e., for every degree above 60^0F, 0.1 degree was added, but for every degree below 60^0 F, 0.1 degree was subtracted from the lactometer reading.

Alcohol test: The alcohol test of milk samples from individual dairy owner‟s cans were taken while supplying milk to the milk collection centers. Alcohol test was performed by putting equal volumes of milk and 75% alcohol in a test tube. The test tube was then inverted several times with the thumb held tightly over the open end of the tube. The tube was then examined to determine whether the milk has coagulated or not. If it has, fine particles of curd were visible (O‟Connor, 1994). Formation of curds indicates that the milk is not fresh, but has turned sour and is not suitable for pasteurization.
Chemical composition:

The major chemical composition of milk and milk products determined include: percent of fat, solids non fat, lactose, protein and water added. Milk compositions were determined using lactoscan milk analyzer.

Microbial Analysis:

Total plate count (TPC): Homogenized sample was serially diluted by adding 1ml into 9 ml of peptone water. For the determination of TPC, 1 ml of each dilution was transferred using sterile pipette and spreader on Triptic Soya Agar (DETROIT MICHIGAN, USA) having 45^0C -50^0C (10-15ml) using a sterile glass spreader for each sample and allowed to solidify for 15min. The plates were then kept in an incubator at 37^0C for 24-48 hours. Following incubation, plates exhibiting 30-300 colonies were counted. The average number of colonies in a particular dilution was multiplied by the dilution factor to obtain the TPC. The TPC was expressed as the number of organism of colony forming units per ml (CFU/ml) of samples according to ISO (1995).

Total coliform count (TCC): was determined by following similar method used for TPC except the agar. In case of TCC, MacConkey agar (OXOID LTD, BASINGSTORE, ENGLAND) was used. Following incubation, plates exhibiting 15-150 coliform colonies were counted. The average number of colonies in a particular dilution was multiplied by the dilution factor to obtain the TCC. The TCC was expressed as the number of organism of colony forming units per ml (CFU/ml) of samples according to ISO (1995).

Reading and interpretation results:

The number of organisms (CFU) per milliliter of milk was calculated using the following mathematical formula (IDF, 1987).

$N=\Sigma C / (1\times n_1+0.1\times n_2)\, d$

ΣC = Sum of all colonies on all plates counted

n_1 = Number of plates in the first dilution counted

n_2 = Number of plates in the second dilution counted

d = Dilution factor of the lowest dilution used

The results of microbial counts were transformed to logarithmic values (log 10)

3.4.5. Data entry and statistical analysis

Microsoft excel was employed for raw data entry, SPSS version 16 was used for the analysis. Descriptive statistics such as mean and percentage were used to compute some of the data. ANOVA test was used to show the difference of bacterial counts at the two collection points and to show the difference of bacterial counts under different milk handling factors. The difference was declared as significant when P-value is ($p \leq 0.05$).

4. RESULTS

4.1. Dairy cow's population

The population of cattle and dairy cows in the study area is shown in (Table 3).The mean of cattle population per household was 6.21, with a minimum and a maximum of 1 and 31 cattle, respectively, while the mean of dairy cows per households was 2.23 with a minimum of 1 and maximum of 12.

Table 3. Dairy cow"s population (N=100)

Variable	Minimum	Maximum	Mean	Standard Deviation
Number of cattle	1	1	6.21	3.5
Number of dairy cow	1	11	2.23	1.53

4.2. Source of livelihood

In the present investigation, 78 % of respondents reported the major farming activity in the area to be mixed farming. While the remaining 22 % of the respondents involved in other activities such as trader and civil servant. Cattle rearing are the most important component of the mixed farming system studied and provides draught power, milk, meat, fuel and income to the farmers.

4.2.1. Source and division of labor

The division of labor among family members with respect to cattle husbandry in the study area was showed in (Table 4). Family members were found to be the major source of labor in their farm activities. Cleaning shed (59.16%), Caring and suckling calves (42.2%), milking (63.82%), milk processing (60%) and selling of milk products (76.55%) are mainly

practiced by women. Moreover, breeding decision (66%), buying of cattle (67%) and selling of cattle (68.5%) were under taken mainly by men. Whereas children‟s (31.31%) under take herding activity.

Table 4. Division of labor among family members in the study area (N=100)

Activities	Responsible family members			
	Men (%)	Women (%)	Childrens (%)	Hired labor (%)
Herding	26.94	17.99	31.31	23.83
Cleaning shed	2.16	59.16	26.16	12.66
Caring and suckling calves	13.49	42.4	32.15	11.24
Feeding and watering of cattle	22.65	35.4	22.8	13.33
Milking	7.83	63.82	19.57	9.66
Milk processing	2.3	60	30.96	5.85
Selling milk products	2.4	76.55	16.85	3.6
Breeding decision	66	25.83	7.83	1
Purchasing cattle	67	21.5	10.5	1
Selling cattle	68.5	24.33	6.83	0.33

4.2.2. Feeding practices

The present study revealed that 47% and 39% of the respondents use grazing and stall feeding systems respectively, while the remaining 14 % of the respondents use both grazing and stall feeding. Although about 74.5 and 25.3% of the respondents reported to use roughage produced on farm and purchased, respectively. While all of the households practicing concentrate feeding use purchased concentrate. 80% and 20% of respondents reported that they use on farm produced and purchased crop residues, respectively (Table 5).

