PRODUCTION PRACTICES, CHEMICAL COMPOSITION AND MICROBIAL QUALITY OF RAW COW MILK PRODUCED BY SMALL HOLDER DAIRY FARMERS IN DALE DISTRICT, SIDAMA NATIONAL REGIONAL STATE, ETHIOPIA.

MSc THESIS

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ADVISOR: FIREW KASSA (PHD)

A THESIS SUBMITTED TO THE SCHOOL OF ANIMAL AND RANGE SCIENCES

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DEDICATION

I dedicate this work to my beloved and respected family members, especially my mother Yenewb Ayenew, my father Lamesgin Waga, and my brother and sisters, for their love, support, and partnership in making my life successful.

STATEMENT OF THE AUTHOR

By signing below, I declare that this thesis is an original work of mine. I have adhered to all ethical and technical research standards while organizing, collecting, evaluating, and compiling the information presented here. All scholarly references cited in this thesis have been cited accurately. This thesis is submitted as part of the requirements for the M.Sc. degree in Dairy Sciences and Technology at Hawassa University and will be stored in the university library, accessible to borrowers under its guidelines. I declare under oath that this thesis has not been submitted to any other institution for any academic degree, diploma, or certificate. Short excerpts from this thesis may be used without special permission, as long as proper and full attribution to the source is provided.

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BIOGRAPHICAL SKETCH

The author was born on January 24, 1988Ec, from her father Lamesgin Waga and her mother Yenewb Ayenew in East Gojjam Zone, Aneded district. She attended her elementary education at Genetua Elementary School. She also attended her senior secondary school at Yesenbet and preparatory school at Debre Markos in East gojjiam zone. After she completed her primary and secondary school studies, she joined Dilla University College of Agriculture in 2010 and graduated with a B.Sc. degree in Animal and Range Sciences in 2013 Ec. After graduation, she was recruited to serve Dilla University as a Graduate Assistant. Then she worked for Dilla University starting from 2013 as a Graduate Assistant until she was enrolled in the Master's program of Hawassa University in 2015 to pursue her M.Sc. degree studies in Dairy Sciences and Technology.

LIST OF ABRVATIONS AND ACRONYMS

AOAC	Association of Official Analytical Chemists
CC	Coliform Counts
CFU	Colony Forming Units
CSA	Central Statistical Agency
ESA	Ethiopian Standard Agency
GDP	Gross Domestic Product
GLM	General Linear Model
HACCP	Hazard Analysis and Critical Control Point
HH	Household
SNF	Solids- Not- Fat
SNV	Stichting Nedderlandse vrjiwilligers (Foundation of Netherlands volunteers)
SPC	Standard Plate Counts
SPSS	Statistical Package for the Social Sciences
SAS	Statistical Analysis System
TBC	Total bacteria count

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ABSTRACT

This study was carried out in Dale district to assess milk production practices, chemical composition, and microbial quality of raw cow milk from smallholder farms in both rural and urban areas. A mix of purposive and random sampling was used to select four kebeles. A total of 185 randomly selected farmers were interviewed using semi-structured questionnaires and key informant interviews. Sixty milk samples were collected from unidentified cross-bred cows for laboratory analysis. Descriptive statistics were used to analyze the data.Most dairy producers (89.2%) were male. In rural areas, 73.1% raised local breeds, while in urban areas, 29.4% did so. Artificial Insemination (AI) was the preferred breeding method for 49.9% of farmers. Daily milk yield was 1.91±0.61 liters (rural) and 2.27±0.63 liters (urban) for local breeds, and 5.29±0.72 liters (rural) and 7.17±0.82 liters (urban) for cross-breeds.The overall lactation periode of local breed cow 55.1%were 7-8 month while,Lactation periods of cross-breeds cows48.6% were9-11 months, About 63.2% kept cattle in separate barns. Most rural barns had muddy floors (81.1%), while urban barns used concrete (62.7%). Bedding was mostly absent (77.8%). Nearly all rural farmers (97.8%) used manure as fertilizer, whereas urban farmers disposed of it. Barn cleaning was done once daily in rural (73.1%) and twice daily in urban areas (80.4%).All farmers practiced hand milking, and 89.2% milked twice daily. Rural farmers mostly stored milk in cool places, while urban farmers sold it immediately. Plastic containers were commonly used for milking (68.6%) and transport (65.4%). Almost all respondents cleaned milk equipment (98.9%) with hot and cold water. Most used Olea Africana smoke to clean containers (96.8%). However, 53.7% of rural farmers did not wash the udder before milking, compared to 74.5% of urban farmers who did. Only 45.5% used individual towels. Key issues affecting milk quality were lack of awareness, poor hygiene, no clean water, and absence of milk cooling systems.The average fat, protein, total solids, solids-not-fat, and lactose contents in rural milk samples were 4.30±0.42, 3.07±0.12, 12.81±0.80, 8.51±0.91, and 4.19±0.32, respectively. In urban areas, the values were 3.90±0.43, 3.04±0.28, 13.33±0.71, 8.43±0.80, and 4.25±0.29, respectively. The overall average values were 4.06±0.47 (fat), 3.09±0.18 (protein), 12.53±0.77 (total solids), 8.46±0.84 (solids-not-fat), and 4.23±0.30 (lactose). There were significant differences ($P<0.05$) in fat and total solids between rural and urban areas. Regarding microbial quality, total bacterial, coliform, yeast, and mold counts were 7.03±0.28, 4.75±0.20, and 4.63±0.15 log cfu/mL in rural areas, and 6.79±0.19, 4.63±0.13, and 4.54±0.08 log cfu/mL in urban areas, respectively. The overall averages were 6.88±0.25 (total bacteria), 4.68±0.17 (coliform), and 4.58±0.08 (yeast and mold) log cfu/mL. These values showed significant differences between rural and urban milk samples. In conclusion, the study found that raw cow milk in the area were often contaminated and did not meet the Ethiopian quality standards. Therefore, it is recommended that awareness be raised among smallholder dairy farmers about proper milk production methods, hygiene practices, and quality control systems.

Key words: Chemical composition, microbial quality, milk handling,milk,production practice

1. INTRODUCTION

1.1.Background of The Study

Livestock contributes 16.5 percent of Ethiopian GDP and 40 percent of its agricultural GDP. According to CSA (2021), Ethiopia has 70 million cattle, of which about 56 percent are female. An estimated 7.5 million dairy cows produce about 4.69 billion liters of milk annually. However, about 98% of the nation's yearly milk production comes from the traditional system, which is dominated by native breeds with little genetic potential for milk production (Habtamu *et al*., 2018).

In Ethiopia, dairy farming is an important subsector of the agricultural production system (Leta and Mesele, 2014). Dairy farming gives smallholder farmers the chance to use resources like land, labor, and feed more effectively while also producing a steady income (Sintayehu *et al*.,2008). The natural product known as milk is derived from the secretions of nursing mammals' mammary glands. In every country, milk and its derivatives are vital to human nutrition (Pandey,2011).

According to Abebe (2014), milk is regarded as the most ideal nourishment nature has given humanity. It supplies nutrition to people of any age group. The milk has Macro and micronutrients of lipids, proteins, carbs, vitamins, minerals, and active chemicals that contribute to health protection. Because it contains all of the necessary elements, milk is widely accepted as a complete diet (Amentie *et al*., 2016). It has a complex biochemical composition and high water activity (Kuma, 2015). As raw milk has a high nutritional content, it might harbor microorganisms that deteriorate its quality (Claeys *et al*., 2013). Therefore, the products need to be of the highest hygienic quality.

Quality is a critical factor in the production of sanitary products, especially for consumer safety, due to the microbiological and chemical properties of milks in its natural state (Pandey, 2011). The quality of raw cow milk is therefore determined by its microbial load. When humans consume milk contaminated by microorganisms, they develop foodborne illnesses (Fadaei, 2014). Due to traditional milk production methods that lack proper sanitary control, milk produced in poor nations like Ethiopia, particularly in the lowland region, is at significant risk of becoming contaminated with pathogenic and spoiling bacteria (Amentie *et al*., 2016). Due to customer demands for safe, high-quality milk, dairy producers, dealers, and manufacturers now bear a significant obligation to produce and market safe milk and milk products (Hawaz & Hailu, 2015). Adverse environmental conditions are highly affecting the quality of milk and milk products (Toghdory *et al*., 2022). Where the climate is hot and humid, the raw milk is 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 a lack of the required dairy infrastructure (Gemechu *et al*., 2015). The microbial and chemical composition of milk and milk products varies depending on the season of the year, agroecology, hygienic practices exercised, processing, and storage conditions (Yilma, 2012).Dairy Production in Ethiopia has one of the largest livestock populations in Africa, including over 11 million dairy cows. The dairy industry contributes to food security, income generation, and employment. Most milk is produced by smallholder farmers, with an estimated 85% of milk entering informal markets where it is sold directly to consumers without quality control measures (FAO & ILRI, 2019).Ethiopian dairy cows currently produce an average of 1.9 liters of milk per day for native breeds and 7.3 to 11.7 liters per cow for crossbreds, depending on environmental conditions and management techniques(Tatek *et al*., 2017). In Ethiopia, crossbred dairy cows have lactation periods ranging from 298 to 374 days under on-station settings, with a milk output ranging from 1,293 to 2,957 liters. Breed, management, and environmental factors all have an impact on the somewhat lower yields and shorter lactation periods reported on farms (Beneberu, 2023a).

Sidama's dairy tradition is deeply woven into its agricultural and cultural fabric. Cattle farming has long been a cornerstone of livelihoods in the region, providing essential dairy products that complement the Enset-based diet. Enset, a staple food known for its resilience and versatility, pairs well with milk, butter, and fat-extracted sour milk, sustaining communities in the Southern Region. Beyond nutrition, dairy production holds economic and social significance, shaping local markets and traditions (Kassu 2016).

Dairy production, particularly from cattle, plays a vital role in the Sidama National Regional State, where milk and its derivatives such as butter and fat-extracted sour milk are fundamental components of the Enset-based diet. Enset, often referred to as the "tree against hunger," serves as a staple food in the Southern Region, complementing dairy products in traditional meals(Samson et al., 2021).

Dairy farming in the Dale District, Sidama National Regional State, Ethiopia, is a crucial component of smallholder livelihoods. The sector operates within a mixed farming system, where dairy cattle are raised alongside crop cultivation. Farmers primarily rely on natural pasture and crop residues as feed sources, maintaining traditional practices. Rivers serve as the primary water source for livestock, and cattle are housed in traditional barns, reflecting the region’s long-standing dairy management approaches (Somano, 2014). Several researchers have studied on dairy production,processing and marketing and also production and reproduction performances of dairy cattle in the Dale District (sintayehu et al., 2008 ; Abera et al., 2018). However there's a scarcity of localized studies assessing the chemical and microbial quality of raw cow milk in Dale District. Conducting region-specific research to provide a clearer understanding of the challenges and inform targeted interventions.

1.2. Statement of the Problem

Dairy production plays a vital role in Ethiopia's livestock sector by contributing to food security, nutrition, and livelihoods. The country's potential for dairy farming is reinforced by its large and diverse livestock population, favorable agroecological conditions, increasing urban demand, and long-standing tradition of dairy consumption (Tegegne et al. 2013).However, challenges related to milk hygiene and quality continue to impact both public health and the productivity of the dairy industry. Microbial contamination of raw cow milk remains a serious concern, as milk can be contaminated at various stages of production, collection, processing, and distribution (O'Connor, 1994). Factors such as poor milking practices, the use of unsanitary equipment, and inadequate storage conditions promote the growth of harmful bacteria. These consumers issues compromise the nutritional value of milk and pose significant health risks (Haile et al.,2012).

In the study area, traditional dairy practices dominate, yet there is limited awareness of hygienic milk handling, along with a lack of essential infrastructure, such as refrigeration facilities and access to clean water. These deficiencies further exacerbate the risk of contamination. Research indicates that poor sanitation during milk production, processing, and distribution leads to elevated microbial loads, reducing milk's safety and shelf life (Yilma

,2020). Without appropriate interventions, these challenges threaten the sustainability of smallholder dairy systems and limit the potential for improving milk quality.

Moreover, while the chemical composition of milk is critical for evaluating its nutritional value, data are scarce on both the chemical and microbiological quality of raw milk in this specific region. Existing studies have largely overlooked the contamination risks associated with traditional production systems, creating a knowledge gap that hampers the development of targeted strategies to ensure milk quality and improve public health outcomes (Tegegne et al. 2013; Yilma ,2020).Therefore, there is a need to assess milk production practices, evaluate the chemical composition, and determine the microbial quality of raw cow milk produced in the area. This study seeks to address these gaps by analyzing current practices and milk quality, thereby providing a foundation for future improvements in hygiene and dairy policy.

1.3. Objectives of the Study

1.3.1. General objective

This study was conducted to evaluate the production practice, chemical properties, and microbial quality of raw cow milk produced in Urban and rural smallholder farm conditions in the study area.

1.3.2. Specific objectives

To assess the hygienic condition of raw milk production practice and identify factors affecting the quality of raw cow milk in the study area

To study the chemical composition of raw cow milk produced in urban and rural smallholder farms in the study district

To investigate the microbial load of raw cow milk produced in urban and rural areas of the study

2. LITERATURE REVIEW

2.1. Dairy Production in Ethiopia

Ethiopia, where livestock and their products are significant sources of food and revenue, faces a severe challenge with dairy production, one of the sectors of livestock production systems, as dairying has not been effectively utilized and promoted in the nation (Getabalew *et al*.,2019). Despite its huge numbers, the livestock subsector in Ethiopia is low in production in general, and compared to its potential, the direct contribution it makes to the national economy is limited (Gebremichael et al.,2019). Even by African standards, the country's milk production is still among the lowest in the world in terms of dairy production because of a Sustainable smallholder livestock farming is hindered by several factors, including inadequate infrastructure, limited access to markets, lack of information and technology, and environmental concerns (Gwaka and Dubihlela, 2020).

According to FAO (2018), the dairy production system in Ethiopia is categorized into three main types: traditional smallholder, peri-urban, and urban/commercial systems. The traditional system is the most widespread and relies on indigenous zebu cattle with low milk yields, minimal inputs, and seasonal production, primarily for household consumption or informal sale. The peri-urban system, found around major towns, features small- to medium-scale farms that commonly use crossbred cows and have better access to inputs such as feed, veterinary services, and artificial insemination, with milk sold in both formal and informal markets. The urban and commercial system is concentrated in cities and involves intensive dairy operations using high-yielding exotic or crossbred cows, with significant investment in inputs and a strong market orientation, supplying milk to formal value chains including processors and supermarkets. These systems reflect the diversity in Ethiopia's dairy sector, shaped by variations in infrastructure, market access, and resource availability.