Table 5. Feeding practices

Variables			Percentage (%)
Feeding system	Grazing		47
	Stall feeding		39
	Both		14
Type of feed	Concentrate	Purchased	100
		Farm produced	-
	Roughage	Purchased	25.3
		Farm produced	74.5
	Crop residue	Purchased	20
		Farm produced	80

4.2.3. Watering

Source of water for dairy cows, distance travelled and frequency of watering during dry and wet season were showed in (Table 6). About 53% of the respondent‟s get water for their dairy cows from river followed by pipeline water. 52% of dairy farmers were watered their dairy cows at home. The majority 79 and 70% of the respondents provided water for their dairy cows twice a day during dry season and once a day during wet season, respectively.

Table 6. Source of water for dairy cows, distance travelled and frequency of watering (N=100)

Variables		Percentage (%)
Water source	River	53
	Well	9
	Pipeline	38
Distance travelled by	Watered at home	52
animals	<1km	5
	1-3km	36
	3-5km	4
	Watered at home and travelled <1km	3
Frequency of watering	Once a day	4
during dry season	Twice a day	79
	Three times a day	17
Frequency of watering	Once a day	70
during wet season	Once in a two days	30

4.2.4. Housing system

All the smallholders had some sort of housing for their animals. About (41%), (28%) and (31%) of the households had semi open, close and simple enclosure housing type, respectively (Table 7). The majority of the barns are constructed from grass/straw roof (61%), stone layer floor (52%) and mud plastered wall (83%). As observed during the farm visit about 42% of the barns were constructed to facilitate drainage of farm wastes and keep the animal space dry and there was no accumulation of manure on the space that the cows were lay down. While the remaining, about 58% of barns were not well drained and easy to clean.

Table 7. Housing type (N=100)

Variables		Percentage (%)
Housing type	Closed	28
	Semi open	41
	Simple enclosure	31
Floor type	Concrete layer	15
	Stone layer	52
	Earthen yard	33
Roof type	Corrugated iron sheet	31
	Grass(straw)	61
	Leaf and grass	8
Wall type	Plastered with mud	83
	Wood and iron sheet	15
	Wood and leaf	2

4.3. Hygienic practices followed during milk production

4.3.1. Hygiene of dairy cows

In the current study about 85% of the households reported to wash teat or udder before milking (Table 8). About 71.8, 21.2, 7.1% of the producers respectively used warm water, cold water and both cold and warm water alternatively, respectively for cleaning udder. The water sources used for cleaning purpose were river (53%) water followed by pipeline water (38%). There was no a trend on teat and hand drying before milking by most milk producers, only (42%) milk producers‟ exercise teat drying before milking however, majority(73.8%) respondents which practiced teat drying milkers used the same towel for all lactating cows. In contrary about 26.2% of dairy producers reported to use separate towel for each lactating cow. The proportion of producers that reported to use teat dip before milking accounts only 4% (Table 8).

Table 8. Hygiene of dairy cows (N=100)

Variables		Percentage (%)
Pre milking udder preparation	Udder wash	85
	Do not wash udder	15
Type of water used for udder washing	Warm water	71.8
	Cold water	21.2
	Both	7.1
Source of water	Pipeline water	38
	River water	53
	Well water	9
Use towel for drying udder	Yes	42
	No	58
How you towel for drying udder	Individual towel	26.2
	Communal towel	73.8
Use teat dips	Yes	4
	No	96

4.3.2. Hygiene of milkers

In the present study (Table 9), about 58% of the respondents reported to wash hands, while the remaining 42% of dairy producers reported not to wash hands. The majority (92%) of them use old clothes for milking practices. The proportion of that of dairy producers reported to use clean out garment during milking accounts only 8%.

Table 9. Hygiene of milkers (N=100)

Variables		Percentage (%)
Wash hand between cows	Yes	58
	No	42
Cloth used for milking	Own old cloth	92
	Clean out garment	8

4.3.3. Utensils in use by smallholders for milking and milk handling

About 94 and 5% of the respondents used plastic and stainless equipment respectively, (Table 10), While the remaining about 1% reported to use "chocho" for milking and about 47 and 48% of the respondent use plastic and clay pot respectively, as storage equipment(Table 10).

Table 10. Milking and storage utensils (N=100)

Variables		Percentage (%)
Milking equipment	Plastic	94
	Stainless	5
	"Chocho"	1
Storage equipment	Plastic	47
	Clay pot	48
	Stainless	3
	"Chocho"	2

The survey results showed that cleaning of milk handling equipment is common among most of the interviewees (Table 11), about 70% of the producers used warm water to wash milk handling equipment, while 27% of them cleaned with cold water and "araressa". Although about 45% of the producers fumigate milk handling equipments using *Olea Africana* stem.