2.1.1. Rural household dairy production system

This system is connected with agricultural cultivation and operates on a small scale. It mostly employs native cattle breeds with an average age at first calving of 53 months, an average calving interval of 25 months, and an average lactation yield of 524 liters, local animals raised in this system typically perform poorly. The household consumes the majority of milk. Challenges include feed shortages, diseases, and limited access to improved technologies. However, there is potential for development due to the country's large livestock population and growing demand for dairy products (MOA 2022). A subsistence farming system that includes rural dairy production accounts for up to 98% of Ethiopia's total milk production (Ayalew and Abatenhe, 2018) and includes pastoralists, agro-pastoralists, and mixed crop-livestock producers . The quantity of milk surplus depends on a number of variables, such as the milk consumption of the home and its neighbors, the size of the herd and the time of year it produces, the ability to produce milk, and the presence of a local market (Asrat *et al*., 2016). The surplus is mostly processed using traditional technologies, and processed milk products like butter, ghee, Ayib, and sour milk are usually sold through the local market once households have met their needs (Asresie *et al*., 2018). Access to land and mixed crop-livestock farming, which generates some of the feed through grazing and crop leftovers, are characteristics of the rural dairy system as a whole.

2.1.2. Peri-Urban and Urban Dairy Production Systems

Peri-urban and urban dairy production systems are located near or within cities, where population density is high and agricultural land is limited due to urbanization. Together, they contribute about 2% of Ethiopia’s total milk production. These systems are predominantly semi-intensive to intensive and are characterized by the use of improved and crossbred dairy cattle, including high-grade Friesians . Peri-urban farms are typically situated along main roads near urban centers and combine crop-livestock practices. Farmers often engage in the liquid milk market and utilize manure as fertilizer. Urban dairy farming, practiced mainly by smallholder and commercial farmers using family or hired labor, is more market-oriented and intensive, with better access to public and private inputs. Land is often used for cultivating fodder, and milk is the primary income source (Tegegne *et al*., 2013; Bekele *et al*., 2015;Tsegaye *et al*., 2022; Alemneh, 2019;Haile,2022).

2.3. Dairy Cattle Production Practices

2.3.1 Feeding

Livestock feeding in Ethiopia primarily relies on grazing and browsing, especially on communal lands in the highlands. This is often supplemented with natural grass hay, crop residues (e.g., straws, chaffs), and agro-industrial by-products like flour/oil industry and brewery residues. Farmers with improved dairy cows also cultivate forages such as elephant grass, oats, vetch, and alfalfa (CSA, 2010a).In Aleta Chuko district, Beriso et al. (2015) identified communal grazing, private grazing, and stall feeding as major systems. Grass was the main feed source for 63% of households, followed by crop residues (22%), improved forages (9%), and industrial by-products (6%).Feed shortages commonly begin in December–

January, when pasture quality and stored crop residues decline. During this time, residues such as teff, bean husks, and cereal straws (e.g., maize, barley, wheat) often become the sole feed. In urban and peri-urban areas, 6.7% of intra-urban dairies practice roadside grazing, while 33% of peri-urban farms use pasture land. Although several feed mills supply balanced concentrates, mainly around Addis Ababa, their high cost makes them inaccessible for most small-scale farmers. Urban dairies are the primary users (SNV, 2006). Non-conventional feeds like Atella and pulp hulls are also common, used by 80% and 47% of farmers, respectively

2.3.2 Water requirements and sources for dairy Cattle

Water makes up 60–70% of a livestock animal's body and is essential for maintaining fluid balance, nutrient metabolism, waste elimination, heat regulation, fetal development, and nutrient transport(Somano, 2014). Dairy cattle obtain water through drinking, moisture in feed, and metabolic processes, with 80–90% of their total water needs met through drinking water.Water intake in dairy cows varies based on factors such as body size, milk production, dry matter intake, environmental temperature and humidity, water quality and temperature, and feed moisture content. Water becomes especially critical during heat stress, while in cold conditions, body water helps retain heat due to its high thermal capacity (Eticha and Tegegne, 2014). In highland production areas like Debre Birhan, Jimma, and Sebeta, water sources are typically located near farms, reducing the need for livestock to travel. However, in areas like Ziway, 54% and 22% of farmers reported animals traveling up to 5 km and over 10 km, respectively, to access water. Common sources of livestock water include rivers, streams, wells, and piped water. Rainwater harvesting using roof catchment systems is also practiced.

In Aleta Chuko, rivers, wells, and tap water are common (Beriso et al., 2016), while in Kersa Malima, rivers are the primary water source for smallholder farmers (Ketema, 2014).

2.3.3. Housing and manure management of dairy cows

In Ethiopia, dairy cattle housing and manure management practices differ significantly between urban and rural settings. In rural areas, traditional housing systems dominate, often with simple structures made of local materials like wood, mud, and thatch. Cattle are typically housed in open or semi-open sheds adjacent to family homes, and manure is commonly collected manually and used as household fuel, organic fertilizer, or simply piled near homesteads. In contrast, urban and peri-urban dairy farms often use more structured housing with better drainage and roofing, especially for improved breeds. Manure in these settings is usually collected regularly and either sold, used for biogas, or dumped in open fields or municipal waste sites, which can pose environmental risks (Tegegne et al. 2013). However, in both settings, poor manure management remains a challenge due to limited awareness and infrastructure, resulting in potential pollution and disease risks, especially in densely populated urban areas.

Dairy cow housing refers to the systems and buildings intended to give dairy cows a place to live and a comfortable environment. Dairy cow production, well-being, and health depend on proper housing (Asrat *et al*., 2015). Dairy cows that live in a clean and comfortable environment are less stressed, which benefits their general health and, in turn, the quantity and quality of their milk. An optimum housing setup includes elements like bedding, ventilation, lighting, and temperature management. By avoiding contamination in this way, milk is also guaranteed to be free of undesirable contaminants (FAO, 2011). Since hygiene has a direct impact on milk quality and animal health, it is essential to provide proper housing for dairy animals. The danger of bacterial contamination and diseases, such as mastitis, is greatly reduced by keeping stalls, bedding, and milking facilities clean. This guarantees that milk will continue to be safer to drink and will also have a higher yield and quality (Galama *et al*. 2020). By guaranteeing that cows are fed a steady and balanced diet, controlled housing improves feed management. Consequently, this enhances the milk's composition and nutritional value. Additionally, regulated feeding settings reduce feed waste and provide improved dietary needs monitoring for every cow(Barre *et al*., 1988). In addition, efficient waste management systems are essential for housing. Manure may reduce environmental contamination, manage odors, and stop the spread of illnesses and pests when it is disposed of and managed properly. Cows can flourish and produce higher-quality milk when their surroundings are clean because they are less stressed (FAO, 2011). In conclusion, adequate housing has a direct impact on the quality of milk produced and is essential for the productivity and well-being of dairy cows. It guarantees a stress-free, cozy, and hygienic environment, which improves milk quality and output.

2.3.4. Breeding

A systematic and well-thought-out breeding strategy is necessary to increase the efficiency and productivity of the dairy industry. To increase milk output, this entails carefully choosing native cattle breeds and crossing them with exotic dairy breeds that produce large quantities of milk.

In addition to breeding, good administration, nutrition, and medical treatment are necessary to promote genetic advancements. To achieve their maximum output, cows with high milk production potential need wholesome meals, disease prevention, and cozy housing.Long-Term

Development in the Dairy Sector: A strong breeding plan helps boost milk production, enhance farmer incomes, and boost the dairy industry's economy. Dairy farming performance can be further increased by establishing breeding programs and teaching farmers about genetic selection and crossbreeding methods (Gebrehiwet,2020).

2.3.5 Animal health challenges in dairy production

Dairy development in Ethiopia is significantly constrained by various animal diseases, including tick-borne illnesses, internal parasites, and infectious diseases. The impact of these diseases varies across ecological zones and management systems. However, veterinary services are generally inadequate, with limited access to diagnostic facilities and high costs for drugs and acaricides (Zelalem et al., 2011). Mastitis and tick-borne diseases are among the most critical health issues in dairy cattle. While 98.95% of the national herd comprises local breeds known for their resilience to diseases and poor management (CSA, 2013), exotic breeds often struggle to adapt to local environmental conditions, feed types, and pathogens. In regions like Dale district of Sidama, the most commonly reported diseases include pasteurellosis, blackleg, mastitis, parasites, and anthrax (Ketema, 2014).

2.3.5. Milk yield and lactation length

In general, native cow breeds are thought to yield less milk. But in Ethiopia, they are the main source of milk, making up 97% of the nation's total milk production (Yigezu, 2021). According to the study of Gemede (2021), who stated that the average estimated daily lactation yield of crossbred and local dairy cows in the Bule Hora district's lowland and highland regions was 5.94 ± 1.42 and 1.67 ± 0.627 liters, respectively. Ethiopian dairy cows currently produce an average of 1.9 liters of milk per day for native breeds and 7.3 to 11.7 liters per cow for crossbreds, depending on environmental conditions and management techniques(Tatek *et al*., 2017). According to Dessalegn *et al*. (2016), Crossbred cows in Bishoftu and Akaki towns produced 11.6 and 10.8 liters of milk per day (DMY), respectively. Similarly, Haile *et al*.(2012), found that the DMY for crossbred cows in Hawassa was 10.32 liters. Similarly, for hybrid cows, milk production per day is 8 to 10 liters (Tadesse *et al*., 2015). The industry has potential, but it also confronts obstacles like low productivity, slow acceptance of new technologies, and infrastructure problems(Shahida,2024). Average daily milk yield, lactation length, and total milk yield per lactation or year are used to assess the lactation performance of dairy cattle (Fikadu, 2023). In Ethiopia, crossbred dairy cows have lactation periods ranging from 298 to 374 days under on-station settings, with a milk output ranging from 1,293 to 2,957 liters. Breed, management, and environmental factors all have an impact on the somewhat lower yields and shorter lactation periods reported on farms (Beneberu, 2023a). Indigenous cows produced an average of 1.85 liters of milk per head per day; this varied from 1.24 liters per day in the rural lowland agropastoral system of Mieso to 2.31 liters per head per day in the rural highland system of Fogera. Crossbred dairy cows produced more milk on average per day in urban systems (10.21–15.9 liters/head per day) than in peri-urban systems (9.5 liters/head per day). In the rural lowland agropastoral system, the lactation milk yield of native dairy cows was 271.4 liters per head; in the peri-urban system, it was 434.8 kg per head. But lactation. From 5.9 months in the rural lowland transhumance system to 9.8 months in the rural highland dairy system of Bure, the length of the indigenous animals was shorter (Tegegne *et al*., 2013).

2.4. Hygienic Practices in Milk Production

According to Pandey (2011), the milk from a healthy cow's udder has very few germs. Milk deteriorates quickly due to additional bacteria introduced by inadequate hygiene. Raw milk's shelf life can be increased by practicing good hygiene during the milking process and when handling the final product. Hygienic milk production is crucial for the customers' safety as well as the milk's quality (Ahmed *et al.* 2022). A hygienic milk production and quality control program must include facility hygiene, which involves maintaining the cleanliness of the barn, access alleys, and milking parlor, among other things (Vissers and Driehuis, 2009). Facility hygiene practices have a big impact on how clean cows are, especially their udders and teats. This, in turn, influences the likelihood of microbial contamination of milk through the teats' outer surfaces as well as the incidence of mastitis. Milk safety and cleanliness are greatly influenced by the sanitary precautions that milk handlers take before, during, and after milking (Fortunate,2013). Unsanitary milking practices, a shortage of drinkable water, an unclean milking environment, and the use of dirty milking and storage containers were some of the factors that led to low milk quality (Shimelis *et al*.,2021). Hygienic circumstances in smallholder systems, particularly when milking. To ensure milk hygiene, awareness, the availability of resources, and appropriate practices are essential. The fundamental actions listed, such as letting the calf suckle for a short while and cleaning the udder before milking, are sensible and efficient ways to decrease contamination and enhance milk quality (Kibebew,2020b). Healthy animals raised in hygienic conditions can provide high-quality raw milk, and precautions are taken to safeguard human health. Maintaining proper hygiene is crucial to producing clean milk (Debela, 2015). Thus, to improve the sanitary conditions of milk, stringent hygienic control methods are required along the food chain(Tekilegiorgis, 2018). According to Ahmed *et al.* (2022), The majority of interviewers (98.34%) milked their cows in the barn, while approximately 88.33% cleaned the barn daily and others once, twice, and three times a week, according to a study on hygiene practices and the bacteriological quality of raw cow milk at a selected dairy farm in Dessie, Ethiopia. According to the study of Abebe *et al.* (2018), the majority of milkers (96.3%) cleaned their hands during milking, and 90.7% cleaned their udders before milking. However, just 3.5% of respondents dried their hands with a clean towel, while 19.6% of respondents cleaned their udders before milking. For a variety of uses, plastic containers were the most widely used milk utensils. The respondents, 46.2% use warm water and soap to clean milk utensils, whereas 53.8% prefer cold water and detergents. Udders, hands, and milk containers were frequently cleaned using water from taps, rivers, springs, and bore wells. Until it was sold, most respondents kept milk at room temperature. Therefore, establishing hygienic practices for the handling of milk and milk products throughout the dairy production is crucial to ensure the safety and acceptability of these food items for consumers.

A variety of factors, including the type of animal house floor, can contaminate raw cow milk. inadequate hand and udder washing right before milking, the type of storage containers used, the source and quality of the water used for hand and milk equipment hygiene, and milk storage

(Pandey, 2011). When it comes to raw milk's microbial contamination, duration is crucial. (Aklilu,2017).In general, there are three primary sources of contamination: inside the udder, outside the udder, and the surface of milk handling and storage equipment. However, other potential sources include the surrounding air, feed, soil, feces, and grass. (Bekele,2024). Environment to milk via dirt (e.g., manure, bedding, and soil) attached to the exterior of the teats. In addition, microorganisms attached to the exterior of the teats can enter the teat canal and cause mastitis. The milking environment, cows, milking staff, milking equipment, milk transportation, and water are the primary risk factors for milk contamination by bacteria (Bekuma and Galmessa, 2018).

2.4.1. Environmental contamination

When dangerous microorganisms, chemicals, or other pollutants are introduced into milk from outside sources during production, handling, or storage, it is referred to as environmental contamination of milk. These contaminants can come from the air, soil, water, feed, and animal bedding, as well as from unsanitary milking and storage equipment (Sarma *et al*., 2015). During grazing or milking, cows may come into contact with tainted soil, water, or excrement. The milk may become contaminated by bacteria, parasites, and other environmental microbes. Cow-related elements: Bacterial contamination of milk can result from cow illnesses or infections, such as mastitis, which is inflammation of the udder. Contamination can also result from improper hygiene procedures used during milking (Abdifatah *et al.*, 2022).

2.4.2. Contaminated equipment

When dangerous bacteria, chemicals, or strange objects get into milk, it can compromise its quality and safety. This is known as milk contamination. This can occur as a result of inadequate cleaning and sanitization of storage tanks, milking apparatus, and utensils used in the milking and processing phases. To avoid contamination and guarantee that milk is safe to drink, proper cleanliness, sanitization, and adherence to food safety regulations are crucial (Chala and Mitiku ,2021).

2.4.3. Human related factors

Milk handlers need to practice good personal hygiene to avoid contamination. A higher risk of foodborne infections can result from the introduction of dangerous bacteria, viruses, and other pollutants into milk by unclean hands, unclean clothing, and poor sanitation procedures. Throughout the milking and processing steps, handlers should always wear clean protective gear, wash their hands thoroughly, and adhere to stringent hygiene rules to ensure the safety of the milk. Adopting appropriate sanitation practices helps preserve the milk's nutritional value and quality while also protecting consumers (Abdifatah *et al*., 2022).