Table 11. Sanitary practices for milk handling equipment used by the farmers (N=100)

Sanitary practices		Percentage (%)
Washing of milk handling equipment	With warm water	70
	With cold water	3
	With cold water and "araressa"	27
Smoking of milk handling containers	No smoking practices	55
	Use of *Olea Africana* stem	45

4.4. Milk processing

For smallholder dairy producers located along major road ways, there was an access to sell fresh whole milk. Most producers, therefore, supply their milk either to collection centers that belong to cooperatives or private collectors. In this study about 63% of respondent‟s process milk in to butter, cheese and yoghurt, but the major milk products (87.3%) are butter and cheese.

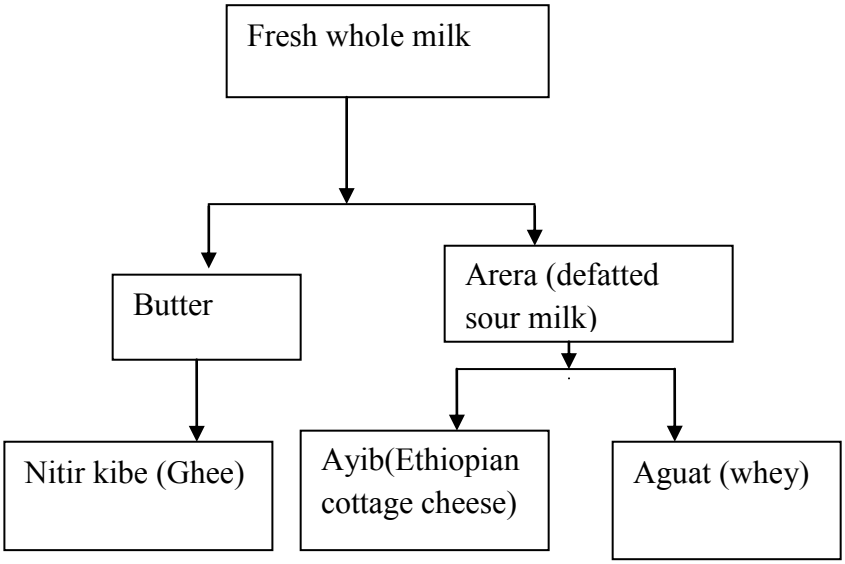

Figure 3. Flow diagram of milk processing in the Debre Libanos district

4.5. Milk marketing

In this study, about 87% of the respondent‟s reports to sell milk to different milk buyers, while the remaining about 13% of the respondents reported not to practice milk selling. About 67.8 and 29.9% of the participants reported to sell their milk to collection center and to private milk collectors, while the others 2.3% of the respondent sell to local market. The majority of the respondents reported to travel 1 up to 2 km to reach the market places

within 15 minute to 1 hour. About 97.7% and 78.2% of the respondents reported to sell with 6-7 birr per litter during dry season and less than 6 birr during wet seasons.

4.6. Preliminary test

4.6.1. Specific gravity and alcohol tests

The specific gravity values of milk were taken from the selected farms while they delivered milk to the milk collection centers. The values were in the range of 1.022 to 1.030. The specific gravity of normal ranges between 1.026 to 1.032 at 20^0C. Only about 36% of the samples in this study had specific gravity values generally within the acceptable range. To the contrary, (64 %) of the samples had values below 1.026, an indication of some adulteration by addition of water. However the milk collection centers were accepted 1.025 as normal parameters for specific gravity of milk. All most all milk samples were negative to the alcohol test at the milk collection centers

4.7. Chemical composition

The mean value for fat, lactose, SNF and protein contents of milk samples in the present study is given in (Table 12). Results from the analysis of variance indicated that adulterated and unadulterated milk samples significantly vary in percentage value of fat, lactose, SNF and protein ($p \leq 0.001$)

Table 12. Mean ± (SE) of chemical contents of raw milk of adulterated and unadulterated (N=65)

Variables	Unadulterated milk	Adulterated milk	Over all mean	p-value
Number of observation	10	55	65	
	Mean±SE	Mean±SE	Mean±SE	
Fat (%)	4.99±0.27a	3.74±0.10b	3.93±0.11	***
Lactose (%)	4.74±0.10a	4.02±0.05b	4.13±0.05	***
SNF (%)	8.64±0.18a	7.34±0.08b	7.54±0.09	***
Protein (%)	3.16±0.07a	2.66±0.03b	2.73±0.03	***

a,b means followed by different letters vary significantly

*** Significant at ($p \leq 0.001$)

4.8. Bacteriological analysis

Mean total bacterial counts and total coliform counts (expressed in log 10 cfu/ml) of raw milk sampled at two critical points are shown in (Table 13). The analysis of variance has revealed that TPC and TCC per ml of raw milk collected from bulk milk tank at collection center were significant higher ($p<0.001$) than udder milk samples. Accordingly, the total plate count and total coliform count increased by 2.67 and 2.41 log10cfu/ml, respectively, between farm (milk sampled directly from the udder) and bulk milk tank at collection center (Table13).