2.4.4. Infected udder

An inflammation of the udder's mammary glands brought on by an infection with pathogenic bacteria is known as mastitis. Moreover, these bacteria may get into the milk and cause sickness if it is ingested. A major source of contamination may be the udder's exterior. The environment in which cows are kept and milked, however, has an impact on the udder's appearance(Meçaj *et al*. 2023). The bacteria found on an animal's skin naturally enter milk through the udder and teat surfaces; these germs also exist in the areas where animals are milked and housed(Getabalew, and Etagegneh ,2020). The outside of the cow's udder and teats can harbor microorganisms that are naturally linked to the animal's skin and those that originate from the surroundings where the cow was kept and milked (Burtscher *et al*. 2023). When cows lie in stalls or are left in muddy barnyards, their udders and teats will unavoidably get dirty. Numerous microbes are present in used bedding. Because urine and feces are absorbed, bedding materials may become highly contaminated (Patel *et al*. 2019).

2.4.4.1. Udder preparation

Contamination is considerably decreased when the cow is well cleaned before milking. One of the most crucial hygienic procedures needed to guarantee clean milk production is cleaning the cows' udders before milking (Pandey 2011; Birhanu *et al*.,2020). This is crucial since the milking cows' udders may come into direct contact with the ground, feces, urine, and feed scraps. To stop various kinds of bacteria from getting into the milk, the udder and flanks must be cleaned and the bedding, manure, and soil particles removed (Kibebew *et al.* 2020a). The towels used to clean the udder need special attention. Reusing cleaning and sanitizing cloths could cause the udder to become contaminated again. Therefore, it is advised to use different towels for cleaning and sanitizing, and if at all feasible, to use one cloth for each cow(Connor, 1995). A maximum reduction of teat contamination of 90% can be achieved with good udder preparation before milking. This depends on the initial level of contamination and the way of udder preparation (Nickerson *et al*.,2019).To further minimize contamination, it becomes even more important to improve the general cleanliness of the cow's surroundings, including the housing and bedding arrangements(Kibebew *et al*. 2020b).

2.4.5. The milker

The milker should maintain good cleanliness and be in good health during milking because they might be a major source of milk contamination. Particularly in smallholder dairy farms where traditional methods are prevalent, milkers are essential to preserving the safety and quality of milk. Numerous Ethiopian dairy producers are cognizant of the need of hygiene, according to studies. Before milking, milkers frequently wash their hands and utensils. Some also clean the udder to lessen contamination. But less typical activities like post-milking teat dipping can raise the danger of infection (Belay and Janssens 2015). When milk handling workers (milkers) are irresponsible, ignorant, or willfully negligent, they may introduce germs and other organisms into the milk (Getabalew and Alemneh 2020). The safety of dairy products and the avoidance of milk contamination depend heavily on the health and cleanliness of the milker. If appropriate safeguards are not performed, milk can spread infectious diseases like tuberculosis(Bekele *et al*., 2024).

2.4.6. Water

When water is used to clean udders, milking equipment, or storage containers, it can be a major cause of microbial contamination in milk. When milk handling equipment is cleaned with inadequate and subpar water, milk residues may remain on the equipment surfaces, providing nutrients for bacteria to thrive and multiply and contaminate the milk (Sintayehu and Haile, 2015). The safety and quality of the milk may be affected if the water is not clean or adequately treated, since it may introduce dangerous germs. When it comes to germs contaminating milk, water is crucial. This frequently happens when water used for storing items, cleaning equipment, or even diluting milk is not adequately cleaned or sanitized. Salmonella, E. Coli, Listeria, and other bacteria can be introduced into milk by contaminated water, lowering milk quality and causing major health hazards (Teweldebrihan ,2025; Getie, 2020). Dairy production, therefore, requires strict hygienic procedures, frequent water quality testing, and making sure that all equipment is completely cleaned and sanitized (Tenorio *et al*. 2019). Care should be made to ensure that drainage that might include human waste and other impurities doesn't enter the source if the water comes from an open water source (Shayo *et al*. 2023).

2.5. Milk Quality and Control Systems

Milk is a valuable source of nutrition but is also highly perishable and susceptible to microbial contamination. In Ethiopia, the dairy sector is a growing component of the national agricultural economy, yet it faces significant challenges related to milk quality and safety. This paper reviews the current milk quality and control systems in Ethiopia, with a focus on the application and enforcement of Ethiopian Standards (ES) such as ES 346:2009. It assesses the performance of quality control mechanisms from production to consumption, identifies institutional gaps, and proposes recommendations for improving the system. Strengthening the milk quality control system is crucial to enhancing consumer health, supporting the dairy economy, and fostering market competitiveness.Milk and its products' adherence to strict safety, quality, and hygienic requirements is ensured through the procedures and controls put in place. To verify that milk is safe for ingestion and free of contaminants, this system tests it for chemical composition, microbiological content, and physical characteristics. Systems for milk quality and control are crucial structures created to guarantee that milk and dairy products are hygienic, safe, and satisfy predetermined requirements for quality. Tests for microbiological contamination, chemical composition monitoring, and appropriate handling and storage procedures are some of the procedures that are part of these systems. To prevent contamination, they also stress the significance of maintaining proper cleanliness during milking, transportation, and processing(Merwan *et al.*, 2018). All milk processing businesses, regardless of size, must have quality control and testing procedures in place. Since milk is 87% water, dishonest intermediaries and unfaithful agricultural workers are likely to adulterate it (Burke *et al*. 2018). Milk's high nutritive value, packed with proteins, lactose, and essential minerals, creates an optimal environment for the rapid growth of bacteria. When milk is handled under unhygienic conditions or stored at ambient temperatures, this promotes the proliferation of harmful microorganisms like E. coli, Salmonella, and Listeria. These bacteria can not only spoil the milk but also pose significant health risks if consumed. This is why proper milk handling practices, like ensuring cleanliness during production, rapid cooling, and storage at low temperatures, are critical to preserving its quality and safety. Pasteurization is also a key process in eliminating harmful bacteria while maintaining milk's nutritional benefits (Feyisa *et al*. 2024). Milk testing for quality can be divided into testing for hygiene and composition. Hygiene Testing: This assesses the cleanliness and safety of the milk. It includes tests for microbial contamination (e.g., total bacterial count or coliform count) and the presence of harmful substances like antibiotics or toxins. Composition Testing: This focuses on determining the nutritional and physical properties of milk, such as fat content, protein levels, and solids-not-fat (SNF). It ensures the milk meets regulatory and product-specific requirements (Sidney et al.,2014). These tests ensure milk meets safety standards and is suitable for consumption or processing (FSAI,2012; Pandey, 2011)

2.5.1. Control of milk spoilage

For milk products to be safe and of high quality, microbial contamination of milk must be controlled. It combines appropriate handling, storage, and treatment techniques to reduce microbial development and preserve quality (Lu *et al*., 2013).

2.5.1.1. Cooling:

One of the most important ways to maintain the quality of milk and stop bacteria from growing is to quickly chill it. Warm temperatures provide the perfect conditions for bacteria to grow quickly, making fresh milk extremely vulnerable to bacterial contamination (Agrawal &

Goyal, 2017).Immediate Cooling: After milking, fresh milk should be cooled to below 4°C as quickly as possible to inhibit bacterial activity and maintain its freshness. Storage and Transportation: Keeping the cold chain stable is essential. Milk should be transported to processing facilities in refrigerated tanks. Refrigeration facilities are installed at the points of collection and transportation methods to keep the temperature as low as feasible to assist in thickening the raw milk supply and transporting the incoming milk. Raw milk will quickly become acidic in Africa's tropical nations due to high ambient temperatures and a lack of refrigeration facilities at the farm and home levels. (Habtamu *et al*. 2018). Therefore, every attempt should be made to lower the temperature of milk by using the systems that are available, such as air circulation, water cooling, or shaded places.

2.5.1.2. Boiling

It is the simplest and most practical way for any household to make milk safe. The process of boiling entails increasing the temperature to the boiling point and holding it there for a short while. After that, the milk needs to be chilled right away. It is important to keep the temperature below 10ºC. Since this might not be feasible at home, the milk should ideally be drunk right away after cooling rather than waiting a long time after boiling and cooling (Hernández-Castellano *et al*. 2019).

2.6. Quality of Raw Cow Milk

For raw milk to be technologically processed into products, its quality is crucial. The total number of bacteria, somatic cell counts (SCC), and residues of inhibitory chemicals are just a few examples of the hygiene and health indicators that are used to determine the quality of milk. Its composition and several technological markers can also be used to characterize it(Falta, 2021). Both dairy farmers and processors are concerned about the quality of raw milk since it influences human health and the use of the product, which in turn impacts its economic value. Although the chemical makeup, hygienic standards, and nutritional value of milk determine its quality, animal husbandry methods, unsanitary harvesting, and processing methods can have an impact (Gwandu *et al*. 2018). The consistency and protection of milk are determined by its chemical composition and microbial state. Important factors affecting the quality and protection of milk products include their chemical makeup and microbial presence (Dave *et al*., 2022). Inadequate post-handling procedures, such as inadequate hygiene of milk equipment and storage containers, predispose the milk to microbial contamination. Hygienic practices include cleaning the udder with clean water to maintain a clean milking barn, drying the udder with individual towels, and washing the milker's hands and milking utensils with low-quality non-boiled water(Abunna 2019). 2.6.1. Compositional quality of raw cow milk

The **compositional quality** of raw cow milk in Ethiopia is governed by the national standard (**ES 2009)**, issued by the **Ethiopian Standards Agency**. This standard sets minimum thresholds for key milk constituents to ensure nutritional adequacy and authenticity. According to ES 346:2009, raw cow milk must contain at least **3.5% milk fat** and a **minimum of 8.5% solids-not-fat (SNF)**, which includes proteins, lactose, and minerals. These benchmarks are designed to detect and prevent adulteration practices such as water dilution and skimming of cream, which compromise the nutritional and economic value of milk. Compliance with these compositional standards is crucial not only for consumer health but also for supporting fair trade and value-based milk pricing systems in the formal dairy market (ES, 2009).In female mammals (more than 4,000 species), milk is secreted by the mammary gland and is frequently the only food supply for the very young (Pereira,2014;

Oftedal,2012). Milk serves to both nourish and defend the immune system. For milk to be suitable for human consumption, it must originate from nursing animals that are healthy and fed properly. This means that veterinary care is prohibited for milk from infected animals (induced by inflammation of the udder). Milk should be at +4°C when it is pasteurized and delivered to consumers (Guetouache *et al*. 2014). The milks produced by cows, buffaloes, sheep, goats, and camels are used in various parts of the world for human consumption. For much of the world population, cow milk accounts for the large majority of the milk processed for human consumption (Park & Haenlein,2008; Mirkena, 2010). Milk's composition varies greatly and is not always the same. First of all, the species of animal determines the makeup. However, there are also significant variations within a species across breeds and between individual animals. Depending on nutrition and temperature, the composition may even fluctuate daily. Additionally, the first and last droplets of milk produced during a single milking are different. Milk's quality, both nutritionally and processing-wise, is mostly determined by its chemical makeup, particularly its fat and protein levels. Milk has a great nutritional profile due to its well-balanced nutrient composition. The main chemical components of milk are fats, carbohydrates, proteins, water, minerals, enzymes, vitamins, and organic acids (Pandey, 2011). Milk comprises 88% water, 3.2% fat, 8.13% fat solids, and 11.4% solid contents (O'Connor 1995; Mehta 2015). The breed and individuality of the cow, the time between milkings, the stage of lactation, the cow's age and health, the feeding schedule, and the thoroughness of milking are the elements that cause variances in the composition of milk (Pandey,2011).

2.6. 2. Microbial quality of raw cow milk

When milk is released into the udder's alveoli, it is essentially a sterile substance. Beyond this point in the production process, however, there are three primary opportunities for microbial contamination to occur: inside the udder, outside the udder, and on the surface of milk handling and storage equipment. Other potential sources of contamination include the surrounding air, feed, soil, feces, and grass (Kuma *et al*., 2015). Few bacteria are present in milk from a healthy udder, but many are picked up from the moment the milk leaves the cow's teat until it is used for additional processing. These microbes serve as markers of the milk's quality as well as how it is handled from milking to consumption. Healthy animals' milk produced in a sanitary environment shouldn't have more than 5 × 105 bacteria per milliliter(Tassew *et al*. 2011). Public health, the quality of milk-derived products, and the suitability of milk for processing all depend on this. Milk hygiene relates to the presence of substances that are foreign to milk but enter it through the udder or during or after milking, as well as any changes that may occur in the milk. Microbial, chemical, and physical hygiene can be distinguished, and substances that could be harmful to the consumer, such as antibiotics, disinfectants, pesticides, and heavy metals, can also enter the milk (Lan *et al*. 2017). Ethiopia, in particular, and undeveloped countries often lack appropriate circumstances for making safe and high-quality dairy products. Milk can be contaminated by numerous microorganisms, including pathogens, which can cause foodborne disorders in consumers due to improper handling practices employed by farmers and following chain actors in Ethiopia (Disassa *et al*. 2017). Since milk is one of the most valuable and nutrient-dense food commodities for humans and young mammals, milk and milk products are a significant economic activity in the Hawassa area and are only becoming more so. Additionally, it offers a great environment for bacteria to develop. Once bacteria have access to milk, they will proliferate quickly, contaminating it or making it unfit for further processing or human consumption (Haile *et al*., 2012). A lot of microbial communities are complex, meaning they are made up of a variety of microorganisms from different taxa. A variety of complicated microorganisms can be found in an environment like raw milk (Tekilegiorgis, 2018). Growing or cultivating these microorganisms and then analyzing them has given us the majority of our knowledge about the identity of the bacteria found in raw milk and the resulting dairy products. Typically, tests like the Standard Plate Count, Coliform Count, and Yeast and Mold Count are used to assess the quality of milk (Markey *et al*. 2013).

2.6.2.1. Total plate count

The quantity and kind of bacteria have a direct impact on the milk's quality, which is mostly assessed in the industry by the total bacterial count (TBC). TBC is used by premium payment systems to price milk to farmers and is a measure of the hygienic conditions at the farm level as well as the hygienic quality of the raw milk. However, TBC does not provide the microbiological makeup of milk; it only provides the number of bacteria present (Markusson,2021). It is widely acknowledged that the most precise and instructive technique for evaluating the microbiological quality of milk is the standard plate count. Important general information on the microbiological quality of milk can be found in the total plate count of microorganisms in milk. Different animals and even different breasts from the same animal have variable bacterial counts in aseptically extracted milk. The total bacterial count (TBC) from teat during milking and milking buckets at the farm level in Gondar was 4.59 ± 0.118 log10 (38,904.51 cfu/ml) and 4.77 ± 0.23 log10 (58,884.37 cfu/ml), respectively. This report states that the count increased from teat to milking buckets by 0.18 ± 0.23 log10, or 19,979.86 cfu/ml 51.36% (Tegegne and Tesfaye ,2017). A major contributing factor to milk contamination is poor cleanliness during the milking process. To lower bacterial counts and guarantee the safety and quality of milk, it is essential to properly clean and disinfect milking instruments and keep the milking area clean (Macharia et al.,2024). Higher TBC of milk samples from milking equipment may result from unsanitary milking procedures, like as not washing the udder and teat before milking, not cleaning the containers before and after milking, and not using a towel to dry your hands after washing your hands and the equipment.

2.6.2.2. Coli form plate count

One important measure of milk quality and cleanliness is the coliform count in dairy cow milk. The bacteria known as coliforms, which include Escherichia coli, Enterobacter, and Klebsiella, ferment lactose to create gas and acid. Their existence in milk may indicate fecal, soil, or water pollution (Kibebew *et al*. 2020a). Good quality milk should not contain a total coliform bacterial count of more than 1000 CFU/ml (ESA, 2006). Based on (Solomon,2015). A non-regulated test called the coliform count (CC) has long been used to evaluate milk production procedures, such as pre-milking udder care, milk chilling, and milking equipment sanitation. Coliform organisms in milk are a sign of unhygienic manufacturing, processing, or storage conditions. Therefore, their high concentration in dairy products is a sign that the goods may be harmful to the health of the customers (Elango et al., 2023). Coliform count indicates unsanitary production practices and/or mastitis infection. A count less than 100 Colony Forming Units (CFU)/ml is considered acceptable for milk. However, according to the report (Walstra, 2009), if present in large numbers, say over 100 coliform organisms per milliliter of raw milk, it means that the milk was produced under improper procedures. Some

2.6.2.3. Yeast and moulds

Yeasts are unicellular organisms that reproduce asexually by budding. They are used industrially to ferment carbohydrates to such products as alcohol and citric acid (Huang and Tang 2007; Kazemi *et al*. 2025). Yeasts are considered spoilage organisms in dairy products because they can cause undesirable changes, such as off-flavors, gas production, or altered texture, especially in products with high sugar content like flavored yogurts or sweetened condensed milk. However, yeasts are not entirely negative in the dairy industry. Some species, such as Saccharomyces cerevisiae, are used as feed supplements for dairy cows to improve rumen fermentation, nutrient absorption, and overall milk yield (Kazemi *et al*. 2025). To avoid yeast contamination, the dairy business must maintain stringent hygiene and appropriate storage conditions. For a total of 78 milk samples taken straight from the udder, storage containers at the farm level (bulk), and distribution containers upon arriving at selling stations in Hawassa, the mean counts of yeast and mold were 3.03, 4.65, and 7.13 log10Cfu/ml, respectively (Haile *et al*. 2012). The overall mean 2.63 ± 0.46 cfu/ml yeast and mould was reported by (Solomon, 2022b) in Worabe townMolds are a diverse category of multicellular creatures that reproduce asexually by fragmentation or spore production. They are typically thought of as spoilage organisms and can grow on a wide range of substrates. Nonetheless, molds are utilized in the manufacturing of several types of cheese and antibiotics. Since molds are aerobic organisms, their growth on food can be slowed down by carefully packing to keep air out. Although mold spores are more resistant to heat, they can be destroyed by quite low heat treatments (Adugna *et al*. 2015).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Dale district Sidama National Regional State, Ethiopia. Dale District is partly located in the Great Rift Valley. It is bordered on the south by Aleta Wendo and Chuko, on the west by Loko Abaya, on the northwest by Boricha, on the north by Shebedino, and on the east by Wensho. The major town in Dale is Irgalem, Irgalem. Parts of Dale woreda were separated to create Loko Abaya and Wensho woredas.The District is situated at 40 km south of Hawassa and at about 320 km south of Addis Ababa. It was located at 6°44' to 6°84'N and 37°92' to 38°60' E with an altitude range of 1001 to 2500 masl (average 1624 masl). The district receives an annual mean average rainfall of 1170 mm and the average annual temperature of 19°C (SEDPSZ, 2004).The district was characterized by food crops like enset (Ensete ventricosum) and maize and diversified cash crops like coffee, fruits (such as banana, avocado, guava), haricot bean and root crops like potato and sweet potato. Livestock farming is also practiced, with animals feeding on enset and their manure used as natural fertilizer for enset cultivation (Behailu *et al.*, 2022).

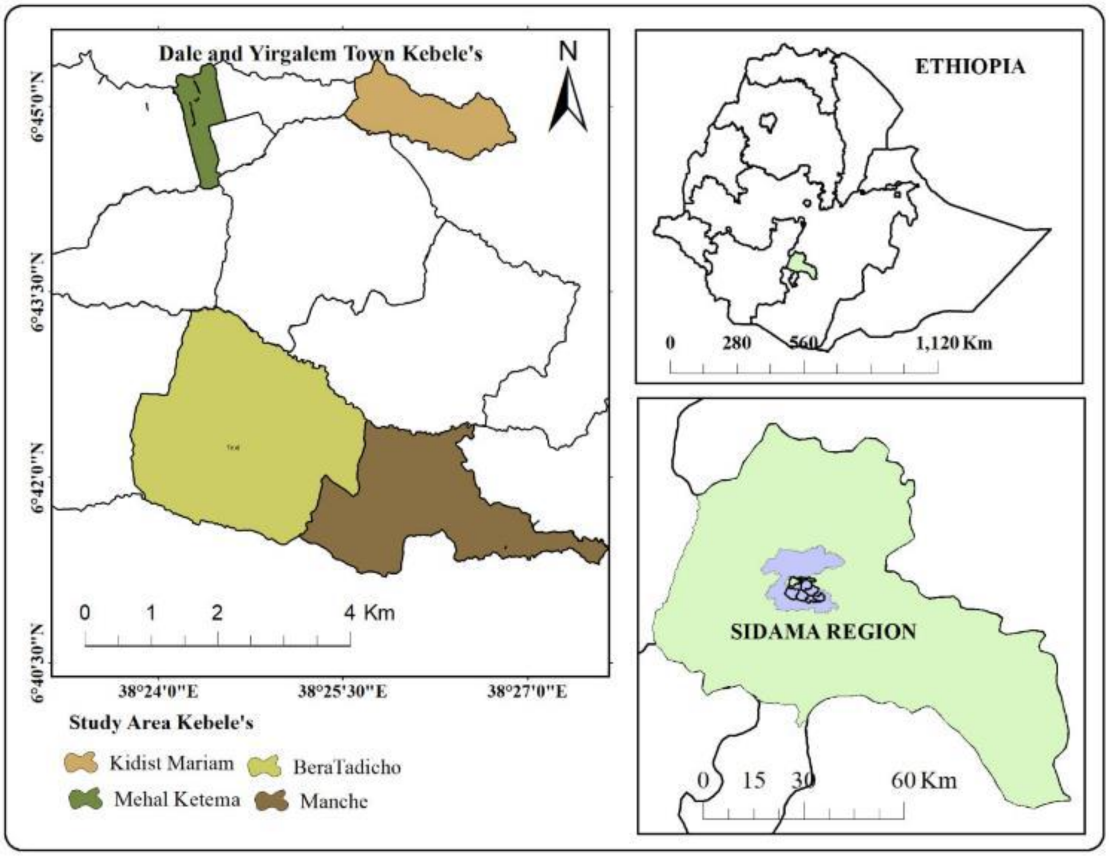


Figure 1Map of the study area

3.2 Research Design

A cross-sectional study was conducted to assess milk production practices using semi-structured questionnaires and key informant interviews. The chemical and microbial quality of milk at the farm level was tested in selected dairy farms located in both rural and urban areas of Dale district.

3.3. Study Population, Sampling Techniques, and Sample Size

The target population of this study consisted of smallholder dairy farmers in Dale district. A multistage sampling technique was employed to select household samples.In the first stage**,** Dale district was purposively selected based on its dairy production potential and accessibility.In the second stage**,** two rural and two urban kebeles were purposively selected due to their relatively high potential for dairy production.In the final stage**,** 185 smallholder dairy farmers were randomly selected using the household registration books maintained by the respective kebele administrations. These registration books, containing a total of 345 households, served as the sampling frame.The sample size was determined using the Yamane (1967) formula**,** as presented below. The respondents were then proportionally distributed across the selected kebeles according to the total household population in each (Table 1). Accordingly, the sample size was determined at a 95% confidence level.

Accordingly, sample sizes with a 95% significance level determination were presented as follows.

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

$n = 345/1+345(0.05)^2=185$

Where: n = the sample size

N = the population size in the selected Kebeles and

e = the acceptable sampling error (0.05).

The sample respondents were taken from each Kebeles proportionally according to (Pandey and Verma 2008).

$n_1 = n * N1/N$ Where; n 1n2, n3 and n4 are sample size of respondents in each kebele

$n_2 = n * N2/N$ N1, N2, N3, and N4 are total number of dairy producers in each kebele

$n_3 = n * N3/N$ n is total sample size of respondents

$n_4 = n * N4/N$

Table 1. Number of households and sample size

District	kebele	No of HHs in milk producers	Sample HH's
Urban	Mehal ketema	50	27
	Kidst maryam	45	24
Rural	Manche	110	59
	Berra tadicho	140	75
Total		345	185

3.4. Data Collection

3.4.1. Type and Sources of Data

Both **primary and secondary data** were collected for this study. Primary data were gathered through household surveys, key informant interviews, and milk samples collected from producers for microbial analysis. Secondary data were obtained from published and unpublished documents, previous research findings, farm records, and reports from the city and district agriculture and livestock offices.

3.4.1.1. Household Survey

A semi-structured and pre-tested questionnaire was used to interview the selected dairy farm owners. The questionnaire collected information on general household characteristics, livestock species composition, production practices, milk handling, feeding systems, labor division in dairy management, production constraints, and related topics.

3.4.1.2. Key Informant Interviews

Key informant interviews were conducted to gather primary data. In total, 10 key informants were interviewed, including local leaders and agricultural experts with experience, involvement, and knowledge in dairy production. Among the informants were development agents and officials from agricultural offices.

3.4.3. Milk Sample Collection and Transportation

For laboratory analysis of fresh whole milk, 60 samples were collected following the procedure described by Richardson (1985). After thorough mixing, approximately 200 mL of milk was collected in sterile bottles for microbial analysis. The samples were transported to the Dairy Science Microbiology Laboratory at Hawassa Agricultural College in an ice box and analyzed immediately upon arrival.The **compositional quality** of the milk samples was analyzed for fat, protein, total solids, lactose, and solids-not-fat. The **microbial analysis** included the determination of colony-forming units (CFUs) of total bacteria, coliforms, and yeast and mold using appropriate media. All media used for microbial analysis were sterilized before use according to the manufacturer's guidelines. Each analysis was conducted in duplicate.

3.4.2 Milk Sample Collection

Milk samples were collected for the determination of the chemical composition and microbial qualities. A total of 60 Milk samples were collected from cross-breed dairy cows for laboratory analysis from rural(24) and Urban areas(36) of the selected kebeles. For each milk sample, 200 ml of milk was collected from the milking equipment into sterile tubes. All samples were coded for identification and stored in an icebox. Then, after the samples were transported to Hawassa University dairy laboratory and stored at 4°C until analyses (Richardson,1985).

3.4.3. Chemical properties of milk

According to principles, compositional properties (fat, protein, lactose, and water) are the features of raw milk related to the natural composition. It has special importance to the value for further processing. Based on the standard principles, the chemical compositions of milk were tested by using the Lacto Scan (LACTOSCAN SPZKN001, Bulgaria) Device was used to analysis the chemical compostion of each sample milk in the Hawassa University dairy laboratory. The milk sample was inserted into to water bath at 30 0c brought to the recommended temperature. The milk sample was poured into the inlet of the LactoScan then analysis was started by pressing the appropriate button. After one minute, the LactoScan analyzed the milk and displayed the results on the screen, then the results were recorded. The device was thoroughly cleaned using the recommended solutions (Mitiku *et al*. 2019).

3.5. Microbial Analysis

The microbial analyses of milk samples include the determination of colony-forming units (CFUs) of total bacteria, coliform bacteria, and yeast and molds using appropriate media. All media used for microbial analyses were sterilized before use according to the manufacturer's guidelines (Richardson,1985) . Serial dilution was a process of diluting milk in a series of steps to obtain a range of concentrations. In the case of determining the bacterial count in the milk.

3.5.1. Media Preparation for microbial quality analysis

All media, except Violet Red Bile Agar (VRBA), were sterilized by autoclaving at 121 °C for 15 minutes, while VRBA was sterilized by boiling for two minutes, in accordance with manufacturer recommendations. After sterilization, the media were allowed to cooled before use. Media preparation was carried out according to the instructions provided by the respective manufacturers. Peptone water, sterilized by autoclaving at 121 °C for 15 minutes and cooled to approximately 30 °C, was used for serial dilution of milk samples for the determination of total bacterial count (TBC), total coliform count (TCC), and yeast and mould counts. All microbial analyses were duplicated to ensure accuracy and reproducibility (APHA, 2017).

3.5.2. Total bacteria count (TBC)

TBC was done using the pour plate method using Standard Plate Count (SPC) agar. This test was carried out to determine the content of microbial contamination of milk. One milliliter (1 ml) of milk sample was serially diluted in 9 ml of 0.1% peptone water in to sterile test tubes up to 1×10^{-7} dilutions by transforming 1ml of the dilution in 9ml of 0.1% peptone water). Sterile duplicate glass Petri dishes were labelled according to the dilution index. This was followed by pouring of standard plate count agar that were autoclaved at 121 °C for 15 min, and then cooled. About 20 ml of molten standard plate count agar solution was added in to plates /dishes until it covers one-third of the plate. Then, One ml of the sample milk that was homogenized by vortex was drawn into sterile petri dishes containing the agar and the sample and the agar was gently mixed by the alternate clock and anti-clockwise rotations then closed immediately after delivery (HPA, 2003).and left to solidify in the Bio safety base workspace. The plates were inverted and incubated at 35°C for 48 h (HPA, 2003). According to Richardson, (1985) the total normal number of colonies expected is between 30 and 300. All counts were made in duplicates. Finally, the colony count was made using a colony counter. Then the recorded data were passed to the next procuders for analysisthe following formula .

$$N = \frac{\Sigma \mathrm{C}}{[(1\mathrm{xn1}) + (0.1\mathrm{xn2})]\mathrm{d}}$$

Where N = number of colonies per milliliter of product.

ΣC = sum of all colonies on all plates counted.

n1= number of plates in lower dilution count.

n2 = number of plates in the next higher dilution count.

d = dilution from which the first count is obtained.

For total plate count, appropriate decimal dilutions that gave the expected total number of colonies on a plate, i.e., between 30 and 300 colonies, were selected (Richardson et al. 1985)

3.5.3. Coliform count

One ml of milk sample was added into a sterile test tube containing nine ml of peptone water up to serial dilution of 10-7and mixed thoroughly. Duplicate appropriate decimal dilutions were surface plated on Violet Red Bile Agar (Pharma, US)and incubate at 37^0C for 24 hours, and typical dark red colonies were considered as coliforms and counted. Then similar computation steps were followed to total bacteria count (Richardson, 1985) .