Table 13. Mean (± standard error) of Total plate counts (TPC) and Total Coliform count (TCC) of raw milk sample (log 10 cfu/ml) (N=50)

Variables	Udder milk		Bulk milk		P-value
	N	Mean±SE	N	Mean±SE	
Total plate count	45	3.61±0.06a	5	6.28±0.02b	***
Total coliform count	45	1.76±0.16a	5	4.17±0.28b	***

a,b means followed by different letters vary significantly

*** Significant at ($p \leq 0.001$)

Mean total bacterial counts and total coliform counts (expressed in log 10 cfu/ml) of raw milk sampled under different hygienic practices are shown in (Table 14) The analysis of variance has revealed that TPC per ml of raw milk collected from households that had less dairying experienced were significant higher ($p \leq 0.001$) than households that had well experienced in dairy farming practices and hand washing between milking tended to influence the TPC at 0.053%. On the other hand, all factors included did not significantly affect the TCC values (Table 14).

Table 14. Microorganism counts in udder milk for different milk handling factors (N=50)

Factor	Type	N	Microorganism count,log10 cfu/ml			
			TPC		TCC	
			Mean±SE	P-value	Mean±SE	P-value
Barn cleaning	Once at two day	1	4.31	NS	2.56	NS
frequency	Once a day	18	3.70±0.16		2.02±0.50	
	Twice a day	18	3.70±0.14		1.69±0.23	
	Three times a day	8	3.43±0.35		1.68±0.24	
Udder preparation	Lets calves suckle	10	3.63±0.07	NS	1.65±0.31	NS
	Udder or teat wash	35	3.53±0.13		1.79±0.19	
Wash hands between	Yes	25	3.47±0.72	0.053	1.71±0.22	NS
milking	No	20	3.72±0.97		1.80±0.23	
Use teat dip	Yes	3	3.59±0.66	NS	0.74±0.74	NS
	No	42	3.77±0.33		1.83±0.16	
Use towel	Yes	22	3.50±0.07	NS	1.56±0.26	NS
	No	23	3.72±0.10		1.95±0.18	
How you use towel	One to one	6	3.70±0.12	NS	1.31±0.62	NS
	Communal	16	3.78±0.21		1.66±0.28	
Milking area	In the barn	27	3.68±0.08	NS	1.80±0.20	NS
	In open air	18	3.50±0.09		1.69±0.26	
Dairying experience	<10 years	10	4.05±0.13a	***	2.00±0.27	NS
	10-20 years	18	3.57±0.09b		1.93±0.24	
	>20 years	17	3.38±0.06c		1.36±0.28	

a,b,c means followed by different letters vary significantly*** Significant at ($p \leq 0.001$), NS means non significant

5. DISCUSSION

The results of this study showed that the mean of cattle population per household was 6.21, with a minimum and a maximum of 1 and 31 cattle, respectively, while the mean of dairy cows per households was 2.23 with a minimum of 1 and maximum of 12.The major farming activity in the study area was crop production followed by cattle rearing. Cattle are the most important component of the mixed-farming system in the study area since they provide draught power, milk, meat and income to the farmers. These functions were reported by Yitaye *et al.* (2001) in southern Ethiopia. The major purpose of keeping cattle in the study area was to provide draught power followed by milk production. Cows provide the only source of milk whereas milk from small ruminants is not consumed in the area because of cultural taboo

Moreover, the source of labour for dairy production was from family member and hired labor. Milking operation is done mainly by women. Rahel (2008) and Ayantu (2006) also reported a similar situation. Sintayehu et al. (2008) also indicated that in 60% of the cases housewives and/or other female household members were involved in milking operations in urban dairy production system of Shashemene and Dilla. But it is contrary to the findings of Adebabay (2009) who found that milking is primarily undertaking by men in Bure district. Selling and purchasing of animals and breeding decisions are undertaken mainly by men. Herding of cattle is the responsibility of children and hired labor. This result showed that women have more responsibility at home and not equally participate in the decision of household affairs i.e. decisions are made solely by male.

The result of this study showed that, all of the smallholders had an experience of housing dairy cows. The majority of the households had close and semi open housing type and most of the barns are made of grass/straw roof, stone layer floor and wood and soil wall. As observed during the farm visit 42% of the barns had well drained and easy to clean. In contrary, the remaining 58% barns were not well drained. Since housed and well built barns

can drain easily, it has positive correlation with overall hygienic conditions of a given milking environment rendering the production of better quality milk (Zelalem, 2006). However, the barns owned by about 58% of the respondents were observed to be not well drained and difficult to clean, which leads to poor quality milk production. It is therefore important that producers consider appropriate drainage condition of the milking environment as an integral part of production hygiene to ensure the supply of safe and good quality milk. It is also essential to implement a regular barn cleaning scheme.

Furthermore, most of dairy farm owners in the current study, washed their dairy cow‟s udder with warm water before milking, but, they did not perform the cleaning sufficiently and do not dry it property. It was reported by Depiazzi and Bell (2002) that pre-milking udder preparation and teat sanitation play important part in the microbial loads of milk, infection with mastitis, and environmental contamination of raw milk during milking. The majority (73.8%) of the dairy owners used a single towel for all cows commonly to dry the udder. The reuse of towel for cleaning and sanitizing may result in recontamination of the udder**.** Since drying was not or insufficiently practiced, contamination level of milk was becoming higher (Alehegne, 2004). On the other hand about 15% and 58% of dairy producers not wash and dried the teat or udder, respectively. Wet teats allow skin and environmental bacteria to have easy access into mammary gland (Ruegg, 2006). Since drying was not practiced by the majority of milk producers, contamination level of the milk can be high.