3.5.4. Yeast and Moulds count

Samples of milk was serially diluted following similar methods as for total bacterial count but dilutions were surface plated on Potato Dextrose Agar (PDA) (Oxoid, Pvt. Ltd. MU 096: UK). The dried plates are then Enqubeted at room temperature for 3 to 5 days. Colonies with a blue green color is count as yeasts and moulds (Yousef and Carlstrom 2003).

3.6. Statistical Analysis

Survey data collected from study area was analyzed by using descriptive statistics such as means, frequency distribution and percentage using SPSS Software (version 20). The data on quantitative variables like amount of milk produced from local and crossbreed cow were analysised using independent t-test. $\chi 2$-test were used to analyze the relationships between dependent variables and independent variables. Index analysis was used for ranking constraints hindering dairy production and quality milk production according to the method suggested by Kosgey (2004),the ranking was expressed as an Index = Index = Rn*C1+Rn-1*C2+…. +R1*Cn/Σ Rn*C1+ Rn-1*C2….R1*Cn Where: Rn= Value given for the least ranked level (example if the least rank is 9^{th} rank, then Rn=9, Rn-1=8 and … R1= 1). Cn= Counts of the least ranked level (in the above example, the count of the 9^{th} rank = Cn, and the counts of the 1strank = C1).Microbiological counts were first transformed into logarithmic value (log10 cfu ml-1) to get normally distributed data. Data on the Chemical compostion and log 10 transformed microbial counts were analyzed using using independent t-test procedure of SPSS (version20). Mean separation was carried out when analysis of variance shows significant differences between means and differences were considered significant at $p < 0.05$.The following model was used for the analysis of the Chemical Composition and microbial quality of milk:

The following model was used for the analysis of the chemical/compositional and bacterial quality of raw milk.

$Yij = \mu + \beta i + eij$

Where, Yij = individual observation for each test

μ = the overall mean

β = the i^{th} effect of milk sources (i= rural and urban)

eij = the error

4. RESULTS AND DISCUSSIONS

4.1. Household Characteristics

As shown in Table 2, the majority of the 185 households surveyed were male-headed, accounting for 89.2%, while only 10.8% were female-headed. This finding aligns with the study by Mitiku et al. (2019), which reported 92.68% male and 7.32% female-headed households. Regarding marital status, most respondents (90.3%) were married, and only 1.6% were divorced. This result is consistent with Samuel (2020), who found that 71.5% of dairy producers were married. In terms of age distribution, a significant portion 40% of smallholder dairy producers fell within the 42–60 age group. This supports the findings of Saba (2015), who reported that 78.3% of respondents were between 16 and 60 years old. This age range represents a productive segment of the population, which is crucial for managing dairy farms and benefiting from training and extension services.

Educationally, 30.8% of the respondents were illiterate, 23.2% could read and write, 25.9% had completed primary education, 14.1% had attended high school, 4.9% held a diploma, and only 1.1% had a degree or higher. This indicates that illiteracy was common among respondents, a finding supported by Gemede (2021), who reported a 36.85% illiteracy rate in the Bule Hora district. Education plays a vital role in building a supportive society and enhancing dairy production through the transfer of knowledge, skills, and attitudes. The high level of illiteracy may hinder the adoption of new technologies in the local dairy sector, as also noted by (Saba ,2015).

Table 2 :Socio-demographic characteristics of respondents

Category		Rural N=134 (%)	urban N=51(%)	Over all N=185(%)
Gender	Male	121 (90.3)	44 (86.3)	165 (89.2)
	Female	13 (9.7)	7 (13.7)	20 (10.8)
Marital statuses	Married	120 (89.9)	47 (92.2)	167 (90.3)
	Divorced	3 (2.2)	0 (0)	3 (1.6)
	Single	5 (3.7)	4 (7.8)	9 (4.9)
	Widowed	6 (4.5)	0 (0)	6 (3.2)
Age category	18-25	3 (2.2)	4 (7.8)	7 (3.8)
	26-33	9 (6.7)	7 (13.7)	16 (8.6)
	34-41	40 (29.9)	15 (29.4)	55 (29.7)
	42-60	64 (47.8)	10 (19.6)	74 (40.0)
	61and above	18 (13.4)	15 (29.4)	33 (17.8)
Educational statusof Household head	Illiterate	49 (36.6)	8 (15.7)	57 (30.8)
	Read and write	33 (24.6)	10 (19.6)	43 (23.2)
	Primary school	42 (31.3)	6 (11.8)	48 (25.9)
	High school	6 (4.5)	20 (39.2)	26 (14.1)
	Diploma	4 (3)	5 (9.8)	9 (4.9)
	Degree and above	0 (0)	2 (3.9)	2 (1.1)

N=Number of respondents

Source: Own survey result 2024

4.2. Milk Production in the Study Area

4.2.1. Purpose of milk production in the study area

The results, as shown in Figure 2, indicate that the primary reasons for keeping dairy cows in the study area were both for home consumption and market, with 38.9% of respondents keeping cows for both purposes, 35.5% for home consumption, and 25.5% for market sales. In contrast, the majority of respondents in the urban areas, 66.7%, kept dairy cows primarily for market purposes. This trend can be attributed to the support provided by the SNV project, which has facilitated better access to markets. These findings are consistent with those of Samuel (2020), who reported that most households in urban areas 74.2% produced milk primarily for sale, while in mixed crop-livestock systems, a significant portion 37.9% used milk for household consumption. As in many parts of Ethiopia, milk plays an important role in the diet of people in the study areas of Dale District, Sidama Region (Azeze and Haji, 2017).

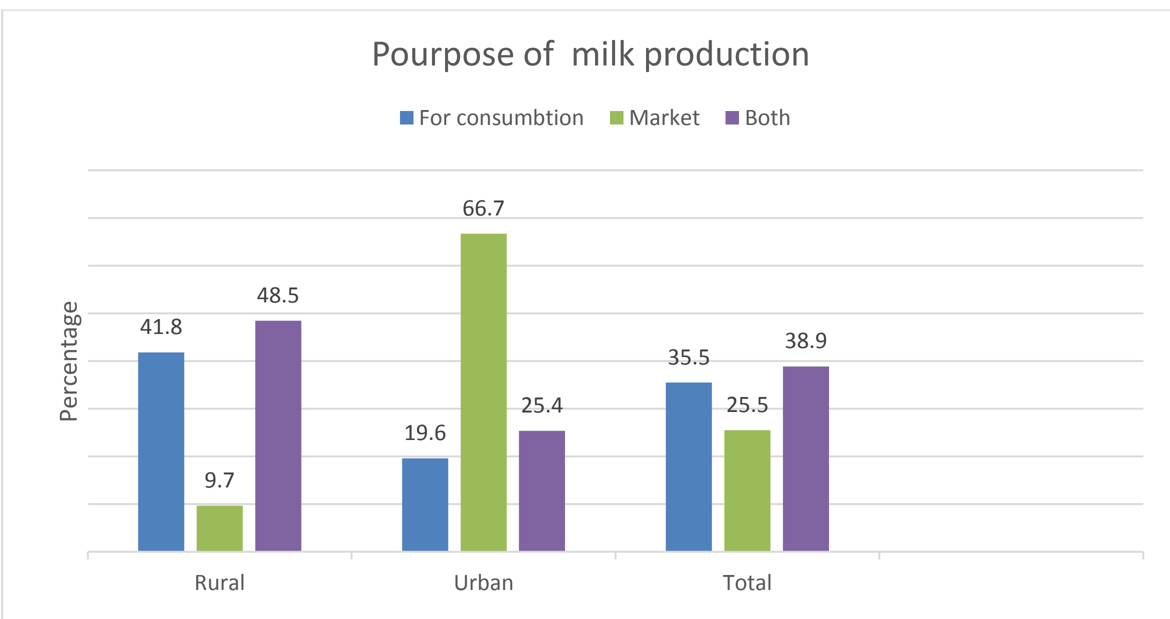


Figure 2: Purpose of milk production

Source: Own survey result 2024

4.2.2. Breed type and breeding system of dairy cows

In the study area, the majority of respondents owned local breed dairy cows, 61.1%, followed by crossbreeds, 21.1%, and those who owned both types, 17.8%. The proportion of crossbred cows was significantly higher in urban areas 49% compared to rural areas 10.4%. These findings are consistent with those reported by Gemmede (2021), who observed that most dairy cattle owners in Bule Hora district relied primarily on local breeds, accounting for 89.5% and 84.1% in the highland and midland zones, respectively. Only a small fraction of farmers in those areas, 8.8% in the highland and 9.5% in the midland, kept mixed breeds. However, the current findings differ from those of Samuel (2020), who reported that purebred dairy cows predominated in the peri-urban and urban areas of Sebeta town in the Oromia region.

Regarding breeding methods, 49.9% of households in the study area preferred artificial insemination (AI). Nonetheless, 30.6% of rural and 15.7% of urban respondents still used natural mating. These findings align with Sintayehu et al.(2008) , who reported that 53.9% of households favored AI. In contrast, Gemede, (2021) found that most dairy farmers (96.5% in the highland and 88.9% in the midland) of Bule Hora district used natural mating as their primary breeding method. The preference for AI in the current study may be explained by the Enset–coffee-based farming system common in the Sidama region, where oxen are not widely used for draught power, resulting in a shortage of breeding bulls. This challenge, as noted by Yilma (2021), has led many farmers in such systems to rely on AI as an alternative breeding method.

Table 3 :Breed type and breeding system of dairy cattle by location in dale district

Variables	Category	Rural N=134(%)	Urban N=51(%)	Over all N=185(%)
Breed Type	Local	98 (73.1)	15 (29.4)	113 (61.1)
	Cross	14 (10.4)	25 (49)	39 (21.1)
	Both	22 (16.5)	11 (21.6)	33 (17.8)
Breeding System	Natural	41 (30.6)	8 (15.7)	49 (26.5)
	AI	46 (34.3)	37 (72.5)	83 (49.9)
	Both	47 (35.1)	6 (11.8)	53 (28.6)

N=Number of respondents

Source: Own survey result;2024

4.2.3 Milk yield and lactation length of local and Cross breed cows

In this study, the average daily milk yield of local cows was 1.91±0.61 liters in rural areas and 2.27±0.63 liters in urban areas. There was asignificance difference observed in the rural and urban area at ($p \leq 0.05$). These findings align with Gemede (2021), who reported 1.67±0.627 liters/day, and Mitiku et al. (2019) , who found 2.23 liters/day in Haramaya District. Similarly, Neamn (2020), reported an average of 1.85 liters/day, ranging from 1.24 liters in rural lowlands to 2.31 liters in rural highlands.can you explain the below red part

For crossbred cows, the mean daily milk production was significantly higher ($p<0.05$), with 5.29±0.72 liters in rural and 7.17±0.82 liters in urban areas. These results are comparable to the 7.3 liters/day reported by Yayeh et al. (2017) in Debre Markos. However, they are lower than the 11.6 and 10.8 liters/day reported by Dessalegn et al. (2016) in Bishoftu and Akaki, possibly due to differences in environment and management (Beneberu , 2023b).

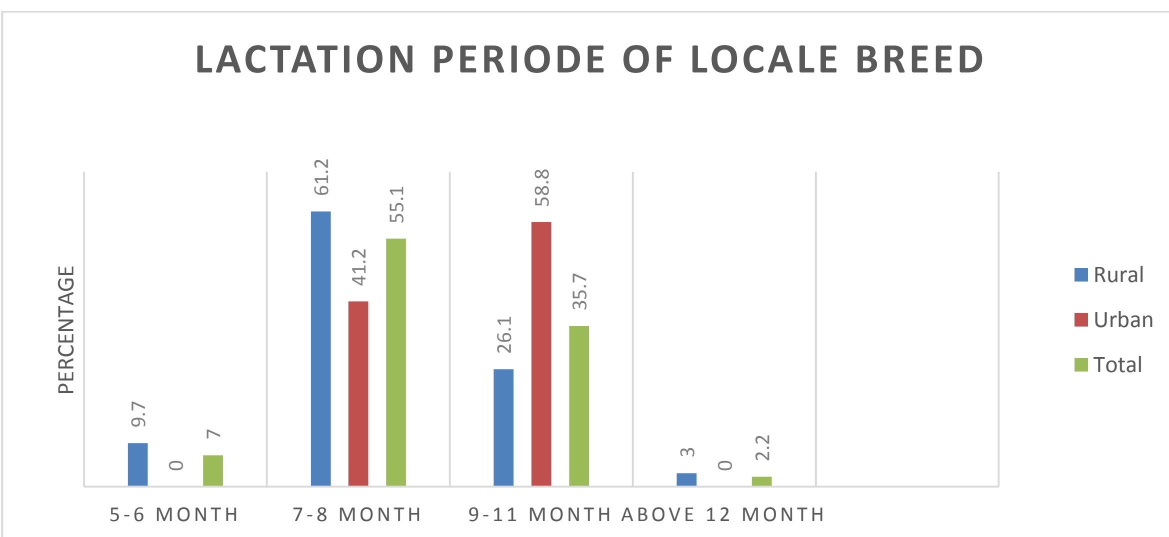
Regarding lactation length, 55.1% of rural households stated that local cows are milked for 7–8 months, while 58.8% of urban respondents reported 9–11 months, likely due to better feed and management in urban areas. This agrees with Yitagesu (2017), who reported lactation lengths of 9.97±0.14 months in peri-urban and 10.75±0.26 months in urban systems. Similarly, Hundie (2014), recorded 10.53 and 12.0 months in Shambu and Kombolcha. For crossbred cows, 50.7% of rural households reported a lactation period of 9–11 months. This aligns with Gemede (2021), who noted 11 months or more for crossbreeds in Bule Hora. (Yay et al. (2017) also reported over 8.7 months in Debre Markos.