Personal hygiene of milkers and health condition can contribute as source of milk contamination. The result of present study indicates that, 58% of milkers washed their hands at the beginning of milking and repeat washing between milking but did not dry their hands. In an earlier study, Zelalem (2010) reported that about 94 and 96% of the respondents reported to wash their hands before milking their local and crossbred cows, respectively. The majority of the respondent‟s not having a separate cloth for milking activity. Rather they use old clothes commonly used for other farm activities like for barn cleaning. Such practices can increase the risk of milk contamination. Therefore, milkers in

addition to keeping good personal hygiene should be in good health during milk operation. Covering hair and dressing gown during milking and handling of milk was also an important practice milkers need to obey.

Selecting appropriate handling equipment and proper cleaning of equipment used for milking, storage, processing and further handling of milk and milk products are essential to keep microbial contamination of the products to a minimum. The result of this study showed that 94% of the respondents used plastic equipment for milking. Similar finding was reported by Sintayehu, *et al*., (2008) the majority (92%) of urban producers used plastic milk utensils. This figure is higher than earlier reported of Zelalem (2010). This might be due to economical difference and commercial availability of plastic utensils in the study area. It was reported by Ashenafi and Beyene (1994) during milking, the major source of bacteria in milk is the milk contact surfaces of milking equipment and milk cans or bulk tanks. The results of current study revealed that most of the dairy cow owners used warm water for cleaning of milking equipments. While, fewer practices cleaning of milking equipment using plants. In addition none of the owners disinfect the milking equipment. However, about 10% of the number of bacteria found in milk can be reduced by cleaning and disinfecting of milking equipment (Murphy, 1996). Smoking milk handling equipment using burning stems of *Olea africana* used to be a common practice in all parts of study area particularly in those farmers processing milk to different by products.

Milk, at its normal state, has unique physico-chemical properties, which are used as quality indicators. The density of milk, among others, is commonly used for quality test mainly to check for the addition of water to milk or removal of cream. The majority of raw milk samples specific gravity recorded in the current study area were lower than the normal ranges of 1.026-1.032 which suggest that the milk analyzed were adulterated by addition of water. O‟‟Connor (1994) indicated a higher milk specific gravity of about 1.035 and lower than normal value (1.020) is indicative of fat skimming off and the addition of water respectively. The majority of raw milk samples checked for alcohol test were negative. This suggests that milk intended to the collection center were fresh.

The proteins and fats are important milk components, for the production of butter, cheese and further processing of milk to different by products. In the current study the mean percentage of fat, lactose, solid-non-fat and protein contents were 3.93, 4.13, 7.54 and 2.73 respectively. The percentage total solids and lactose content of the milk from the current study was within the acceptable standard ranges of 10.5-14.5% and 3.6-5.5% respectively, (O‟Connor, 1994). The percentage of fat content were within the acceptable standard ranges of <3.25% (Food and Drug Administration (FDA)). The results of the chemical composition (fat, total solid lactose) therefore, imply that the cattle were mature, and were not underfed. On the other hand the SNF and protein contents of milk in the study area were below the acceptable standard range of 8.25% (FDA) and 2.9%-5% O‟ Connor (1994). The lower percentage of protein content in the current study might be the milk was collected and analyzed during the late lactation. The milk must have been collected and analyzed during the early lactation periods accounting for the standard protein content (O‟ Mahoney, 1988). It have been reported by O‟ Connor, (1994) the fat and SNF contents of milk can be reduced by diseases particularly mastitis and underfeeding.

Milk adulteration was commonly practiced in the present study area. The mean percentage of fat density, lactose, solids non fat and protein contents recorded in adulterated milk indicating improper handling of milk. The result of analysis of variance indicates there was high significant difference ($p \leq 0.001$) between unadulterated and adulterated milk. Adulteration of milk with water therefore reduces nutritional and processing quality, palatability as well as marketing value of milk (Swai and Schoonman, 2011). This may also introduce microbial contaminants to the milk if it is unclean water.

The total plate counts observed in the current study had low rate of increase as compared to that of Godafaye and Molla (2000); Haile *et al*. (2012) from point of production to arrival at collection center (selling point) 3.0 log 10 cfu/ml reports.

In case of udder milk samples lower mean value of TPC were found as compared to that of Alehegh (2004) for milk samples collected in small holder dairy farmers in Debre Zeit,

Ethiopia, Haile, *et al.* (2012) for milk sample collected from different farm size in Hawasa reports. The present TPC (3.61 log cfu/ml) ranges within the reported mean by Mogessie and Fekadu (1993) for udder milk samples (3 to 4 log 10 cfu/ml) of Awassa College of Agriculture dairy farm, Ethiopia.

In addition, total bacteria counts of raw milk obtained from collection center are lower than that of Francesconi (2006) for raw milk sampled from most of the dairy cooperatives operating in the Ethiopia, Assaminew and Eyassu (2011) for raw milk collected from farmers and dairy cooperatives in Bahir Dar zuria and Mecha district, Alehegh (2004) for milk samples collected in smallholder dairy farmers in Debre Zeit, Ethiopia, Godafey and Molla, (2000) for milk samples from selected dairy farms in Addis Ababa, Ethiopia and Haile *et al*. (2012) for raw milk produced under different farm size in Hawassa, southern Ethiopia.

Legal and voluntary bacteriological standards vary widely from country to country and there are different standards for different groups and species of microorganism‟s specific to specific products. Standard plate count (SPC) values for raw milk can range from <1000 cfu/ml, where contamination during production is minimal, to >1 x 10^5 cfu/ml. Consequently, high initial SPC values (>10^5 cfu/ml) are evidence of serious hygienic problem during production, likewise SPC values of <2x10^4 cfu/ml reflect good sanitary practices (IDF, 1994).The results of this study showed that 100% of TPC from udder milk sample were acceptable value of 10^5 cfu/ml for milk in most European counties (IFCN, 2006). In contrary all of raw milk sample from collection center had higher TPC than the international acceptable standard.

Such differences might be attributed to the differences in the hygienic conditions such as the quality of cleaning water, milking containers, personnel hygiene followed by the various producers. Higher counts suggest that the milk has been contaminated by bacteria from different possible sources. This may be due the contribution of insufficient pre-milking udder preparation, insufficient cleaning of milk handling equipments, and the use

of poor quality water for cleaning without heat treatment, the storage time and lack of cold chain facility starting from the production site to the selling points. As reported by Van Kessel *et al*. (2004), the use of insufficient and poor quality water for cleaning of milk handling equipments can result in milk residues on equipment surfaces that provide nutrients for the growth and multiplication of bacteria that can then contaminate the milk (Haile *et al*., 2012). The lower value obtained in current study may be due to better handling of milk as well as animal health and differences in farm condition.

In the current study low rate of increase in coliform count were found as compared to that of Halie *et al*. (2012) for milk samples collected from point of production to arrival at collection center (selling point) reports. TCC of samples collected from udder (1.76 log 10 cfu/ml) were however, lower than reported of Alehegn (2004) for milk samples collected in small holder dairy farmers in Debre Zeit, Ethiopia, Haile *et al*. (2012) raw milk produced under different farm size in Hawassa, Southern Ethiopia. Whereas the current result (1.76 log 10 cfu/ml) were higher than reported of Mogessie and Fekadu (1993). For the udder collected milk samples (1.0 log 10 cfu/ml from dairy farmer in Awassa, Ethiopia.

Coliform count provides an indication of unsanitary production practices and/or mastitis infection. A count less than 100 Colony Forming Units (CFU)/ml are considered acceptable for milk intended to be pasteurized before consumption. Counts of 10 CFU/ml or less are achievable and desirable if raw milk will be consumed directly (Ruegg, 2003).

When the mean TCC of the raw milk at collection center obtained in this study was compared with previous reports, the TCC was lower than that of Alehegh (2004); Assaminew and Eyassu (2011); Haile *et al.* (2012). The lower values found in this study for TCC as compared to the previous reports were attributed to cumulative results of milk handling improvement at farm as well as at milk collection center. Even if, milk in the current study had better quality as compared to milk in other part of the country, 31.1 and 100% of raw milk samples observed for TCC from udder and collection center were found higher than international standards of the upper limit for coliform counts ($1.5x10^2$). The

presence of coliforms in milk confirms that the milk has been contaminated with fecal materials and it is an indicator of the inappropriate sanitary conditions in the production and handling of the milk starting from the production site to the collection point (selling points). Accordingly, poor herd/farm hygiene, use of contaminated water, unsanitary milking practices, and use of improperly washed equipment for storage and distribution can all lead to elevated coliform count (CC) in raw milk (Haile *et al*., 2012).

Dirty stall was associated with elevated PIC, which could be attributed to contamination from the exterior of the udder and teats by bacteria from the cows‟ environment (Jayarao *et al*., 2004). The current study results showed that lower mean of TPC and TCC in those households who practice barn cleaning three times per day. This confirms that barn cleaning frequency had an effect on TPC and TCC, because, as the barn cleaning frequency increase the cleanness also high and this can reduce the microbial contamination.

Dirty teats and udders are considered one of the main sources of environmental bacteria in milk. Between milking, the teats and udder often become soiled with manure and bedding materials. If the teats were not thoroughly cleaned and dried before milking, this dirt with the associated microorganisms will be transferred into the milk (Chambers, 2002). Contamination from the exterior of the udder and teats can contribute microorganisms from the cow environment such as streptococci, staphylococci, spore-formers, coliforms, and other gram-negative bacteria, which in turn can elevate TAC, and CC (Murphy, 1997). In present study higher mean of TPC and TCC were found in households who let calves suckle than households who wash teat or udder before milking. Milking heavily soiled cows could potentially result in microbial contamination of milk during milking activities.