Table 4: Daily milk yield (DMY) per cow by breed type and study area

Variable	Study area		
	Rural Mean±SD	Urban Mean±SD	P
DMY/day/cow (local)	1.91±0.61	2.27±0.63	0.018
DMY/day/cow (crossbred)	5.29±0.72	7.17±0.82	000

Number of respondents:Rural=134:Urban=51; SD = Standard deviation

Source: Own survey result 2024



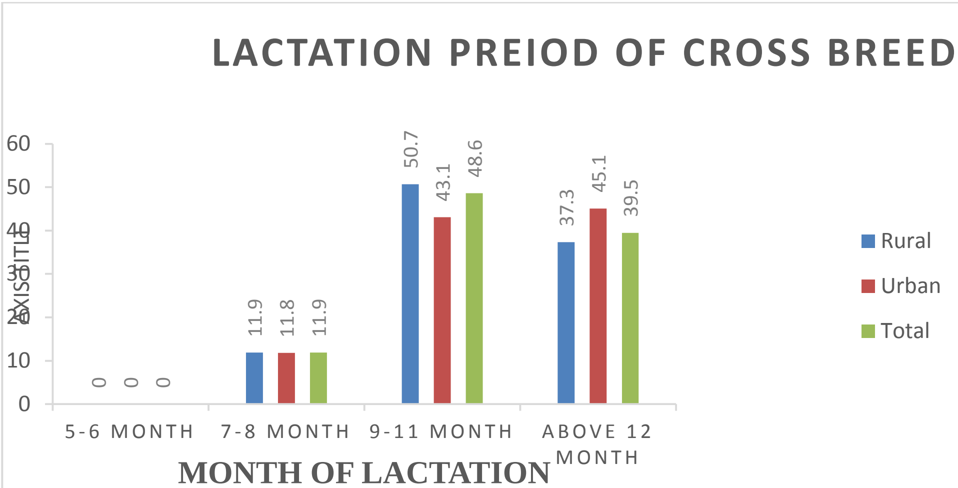


Figure 3 lactation period of dairy cows

4.3. Husbandry Practices of Dairy Cows

4.3.1. Dairy cattle housing and manure management

Table 5 summarizes housing types, flooring, manure management, and cleaning practices. In this study, 63.2% of households kept cattle in separate barns, while 36.8% shared their living space with animals. This agrees with findings from of Tsegaye *et al*. (2022) and Mitiku *et al.* (2019), who reported 80% and 85.37% of respondents, respectively, housed cattle separately. In contrast, Babege *et al*. (2020b) found that 96.7% kept animals inside the family house for protection, with only 3.3% using separate barns. Most respondents (77.8%) did not use bedding materials, consistent with Mitiku *et al*. (2019). However,Kibebew *et al*. (2020a) reported that 88.9% used low-quality grass or straw bedding. The low usage may be due to cost, limited availability, or tradition (Lakew *et al*., 2019). A majority (66.5%) used muddy floors, while 62.7% of urban respondents preferred concrete flooring. This supports Gemede (2021), who found 91.1% of households used earthen floors.

Regarding manure management, 75.1% of respondents used it as fertilizer especially in rural areas (97.8%). In contrast, 80.4% of urban households paid to dispose of manure. This highlights its value for crop production and nutrient cycling in rural areas. Although manure can also be used for biogas, this was not practiced in the study areas. Therefore, extension

	Rural	Urban	Total

systems should find ways to utilize surplus manure from urban farms(Berhe *et al*. 2024) .

In terms of hygiene, 58.7% of households cleaned barns daily, while 80.4% of urban respondents cleaned twice a day, likely because cattle remain confined. This aligns with Oumer *et al*. (2017), who reported most smallholders cleaned daily (87%). Regular cleaning is essential

		N=134 %	N=51 %	N=185 %
Housing Type	Separate house	71 (53)	46 (90.2)	117 (63.2)
	Share with family	63 (47)	5 (9.8)	68 (36.8)
Floor Type	Concrete	22 (16.4)	32 (62.7)	54 (29.2)
	Cement	2 (1.5)	4 (7.8)	6 (3.2)
	Muddy soil	110 (81.1)	13 (25.5)	123 (66.5)
	Wood	0 (0)	2 (3.9)	2 (1.1)
Bedding Material	No bedding	107 (79.9)	37 (72.5)	144 (77.8)
	Grass or cereal straw	10 (7.5)	1 (2)	11 (5.9)
	Saw dust	17 (12.7)	13 (25.5)	30 (16.2)
Manure Management	Used as fertilizer	131 (97.8)	8 (15.7)	139 (75.1)
	used for biogas	2 (1.5)	2 (3.9)	4 (2.2)
	Used energy	1 (0.7)	0 (0)	1 (0.5)
	remove without use	0 (0)	41 (80.4)	41 (22.2)
Barn Cleaning Frequency	Once /a day	98 (73.1)	9 (8.4)	107 (57.8)
	Twice/ a day	34 (25.4)	41 (80.4)	75 (40.5)
	Once /every 2 days	2 (1.5)	0 (0)	2 (1.1)
	Three x / day	0 (0)	1 (2)	1 (0.5)

for hygienic milk production and is highly recommended.

Table 5: Housing type and manure management

N=Number of respondents

Source; own survey result; 2024

4.3.2. Source of feed and feeding systems

Table 6 presents the types of feed resources and their seasonal variation in the study area. During the dry season, enset was the primary feed source, used by 31.9% of farmers, followed by crop residues at 23.3%. In contrast, during the wet season, natural pasture was the most common feed, accounting for 38.4%, followed by enset 18.4%, hay 17.8%, supplementary feeds and home byproducts 12.4%, and crop residues 8.6%. Additional feed sources included chopped enset pseudo-stems, whole or chopped maize plants, and leaves from various fruit and tree species. These findings are consistent with Asrat et al.(2015), who reported that during the dry season—especially in enset-based rather than cereal crop-based systems farmers commonly feed cattle with enset pseudo-stems, banana leaves, parts of sugarcane and bagasse, and a variety of tree leaves. These feed types are valued for their high nutritional content and year-round availability.

In enset and coffee-based farming systems, cows are typically grazed along roadsides or tethered in backyards. A majority of rural respondents 75.4% practice stall feeding with limited grazing, while 47.1% of urban respondents rely solely on stall feeding. Regarding feed sources, 60.5% of dairy farmers produce feed on their own farms. An additional 20.5% use both farm-produced and purchased feeds, while 18.9% rely entirely on purchased feeds. Notably, in urban areas, 82.9% of dairy producers purchase all their feed, primarily due to land shortages caused by urbanization.

Table 6: Feed resources and feeding system for cows in rural and urban areas

Feed Resources /Feeding System		Rural N=134 %	Urban N=51 %	Total N=185 %
	Natural pasture	6 (4.5)	2 (3.9)	8 (4.3)
	Crop residues/straw	33 (24.6)	10 (19.6)	43 (23.2)

Dry Season Feed Resources	Enset	52 (38.5)	7 (13.7)	59 (31.9)
	Supple and home-produced by-products	6 (4.5)	9 (17.6)	15 (8.1)
	Hay	32 (23.9)	16 (31.4)	48 (25.9)
	Improved forage	5 (3.7)	7 (13.7)	12 (6.5)
Wet Season Feed Resources	Natural pasture	59 (44)	12 (23.5)	71 (38.4)
	Crop residues/straw	13 (9.7)	3 (5.9)	16 (8.6)
	Enset	31 (23.1)	3 (5.9)	34 (18.4)
	Supplements and home-produced by-products	8 (6)	15 (29.4)	23 (12.4)
	Hay	20 (14.9)	13 (25.5)	33 (17.8)
	Improved forage	3 (2.2)	5 (9.8)	8 (4.4)
Feeding System	Free grazing (fulltime)	12 (9)	0 (0)	12 (6.5)
	Stall feeding	20 (14.9)	24 (47.1)	444 (23.8)
	Stall feeding with limited grazing	101 (75.4)	13 (25.5)	114 (61.5)
	Cutting and caring	1 (0.7)	14 (27.5)	15 (8.1)
Major Source of Feed	Own farm produced only	112 (83.6)	0 (0)	112 (60.5)
	Purchased only	6 (4.5)	29 (82.9)	35 (18.9)
	Both produced and purchased	16 (11.9)	22 (57.9)	38 (20.5)

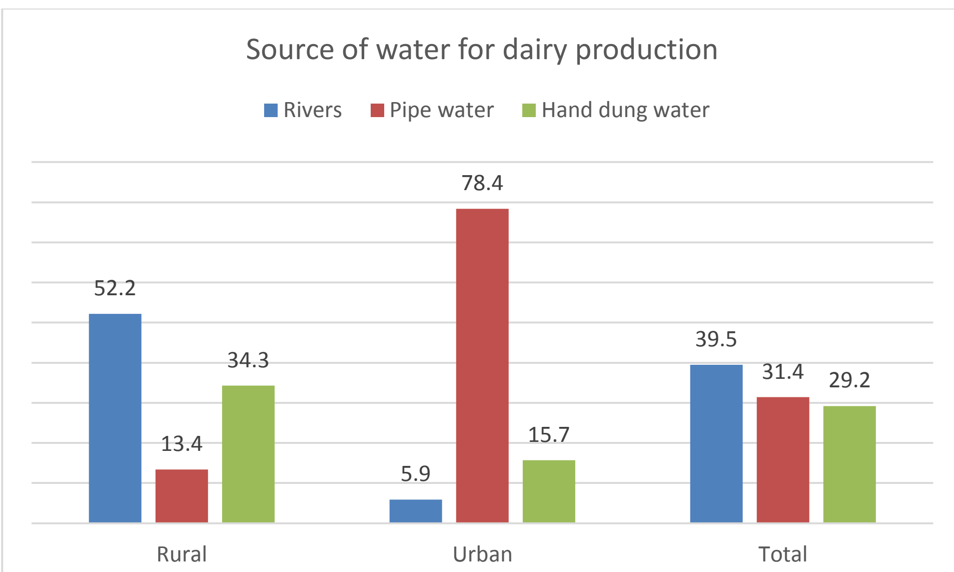
Industrial by product **Enset**

Improved forage (Elephant grass) **Concentrate**

Figure 4: Sources of feed in the study area

4.3.3 Source of water

The main water sources in the study area were rivers 39.5%, pipe water 31.4%, and hand-dug wells 29.2%. In urban areas majority 78.4% of households relied on tap water. Access to clean water is essential for maintaining hygiene in dairy production, as it allows farmers to properly clean the cows, the milking environment, and equipment ensuring the production of safe and hygienic milk.These findings align with the study by Yitagesu (2017), who emphasized the importance of water quality in maintaining dairy cattle health and milk quality. Similarly, Yetera et al. (2018a), highlighted that regular monitoring and treatment of water sources are critical to prevent waterborne diseases and to support animal health and productivity.



Source: own survey result 2024

4.4. Milk Handling and Hygienic Practice

4. 4.1. Milking Practices and Milk Handling

All respondents 100% in the study area practiced hand milking, which is consistent with findings by Kibebew *et al*. (2020b), who reported that all households in the Cheha District of the Gurage Zone, Southern Ethiopia, also used hand milking. Similarly, Yieng *et al*.(2015) observed that all dairy farmers in the Gambella region used the same method.

In terms of milking frequency, 89.2% of households in the study area milked their cows twice a day, a result that aligns with the findings of Kibebew *et al*. (2020b), who reported that 96.7% of dairy farmers milked twice daily, while 3.3% milked once per day.

Regarding milk handling, the study revealed that 54.6% of respondents did not filter the milk before use. Additionally, 52.4% of households reported consuming both raw and processed milk, indicating varied milk consumption habits among the population.

These results suggest a need for improved training and awareness on hygienic milk handling and processing methods. Promoting better sanitation practices, including filtering milk and encouraging pasteurization, could enhance the quality of milk for both producers and consumers.

Table 7. Milk handling practice in the study area

Variables		Rural N=134 (%)	Urban N=51 (%)	Total N=185 (%)
Method of Milking	Hand milking	134 (100)	51 (100)	185 (100)
Milking Frequency	once/day	5 (3.7)	0 (0)	5 (2.7)
	twice/day	121 (90.3)	44 (86.3)	165 (89.2)
	Three times per day	8(6)	7(13.7)	15(8.1)
Filter Milk after milking	Yes	53 (39.6)	31 (60.8)	84 (45.5)
	No	81(60.4)	20(30.2)	101(54.6)
Milk Consumption Ways	Fresh raw milk	3 (2.2)	7 (13.7)	10 (5.4)
	Boiled milk with coffee	20 (14.9)	33 (64.7)	53 (28.7)
	Processed into traditional Ergo	3 (2.2)	7 (13.7)	10 (5.4)
	Processed into Arera	11 (11.2)	0 (0)	15 (8.1)
	Both raw and processed milk	93 (69.4)	4 (7.8)	97 (52.4)

N=Number of respondent

4.4.2. Milk preservation methods

The majority of respondents in the study area 60.3% reported using some form of milk preservation. In rural areas, 45.5% of respondents preserved milk by keeping it in a cool place, while 38.8% used traditional smoking methods at room temperature to extend shelf life. In contrast, 35.3% 64.5% of urban households did not preserve milk at all, opting instead to sell it immediately after milking.These findings are consistent with the study by Gemede (2021), who found that a large proportion of dairy farmers 84.2% in the highlands and 79.4% in the midlands preserve milk by storing it in cool environments. However, a key challenge in both rural and urban areas of the current study is the lack of proper cooling facilities, which limits the effectiveness of milk preservation and poses risks to milk quality and safety.This situation highlights a critical gap in milk preservation infrastructure, particularly the absence of effective cooling systems, affecting rural and urban producers. As supported by previous research, such as Gemede (2021), cold storage is essential for maintaining milk quality.

Table 8: Milk preservation practices among rural and urban households

Catagory		Rural	Urban	Total
		N=134(%)	N=51(%)	N=185(%)
Do you preserve milk?	Yes	114 (85.1)	18 (35.5)	132 (60.3)
	No	20 (14.9)	33 (64.5)	53 (39.7)
Method of Preservation	Cooling at ambient temperature	52(38.8)	1 (2)	53(20.4)
	Refrigeration (fridge)	1 (0.7)	15 (29.4)	16 (15.1)
	Cold place storage	61 (45.6)	2 (3.9)	63 (24.7)
	No preservation	20 (14.9)	33 (64.7)	53 (39.8)

N=Number of respondents

4.4.3 Milk hygiene practice in the study area

4.4.3.1. Milk handling material and its hygiene

The cleanliness and type of milk handling equipment significantly affect the quality and safety of milk and milk products. According to Chala and Mitiku (2021), proper cleaning of milking and storage utensils is essential, as milk is highly perishable and easily contaminated. Regular cleaning and proper drainage of equipment after each milking session help minimize microbial contamination. As Gabe (2023) emphasized, dairy producers must pay close attention not onlyto the cleanliness but also to the type of containers used during milking and storage.In the study area, plastic containers were the most commonly used milking equipment, reported by 68.6% of respondents. Among rural households, 20.9% used quill, and 16.4% used clay pots for milking. These findings were consistent with Kibebew *et al*. (2020a), who found that 95.6% of dairy households in the Cheha District of Gurage Zone used plastic containers, while only 4.4% used stainless steel. However, these results differ fromMitiku *et al*.(2019) , who reported the predominant use of traditional gourd vessels (67.48%) and plastic jerry cans (28.45%) in the Haramaya District. Regarding storage, 62.7% 63.4% of rural dairy producers used clay pots, while in urban areas, 74.5% relied on plastic containers. For milk transportation, 65.4% of producers used plastic jerry cans, while in rural areas, 63.4% also stored milk in clay pots until enough volume was collected for processing. However, plastic containers, while affordable, are harder to clean thoroughly compared to metal containers, increasing the risk of contamination from leftover milk and dirt particles. Although metal containers are ideal due to their ease of cleaning and disinfecting, their high cost limits their use among smallholder farmers.

All respondents in the study area reported washing their milking equipment. The majority 36.2% used both hot and cold water alternately, while in urban areas, 56.9% used hot water specifically. These findings align with Haile *et al*. (2012), who found that 85.6% of producers in Hawassa cleaned milk containers using warm water with detergents, while 12.1% used only cold water. Moreover, 100% of respondents practiced fumigation of milk containers using "Ejersa" (*Olea africana*) after washing. This traditional method of disinfecting milk utensils is widely practiced and confirmed by studies such as Nuredin (2020) , who reported universal use of *Olea africana* for smoking milk vessels. Other studies, including (Mitiku *et* *al*. 2020; Getaneh 2023; Mebrate *et al*.,2020; Azeze *et al*. 2024; Teshome *et al*.,2023), also confirm the widespread use of *Olea africana* across various parts of Ethiopia. In summary, the type and hygiene of milking equipment are major factors influencing milk quality. Although plastic is the most commonly used material due to its affordability, its limitations in cleanliness pose challenges. Traditional cleaning and fumigation methods remain vital in maintaining milk safety, especially in areas lacking access to modern equipment. One of the major factors affecting the quality of dairy products is milking utensils. The interviewed households used different equipment for milking, storage, and transporting in the Dale district.

Table 8. Milking equipment and its hygiene in the study area

Variable		Rural	Urban	Total
		N =134(%)	N=51(%)	N=185(%)
Milking equipment	Aluminum	0 (0)	8 (15.7)	8 (4.3)
	Plastic	84 (62.7)	43 (84.3)	127 (68.6)
	Quil	28 (20.9)	0 (0)	28 (15.1)
	clay pot	22 (16.4)	0 (0)	22 (11.9)
A container to store milk	Pots	85 (63.4)	0 (0)	85 (45.9)
	Plastic	36 (26.9)	38 (74.5)	74 (40)
	Aluminum	13 (9.7)	13 (25.5)	26 (14.1)
A container to transport milk to market	Plastic (jerry-can)	83 (61.9)	38 (74.5)	121 (65.4)
	Quill	44 (32.8)	0 (0)	44 (23.8)
	Aluminum containers	7 (5.2)	13 (25.5)	20 (10.8)
Wash equipment before milking.	Yes	134 (100)	51 (100)	185 (100)
	No	0 (0)	0 (0)	0 (0)
Types of water for wash equipment	Cold water	38 (28.4)	15 (29.4)	53 (28.6)
	hot water	38 (28.4)	29 (56.9)	67 (36.2)
	Both alternatively	58 (35.1)	7 (13.7)	65 (35.1)
Smoke milk handling equipment	Yes	129 (96.8)	50 (98)	179 (96.8)
	No	5 (3.7)	1 (2)	6 (3.2)

N=Number of respondent

4.4.3.2. Personal hygienes

In the study area, women were primarily responsible for milking and cleaning activities, accounting for 70.3% of the participants involved. This was followed by herded laborers 12.4%, men 10.8%, and children 6.5%. These results were consistent with Mitiku et al .(2019), who found that most dairy farm operations were carried out by female household members. Regarding hygiene practices, 76.8% of the dairy producers reported washing their hands both before and after milking, an important step in reducing contamination. This finding aligns with Mitiku *et al* .(2019), who reported that 94.31% of milkers in the Haramaya district washed their hands before milking. However, personal hygiene practices related to protective clothing were less common. In the study area, 56.4% of producers did not use hair covers during milking, while only 38.4% did. This contrasts with the findings of Saba (2015), who observed that milk producers and collectors in the West Shoa Zone also neglected to use hair covers or gowns during milk collection.

Maintaining proper personal hygiene is critical in preventing milk contamination. As Mohamed *et al*. (2024)**,** highlighted, the milker can be a key source of contamination, and therefore, strict hygiene practices such as washing hands, covering hair, and using clean clothingare essential for ensuring the safety and quality of milk.

Table 9. Personal responsibility and hygiene in the study area

Variables		Category of urban and rural kebeles		
		Rural N=134 , %	Urban N=51, %	Total N=185, %
Responsible for milking	Men	9 (6.7)	11 (21.6)	20 (10,8)
	Women.	106 (79.1)	24 (47.1)	130 (70.3)
	Children	12 (9)	0 (0)	12 (6.5)
	Hired laborer	7 (5.2)	16 (31.4)	23 (12.4)
Wash hands during milking.	Yes	134 (100)	51 (100)	185 (100)
	No	-	-	-
Timing of washing hands	Before milking	35 (26.1)	0 (0)	35 (18.9)
	After milking	8 (6)	0 (0)	6 (4.3)
	Both	91 (67.9)	51 (100)	142 (76.8)
Wear a hair cover during milking.	Yes	54 (40.3)	26 (51)	80 (43.2)
	No	80 (59.4)	25 (49)	71 (56.8)

N=Number of respondents

Source: own survey result 2024

4.4.3.3. Cow hygienic practices

Based on the survey result, most of the respondents, 54.1%, in the study area practiced udder washing large number of dairy producers, 44.3%, washed udder before milking only, followed by 9.7% of the respondents who washed udder both before and after milking. However, most of the respondents, 53.7% of households in the rural area, did not wash the udder. This might be due to a lack of training in the study area. The study was similar to the findings of Chala and Mitiku (2021), who reported 66.15% of the respondent washed the udder of the cow before milking, and 33.85% did not wash and simply allowed their calves to suckle before milking. Also similar to the study of Saba (2015), reported that 62.2% of the dairy producers washed their cows' udder before milking, and 37.8% did not wash and simply allowed their calves to suckle before milking. The current result was lower than the result of Haile *et al*. (2012), who reported that 82.5% of the small-sized farm owning households in Hawassa city practice pre-milking udder washing. However, the present study is not agry with the study of Abebe *et al*. (2012) who reported that not all respondents did not used udder washing before milking in the Gurage Zone, Ezha district. However, most of the respondents practice udder washing in the study area. There is a lack of awareness about proper drying of the udder of dairy cows because of improving the quality of milk, all respondents should be well trained bout udder washing and proper drying.

The result shows that about 42.3% of dairy producers from participating udder washing use towels for dring of udder after milking, from these bout 25.4% use common towel, while bout 8.6% of the dairy producers use individual towels for all lactating cows, the study was slightly agry with the study of Abebe *et al.* (2018), who reported that about 42 % of the householdes used the same towel to dry the udder of all lactating cows; while 38% used their hands to wipe the water from the udder. Only 19.6% use an individual towel for each lactating cow. This might be mainly due to a lack of awareness and low level of educational status, absence of training related to hygienic practices in milk production, and lack of awareness about the effect of hygiene on milk and milk products quality. The proportion of using common towels was greater than that of using individual towels, which leads to the transfer of disease from infected cows to other noninfected healthy cows and also causes microbial contamination of milk.

Based on the survey result, most of the householders about 37.8%, wash udder with cold water. The result was contrasting with the reporte of Abebe *et al*.(2018) who said that About 72.5% use warm water for cleaning udder .

Table 10. Cow hygiene practices in rural and urban area of the study.

Cow hygiene practice		Category of urban and rural kebeles		
		Rural	Urban	Over all
		N=134 (%)	N=51(%)	N=185(%)
Washudder during milking	Yes	62 (46.3)	38 (74.5)	100 (54.1)
	No	72 (53.7)	13 (25.5)	85 (45.9)
Timing of udder washing	Both before and after milking	13 (9.7)	5 (9.8)	18 (9.7)
	Before milking only	49 (36.6)	33 (64.7)	82 (44.3)
Use towel for drying the udder after washing	Yes	32 (23.9)	31 (60.8)	63 (42.3%)
	No	30 (22.4)	7 (13.7)	37 (20)
Typeof towel used for udder drying	Common towel	24 (17.9)	23 (45.1)	47(25.4)
	Individual towel	8 (6)	8 (15.7)	16 (8.6)
	Bare hands	30 (22.4)	7 (13.7)	37 (20)
Water temperature used for washing	Cold	43 (32.1)	27 (52.9)	70 (37.8)
	Warm	11 (21.6)	11 (8.2)	22 (11.9)
	Both alternatively	8 (6)	0 (0)	8 (4.3)
	No wash at all	72 (53.7)	13 (25.5)	85 (45.9)

N=Number of respondents
Source: own survey result 2024

4.3.3.4. Constraints and opportunities for dairy production

The major constraints affecting dairy production in the area were presented in Table 14.

The constraints in the study area were identified and ranked with their priorities using the index method. In the Rural and Urban areas of the Dale district. The shortage of land occupied the first position, followed by the feed shortage in the rural area of the Dale district. On the other hand, feed shortage was ranked first as a major constraint for dairy cow production in the urban area of the study, followed by shortage of land. Accordingly, the major constraints hindering dairy production in the current study area were feed shortage, disease, lack of improved breeds, water scarcity, and market problems. The study findings were in line with (Tsegaye *et al*. 2015; Ahmedin and Yishak 2020), who reported that shortage of feed, health problems, water scarcity, and labor scarcity as major challenges that affect dairy cattle production and productivity in the selected district of Sidama Zone, Southern Ethiopia. The result was also similar to the study of Belay and Janssens (2016), which reported that feed shortage was the major constraint in Jimma town, Ethiopia.

Even though the dairy cow production was constrained by various problems mentioned earlier. There were many opportunities, especially in the study area, during data collection, the agricultural office head said that at the moment the SNV Project is working with the cooperative with the dairy farmers and gives training for farmers to increase the quality of milk, and also the productivity of dairy cows and create market opportunities. There was a cooperative group that collected milk from the urban and rural areas and sold it to the dairy processing industry that was found in Addis Ababa. This was the main opportunity for dairy farmers for now and for the future.

The area was experiencing increasing demand for milk and milk products from time to time. Access to veterinary services, implementation of vaccination before the outbreak of the diseases, availability of different feed resources, although they vary seasonally, and the infrastructure development in the area. Moreover, the area practiced integrated crop livestock production, which could contribute to the future improvement prospects, via the introduction of intercropping of improved forage species, even though land holding was small across the study area, particularly in Dale. The study was similar to (Abera *et al*. 2018).

Table 11. Constraints of rural dairy production in the study area

	Priority level									
Constraint	1	2	3	4	5	6	7	8	9	index	rank
Feed shortage	58	16	3	35	11	6	5	0	0	0.16	2
Drought	4	0	37	9	17	9	16	2	40	0.09	6
Disease	0	9	32	29	17	9	14	22	2	0.11	4
Market problem	49	17	13	40	5	10	0	0	0	0.16	3
Lack of improved breed	0	0	3	10	30	33	37	15	6	0.08	7
Lack of veterinary service	0	0	0	1	25	14	32	39	23	0.06	8
Lack of extension service	0	0	0	1	9	22	14	27	61	0.05	9
Water scarcity	10	13	17	6	11	30	16	29	2	0.10	5
Shortage land	13	79	29	3	9	1	0	0	0	0.17	1

Table 12. The constraints of urban dairy production in the study are

	Priority level									
Constraint	1	2	3	4	5	6	7	8	9	index	rank
Feed shortage	47	4	0	0	0	0	0	0	0	0.198	1
Drought	0	0	7	0	0	4	0	f0	40	0.045	9
Disease	0	13	7	11	8	0	5	7	0	0.125	4
Market problem	4	15	7	16	0	4	0	5	0	0.142	3
Lack of improved breed	0	0	0	7	12	5	27	0	0	0.088	7
Lack of veterinary service	0	0	5	8	12	10	1	15	0	0.094	5
Lack of extension service	0	0	8	7	7	13	5	0	11	0.091	6
Water scarcity	0	0	0	2	5	7	13	24	0	0.066	8
Shortage land	0	19	17	0	7	8	0	0	0	0.17	2

4.5. Constraints of Quality Milk Production

The major constraints of quality milk production in the study area were a lack of clean water41%, followed by a lack of cooling facilities32.1 in the rural area, and environmental hygiene 52.9%, followed by cooling facilities29.4% in the urban area, respectively .

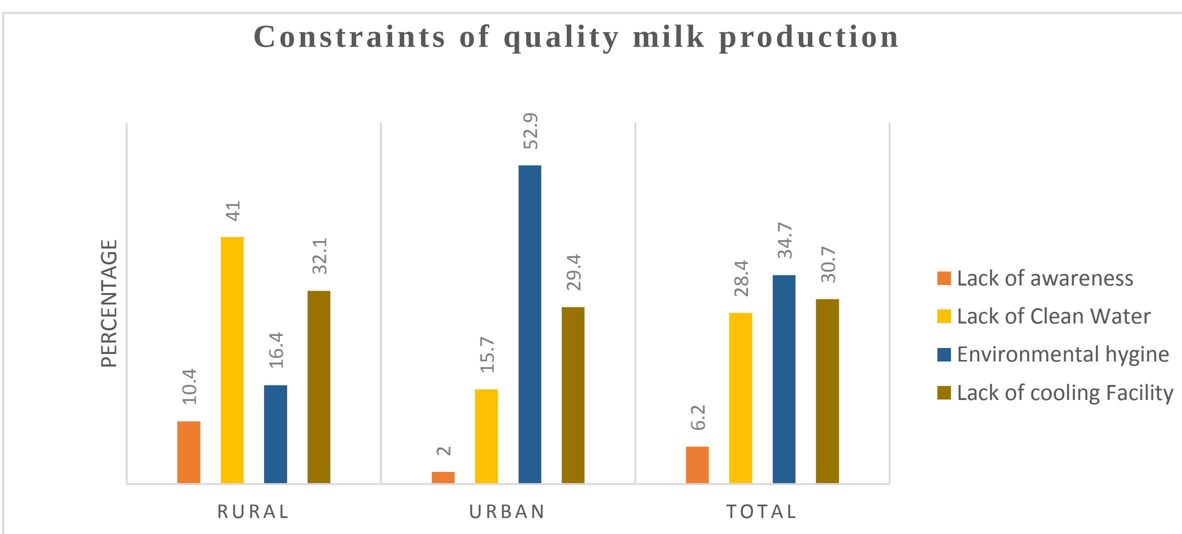


Figure 5: Constraints of quality milk production

4.6 Association of the Household Characterstics with Hygenic Practices

A, Association of Age with hygienic milking practice

The study reveals age-based variations in hygienic and management practices among dairy farmers. While handwashing during milking was widely practiced across all age groups (above 85%), the practice of washing cow udders both before and after milking significantly differs ($p = 0.005$), with younger farmers (26–33) showing better adherence (81.2%) compared to older groups (52.7% in 42–60). Similar trends are observed in the type of water used for udder washing ($p = 0.000$), where younger farmers prefer warm water (56.2% in 26–33), which was more effective in reducing bacterial load (Girma, 2022), while older groups rely on cold water. The milking frequency was also significantly influenced by age ($p = 0.023$), with most farmers milking twice per day, aligning with findings by (Yeserah, 2020)in Bahir Dar, where twice-daily milking was common for improved breeds.Moreover, while filtering milk after milking was more common among younger farmers (71.4% in 18–25), the practice declines among older groups, potentially increasing contamination risk. The type of milking equipment showed statistically significant variation ($p = 0.020$), with plastic containers most commonly used, although these are harder to clean effectively and pose hygiene risks compared to aluminum (Zelalem & Inger, 2000). Barn cleaning frequency, though not significantly different across groups, was highest in older farmers, perhaps due to greater routine discipline.When compared to similar studies such as Yilma et al. (2011) and SNV (2008), the current results support the conclusion that hygiene awareness and modern practices are more prevalent among younger and middle-aged farmers. However, access to resources (e.g., warm water, aluminum containers) and awareness campaigns may still be lacking among older groups or rural settings.