Several studies have investigated pre milking udder hygiene techniques in relation to the bacteria count of milk. Thorough cleaning of the teat with a sanitizing solution (predip) followed by thorough drying with a clean towel is effective in reducing the numbers of bacteria in milk contributed from soiled teats. In the current study households who use one to one towel achieve lower mean value of TPC and TCC as compared to those households

who use communal towel. The reuse of towel for cleaning and sanitizing may result in recontamination of the udder (Alehegh, 2004). Since, drying was not or in sufficiently practiced; contamination level of milk was becoming higher. The result of this study showed that the mean value of TPC and TCC were found higher in those households who do not use teat dips than households who use teat dips. Dipping of teat before and after milk plays an important role in reduction of microbial contamination of milk. Jayarao *et al*. (2004) reported a reduction in environmental mastitis pathogens and psychrotrophic and thermoduric bacteria with the use of teat pre dipping.

Equipment used for milking, processing and storage determine the quality of milk and milk products. Therefore, producers should pay particular attention for the type as well as cleanliness of milk equipment. Milking equipment should be easy to clean. Aluminum and stainless steel equipment are mostly preferred. Handling of milk into different plastic containers and sieves may cause the contamination of milk higher, since as the number of plastic containers and sieves increased the chance of contamination is also increased and most plastic containers have characteristics that make them unsuitable for milk handling. Since plastic containers scratch easily and provide hiding places for bacteria during cleaning and sanitization and plastic containers are poor conductor of heat and hence will hinder effective sanitization by heat (Shalo, 1990; Alehegn, 2004). In current study the majority households use both plastic and clay pot for milking and storage and use warm water for sanitation purpose. Those households who use stainless had lower mean of TPC and TCC than those households use plastics, clay pot and “chocho” as milking utensils. This might be stainless stills are easy to clean and well cleaned utensils had no milk residue for microbial multiplication.

Although the air of the milking environment rarely contributes a significant number of the total microbial count of milk, extremely dusty conditions may increase the counts. Polluted water may also cause entry of pathogens into milk (Gudeta, 1987; DeGraaf *et al.,* 1997). The soils, while the cows are in pasture, manure, the animal coats, tails etc. are some of the possible sources of contamination of milk (Teka, 1997). The mean value of TPC and TCC

were found higher in this study on dairy producers‟ milk their dairy cows in the barn. This might be results from the high risk of milk contamination from dung and other dirty materials in the barn. Separate milking parlors were not available in the studied farms which could increase the risk of contamination of milk by microbes of fecal and environmental origin (Chaye *et al*., 2004). Furthermore, there was significance difference in total plate counts ($p \leq 0.001$) between experienced and less experienced farms. This might be experienced dairy farmers had more awareness on milk handling due they trained more on milk handling and other farm activities. This might encourage dairy producers to investigate on milk quality.

6. CONCLUSION AND RECOMMENDATIONS

The chemical composition of milk analyzed in Debre Libanos district, were unacceptable and not comparable to the international standards (FDA) in its solid non fat and protein contents. Majority of raw milk samples analyzed for chemical composition were adulterated. Adding water to the milk affects not only the chemical composition but also the rout for microbial entry to the milk with water and can reduce the quality of milk.

Bacteriological analysis results from the two sampling points showed that high contamination of milk as it goes from the first moment milk let the udder to the collection centers. The difference between TPC and TCC at the two sampling points indicates numerous sources of milk bacterial contamination as milk goes from point of production to the collection center or point of selling. The milk is generally exposed to different contaminants when it transferred from one container to another.

All of raw milk samples from collection centers and 31.1% of milk samples from udder had high TCC of unacceptable level compared to international standards and EU requirements. The TPC of milk samples from collection centers had also the same unacceptable level. Whereas, the TPC of milk samples from udder had acceptable level to international standard. Milking hygiene conditions were found positively associated with microbial load of udder milk samples.

Based on the above conclusion the following points are recommended:

- Dairy producers should be provided/supported with training/extension service on the importance of keeping barns clean, proper pre-milking udder preparation, personal hygiene, use of hygienic milk handling equipments and use of clean water for good quality milk production.
- There should be an incentive mechanism to encourage farmers to produce quality milk, like introducing bonus payment for producers with quality product.
- Milk collection centres‟ should be equipped with cold chain and the necessary equipments and quality water to avoid/minimize milk contamination.
- Establishing milk processing plants around high milk producing areas, could contribute towards reducing further contamination of milk due to time elapsed during transportation.

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8. ANNEXES

Annex 1: Questionnaires format

Région_____ Zone_____Distric _____

PA _____Village _____Date_____

1.1. When did you start dairy farming practices?_____

I. Livestock herd size and composition: Completed after observation.

Type	Number	Blood level				Age	Origin
		25-50	50-75	>75	Unknown		
Local cows							
Crossbred cows							
Local oxen							
Crossbred oxen							
Local heifers							
Crossbred heifers							
Local bulls							
Crossbred bulls							
Local calves							
Crossbred calves							

1.2 Indicate members of household responsible for livestock management in this year

II Rank the responsibility of the household for the following activities

Dairy activities	Husband	wife	Sons	Daughter	Hired labor
Herding					
Cleaning sheds					
Caring for suckling calves					
Feeding and watering of cattle					
Milking					
Milk processing					
Selling milk products					
Breeding Decisions					
Purchasing cattle					
Selling cattle					
Others (specify)					

III. Feeding management of animals

1. Feeding System: a) Grazing b) Stall feeding c) Both

2 Roughage: a) Farm produced b) Purchased c) Both

3. Concentrate: a) Farm produced b) Purchased c) Both

4. Crop residues a) Farm produced b) Purchased c) Both

IV. Watering Management

1. What are the sources of water to your animals?

a) River b) Pond c) Well d) Pipe water e) Other (specify)

2. What is the average distance travelled by livestock to the water point?

a) Watered at home b) < 1km c) 1-3km d) 3-5km e) >5km

3. How frequently cattle are watered during dry season?

a) Once a day b) Twice a day c) Adlabitum d) Once two days e) Once three days f) other (specify) ----------

4. How frequently cattle are watered during wet season?

a) Once in a day b) Twice in a day c) Ad libitum d) Once in two days e) Once in three days f) other (specify)

5. How many times do you wash your milking cows? a) Once a week b) twice a week c) once at two weeks interval d) once a month e) no wash at all

V. Barn facilities and ease for cleaning

1. Do you have an experience of housing your dairy animals? a) Yes b) No

2. If yes, what type of housing system?

a) Communal with the people b) Isolated c) Simple fenced area (beret)

3. Barn cleaning frequency

a). One times a day b) Two times a day c). Three times a day d). Other specify

VI. Milking practices

1. What is the source of the water used for washing the udder and milk utensils? a) Cold tap water b) River c) Well d) Warm water e) Others (Specify)

2. Do you heat-treat/warm tap water before using it for cleaning? a) Yes b) No

3. When the water source is other than tap, what treatment measures are taken before using the water for cleaning? a) Boiling b) Filtering c) Chemicals (indicate) d) No treatment e) others (specify)

4. How frequent do you milk your cows per day? a) Once b) twice c) three times d) others (specify)

5. Pre- milking udder preparation and hygiene

a) Wash milking equipments b) Let calf suckle and milk. c) Wash hands d) cleaning flanks e) Udder or teats washing

6. Where are cows milked?

a). In the barn b) outside in the open air c) in a separate milking parlour

7. Are hands washed between cows? a) Yes b) No

8. Wash the teats a). Yes b). No

9. Do you use teat dips a). Yes b). No

10. Do you use towel? a) Yes b) No

11 if yes how? a) One for one cow b) Communal

12. If yes, when a) Pre-milking b) Post-milking c) Both

13. Commonly used teat dip products_____

14. What kind of equipment do you use for milking? _____

15. What kind of equipment do you use for storage/ fermentation? _____

16. How many times milk is transferred from one equipment to another at farm level____

17. Do you encounter problem of udder infection? a) Yes b) No

18. If yes, how frequent per year? a) Once b) Twice c) Three times d) Others (specify)

19. What measure was taken to correct this? a) Tradition treatment b) Veterinary service c) Both d) Others (Specify):_____

VII. Milk processing and conservation/storage practices

1. Do you process your milk? a. Yes b. No

2. What are the common processed products? A). Butter b). Cheese c). Yoghurt (*Ergo*) d). Butter milk (*Arera*) e). Cream f). Skim milk g). Whey (*Aguat*) h). Others (Specify)

4. Do you practice smoking milking equipment a). Yes b). No

5. If yes herbs/ plants/ used for smoking? _____

6. Why do you use these plants?

a). Give good flavor and aroma, b). Increase the shelf life of the milk c). Facilitate fermentation d). It just a tradition e). Other (Specify) _____

7. Mastitis cows are milked a) At first b) At last c) Any position

8. Do you practice milk selling? a) Yes b) No

9. If yes where do you sell milk? a) To local market b) To milk collection center c) renting to individuals d) others (specify) _____

10. how far is the market place (milk collection center) and how long does it take to arrive there? Distance in km ----------time.min ----------

11. Do you process milk at farm? a). Yes b). No

12. If yes to which products?

a). Butter b). Cheese c). Yogurt d). Others (specify)_____

13. What is the price per litre/kg of whole milk during dry season----------birr/litter, wet season ----------birr/litter?

14. What is the price per kg of butter during dry season----------birr, wet season----------birr?

15. What is the price per kg of cheese during dry season----------birr, Wet season ----------birr?

Farm visit

Farm owner‟s name

Sex

Woreda

Housing condition

Housing type close, semi open simple enclosure

Floor - concrete cement stone layer earthen yard

Roof corrugated iron sheet grass (straw) other materials

Wall material used

Bedding materials:

Ventilation good poor

Cleanness good poor

Space per animal adequate not adequate

Feeding and watering troughs Space adequacy, cleanness,

Milking equipment inspection

Utensils used for milking, milk storage milk processing

Cleanness of the milking equipment good poor

Water source and quality (water used at farm for different hygienic purposes)

Manure disposal system

Well drained

Not well draiened

Milkers clothing clean out garment, own clothes

9. DECLARATION

I the undersigned, declare that the thesis is my original work and has not been presented for a degree in any University and that all source of material used for the thesis have been duly acknowledged.

Name: Mezgeb Workiye Signature:_____

Place: Addis Ababa University, Debre Zeit, Ethiopia

Date of submission

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

Dr.Mekonnen H/mariam:_____

Dr.Girma Zewde:_____