Parameters	Catagory	Age						
		18-25	26-33	34-41	42-60	61 and above	X2	P-value
Wash hands during milking	Yes	85.7	87.5	92.7	94.6	93.3	1.648	0.800
	No	14.3	12.5	7.3	5.4	6.7		
When you wash your hand	Before milking	-	18.8	20	24.3	9.1	11.329	0.184
	After milking	-	-	3.6	8.1	-		
	Both	100	81.2	76.4	67.6	90.9		
When you wash cow udder	Both before and after milking	-	-	3.6	14.9	27.3	21.850	0.005
	Before milking only	100	81.2	61.8	52.7	54.5		
	No washing at all	-	18.8	34.5	32.4	18.2		
Type of water used for washing udder	Cold	85.5	18.8	50.9	50	60.6	41.997	0.000
	Warm	14.3	56.2	7.3	6.8	24.2		
	Both	-	-	7.3	8.1	-		
	no wash at all	-	25.0	34.5	35.1	15.2		
Types of water for wash equipment	Cold water	14.3	68.8	36.4	2312.1		29.613	0.000
	hot water	71.4	-	30.9	35.1	57.6		
	Both alternatively	14.3	31.2	32.7	41.9	30.3		
Milking frequency	once/day	14.3	-	1.8	2.7	3	17.381	0.023
	twice/day	85.7	81.2	94.5	93.2	75.8		
	threex/day	-	18.8	3.6	4.1	21.2		
Filter milk after milking	Yes	71.4	56.2	43.6	39.2	51.5	4.392	0.356
	No	28.6	43.8	56.4	60.8	48.5		
Milking equipment	Aluminum Containers	28.6	-	1.8	4.1	6.1	24.051	0.020
	Plastic	57.1	81.2	70.9	59.5	81.8		
	quil	14.3	-	14.5	20.3	12.1		
	clay pot	-	18.8	12.7	16.2	-		
Barn cleaning frequency	Once /a day	42.9	43.8	52.7	63.5	63.6	10.678	0.557
	Twice/ a day	57.1	56.2	41.8	36.5	36.4		
	Once /a 2 day	-	-	3.6	-	-		
	three/day	-	-	3.6	-	-		

Table 13:Association of age with hygienic milking practice

Where X2=Chi-squer test

B, Association of education with hygienic milking practice

The results indicate that handwashing during milking was a highly practiced hygiene measure across all education levels, with no statistically significant difference ($p = 0.473$), reflecting general awareness regardless of formal education. Extension service coverage tends to increase with education up to the primary and high school levels, peaking at 77.1% and 73.1%, respectively, though not significantly different ($p = 0.073$), suggesting that more educated farmers are slightly more likely to receive advisory support. When it comes to udder washing, the majority across all education levels practice washing only before milking, with low adherence to washing both before and after milking, and this practice does not vary significantly with education ($p = 0.754$). Notably, the type of water used for udder washing showed a significant association with education ($p = 0.023$), with more educated farmers (diploma holders) favoring warm water (55.6%) which is known to be more effective in reducing microbial contamination (Yeserah 2020), whereas illiterate and less educated farmers tend to use cold water or sometimes do not wash at all.These findings align with similar Ethiopian studies, such as those by (SNV 2008), which documented that education and extension contact positively influence dairy hygiene practices but are not uniformly effective in changing all aspects of farm hygiene behavior. The relatively high practice of washing hands but lower practice of thorough udder washing may reflect gaps in knowledge or resource availability.

Table 14:Association of education with hygienic milking practice

Parameters	Ctagory	Illiterate	Read and write	primary school	high school	Diploma holder	Degree holder and above	X^2	P-value
wash hands during milking	Yes	96.5	93	91.7	92.3	77.8	100	4.555	0.473
	No	3.5	7	8.3	7.7	22.2	-		
Been provided with extension services	Yes	59.6	62.8	77.1	73.1	44.4	-	10.063	0.073
	no	40.4	37.2	22.9	26.9	55.6	100		
When you wash cow udder	Both before and after milking	14	11.6	10.4	15.4	-	-	6.696	0.754
	Before milking only	54.4	65.1	54.2	65.4	77.8	100		
	No washing at all	31.6	23.3	35.4	19.2	22.2	-		
Type of water used for washing udder	Cold	42.2	60.5	47.9	61.5	33.3	100	27.748	0.023
	Warm	14	7	10.4	23.1	55.6	-		
	Both alternatively	10.5	4.7	4.2	-	-	-		
	No wash at all	35.2	22.2	33.3	7.4	1.9	-		

4.7. Milk Quality

4.6.1. Chemical composition of milk in the study area

4.7.1.1. Milk Fat Content

The results of the current study revealed that the average fat content of raw cow milk was significantly higher in rural areas (4.30 ± 0.42%) than in urban areas (3.90 ± 0.43%) ($P < 0.001$), with the overall mean (4.06 ± 0.47%) exceeding the minimum requirement set by the Ethiopian standard (≥3.5%) (ESA, 2009) and aligning well with international ranges (3.5–4.5%) (FAO, 2013). This result is consistent with the findings of Bekele et al. (2015), who reported a mean fat content of 4.38% in crossbred cows (local breed × Holstein Friesian) in Dangla town. It also closely aligns with Adinow et al. (2019), who found 4.46% milk fat in the Lemo district of Hadiya Zone.According to the U.S. Food and Drug Administration (FDA) and the Milk Ordinance and Code, the minimum acceptable milk fat content for fluid milk is 3.25% (Raff, 2011). The milk fat levels found in this study exceed the standard, indicating good fat quality. The variation in milk fat content may be attributed to several factors, including lactation stage, feeding practices, individual cow condition, and parity. These differences highlight the impact of both management and biological factors on milk composition.Rural advantage may be linked to better feeding regimes.

4.7.1.2. Protein Content of Milk

The protein content showed no statistically significant difference between rural (3.07 ± 0.12%) and urban (3.04 ± 0.28%) samples ($P > 0.05$), and the overall value (3.09 ± 0.18%) met both Ethiopian (≥3.0%) and international (3.0–3.5%) standards, indicating generally consistent nutritional quality (ESA, 2009; IDF, 2008). This finding was consistent with several previous studies.Mitiku et al. (2019), who reported a protein content of 3.24% in milk from the Haramaya District, and Adinow et al. (2019), found 3.21 ± 0.20% in Lemo District of the

Welayita Zone. Similarly, Saba, H(2015) recorded 3.09% protein content in milk from Adea Berga and Ejerie districts in the West Shoa Zone of Ethiopia.

Milk protein composition is generally stable and largely determined by genetic factors rather than environmental conditions such as diet or management practices (Falta 2021). While feeding and care can affect milk yield and fat content, the proportions of major milk proteins like casein and whey remain relatively constant.

However, some biological factors particularly the stage of lactation do influence protein levels. According to Mishra *et al*. (2022), protein concentrations are typically higher during early and late lactation, and may decrease during peak milk production in the middle of the lactation cycle.

4.7.1.3. Lactose

The average lactose content of raw milk in the study area was 4.23 ± 0.30%. No significant difference ($p > 0.05$) was found between the rural and urban areas. lactose content did not differ significantly between locations and remained around 4.2%, meeting the lower limit of national and international norms ((ES, 2009; FAO, 2013). This result is similar to the findings of Mitiku et al.(2019), who reported a lactose content of 4.27% in milk from the Haramaya district. However, the lactose content in this study was lower than that reported by Adinow et al. (2019), who found 4.9 ± 0.38% in the Lemo district of the Welayita Zone. According to EU quality standards Skovgaard (2009) , the lactose content in milk should be at least 4.2%, which aligns with the results of this study. Therefore, the lactose levels observed in this study are consistent with both EU and FDA recommendations.No significant variation; indicates stable carbohydrate content across sources

4.7.1.4. Solid-Not-Fat (SNF) Content in Milk

The average solid-not-fat (SNF) content of milk in the study area was 8.46 ± 0.84%, as shown in the table below. There was no significant difference ($p > 0.05$) between the rural and urban areas. The solids-not-fat (SNF) content averaged 8.46 ± 0.84%, which is slightly below the Ethiopian minimum requirement (≥8.5%) (ES ,2009). particularly in urban milk (8.43 ± 0.80%), suggesting possible nutrient dilution.This finding is similar to the study byTeklemichael et al.(2015), who reported an 8.75% SNF content in milk from Dire Dawa Town. According to the FDA and EU quality standards, the minimum acceptable SNF content in whole milk is 8.25% (Raff 2011). The SNF content in the study area likely varies due to factors such as nutrition and the stage of lactation.

4.7.1.5. Total solid

The overall mean total solids (TS) content of milk in the study area was 12.53 ± 0.77%. A significant difference was observed between rural and urban areas ($p < 0.05$), as shown in Table 19, Total solids were significantly higher in rural milk (12.81 ± 0.80%) compared to urban (12.33 ± 0.71%) ($P = 0.006$), with the overall mean (12.53 ± 0.77%) barely satisfying the national standard (≥12.5%) (ES, 2009). The highest TS content, 12.81 ± 0.80%, was recorded in the rural areas. This result is consistent with the findings of Mitiku et al. (2019), who reported a TS value of 12.78% in milk samples from the Harar Milk Shed, Eastern Ethiopia. However, it is lower than the TS content reported byBekele et al.(2015), which was 13.87% in the urban and peri-urban areas of Dangila town, in the Western Amhara Region.

According to the Ethiopian Quality Standards Authority (ES 2009), the minimum acceptable TS content in raw cow milk is 12.80%. The rural samples in this study met this standard, while the overall mean was slightly below the requirement.Variations in total solids content can be attributed to several factors, including the cow's diet, stage of lactation, breed, and overall management practices(Asefa and Teshome ,2019).These findings imply that while the milk generally meets key compositional standards, urban milk may be subject to handling issues or adulteration, particularly affecting fat, SNF, and total solids content, and call for strengthened quality control in the milk supply chain (Mitiku et al.,2019)

Table 15. chemical composition of milk samples collected from rural and urban areas

Parameters	Study area			
	Rural (X±SD)	Urban (X±SD)	Overall (X±SD)	P<0.05
Fat	4.30±0.42	3.90 ±0.43	4.06±0.47	0.000
Protein	3.07±0.12	3.04±0.28	3.09±0.18	ns
Lactose	4.19±0.32	4.25±0.29	4.23±0.30	ns
SNF	8.51±0.91	8.43±0.80	8.46±0.84	ns
Total solid	12.81 ±0.80	12.33±0.71	12.53± 0.77	0.006

X=Mean,NS= None significance ,SD=Standard devetion

4.7.2. Microbial quality of milk in the study area

4.7.2.1. Total plate count (TPC)

The overall mean Total Plate Count (TPC) of raw milk in the study area was 6.88 ± 0.25 $\log_{10}$ cfu/mL, with a significant difference between rural (7.03 ± 0.27 $\log_{10}$ cfu/mL**)** and urban (**6.79** ± 0.19 $\log_{10}$ cfu/mL) samples ($p < 0.05$**),** as shown in Table . This suggests higher bacterial contamination in rural areas. These findings were comparable to those reported by Amentie et al.(2016)**,** in Eastern Ethiopia (6.02 ± 0.14 $\log_{10}$ cfu/mL),Bekele et al.(2015), in Dangila (6.14 ± 0.72 log_{10} cfu/mL), and Kumssa (2018) in Haramaya University (6.65 log_{10} cfu/mL).However, the TPC in this study was higher than that reported byAbdifatah et al. (2022), in Dessie (5.09 to 5.76 log_{10} cfu/mL), but lower than the findings of Mohamud (2022), who reported (8.70 log_{10} cfu/mL from milking buckets).According to the Ethiopian standard (ES ,2009), the acceptable limit for TPC in raw cow milk is 5.3 log_{10} cfu/mL, while the European Union standard sets the limit at 5.0 log_{10} cfu/ml Skovgaard, (2009). Therefore, the overall mean TPC observed in this study exceeds both the Ethiopian and international acceptable limits, indicating poor microbial quality of raw milk in the study area.

The total bacterial counts in this study exceed the acceptable limits set by international standards, such as Pandey (2011), which recommend TPC $\leq 10^5$ cfu/mL for raw milk. The high microbial load may be due to poor awareness of milk hygiene, low education levels, inadequate training, dirty barns and bedding materials, absence of cooling facilities, and improper milking hygiene practices.

4.7.2.2. Coliform count (CC)

The average coliform count was 4.68 ± 0.17 log_{10} cfu/mL, with significantly higher levels in rural (4.74 ± 0.20 log_{10}) than urban areas (4.63 ± 0.13 log_{10}) ($p < 0.05$). The Ethiopian raw milk standard (ES 2009), recommends TCC $\leq$ 100 cfu/mL, or $\leq$ 2.00 log_{10} cfu/mL.The mean 4.68 log_{10} cfu/mL was over 400 times higher than the acceptable limit.This indicates widespread microbial contamination in both rural and urban milk sources.TCC was slightly higher in rural areas (4.75) compared to urban areas (4.63).This poses a serious public health risk, especially if milk is consumed raw or inadequately processedThese results align with the findings of Mitiku et.al (2019) (4.82 log_{10} cfu/mL in Meta District) and Mitikuet.

al. (2020), (4.49 ± 0.09 $\log_{10}$ cfu/mL in Girar Jarso District).The observed coliform levels far exceed the standards set by the American Public Health Service, which specify <100 cfu/mL for Grade A milk and 101–200 cfu/mL for Grade B (Van Kessel et al. 2004). High coliform levels suggest possible fecal contamination, which may result from poor hygiene, unclean milking equipment, dirty hands, or inadequate barn sanitation (Macharia et al., 2024).The p-value (0.019) indicates this difference was statistically significant, suggesting environmental, infrastructural, or hygienic disparities between rural and urban milk handling.

4.7.2.3. Yeast and mold count (YMC)

The overall mean yeast and mold count (YMC) was 4.54 ± 0.08 $\log_{10}$ cfu/mL, with rural milk samples recording slightly higher levels (4.63 ± 0.15 $\log_{10}$ cfu/mL) compared to urban samples (4.54 ± 0.08 $\log_{10}$ cfu/mL**)**, a statistically significant difference **(**$p \leq 0.05$**).**When compared to the Ethiopian microbiological standard for yeast and mold count in raw milk**,** which recommends a maximum of 4 $\log_{10}$ cfu/mL**,** the results from both rural and urban samples exceed the acceptable limit, indicating poor microbial quality (ES, 2009).These findings are also higher than those reported in Worabe town (2.95 ± 0.44 $\log_{10}$ cfu/mL), but comparable to the results of Haile et al. (2012)who found a YMC of 4.65 $\log_{10}$ cfu/mL from milking equipment.The elevated YMC observed in this study could be attributed to multiple factors, including contamination from airborne spores, use of unclean containers, poor hygienic practices by milkers, and prolonged exposure of milk to ambient temperatures especially during transportation without adequate cooling (Bereda et al. 2018).

Table 16. Microbial quality of milk in the study area

Parameter	Rural Mean±SD	Urban Mean±SD	Overall Mean±SD	P
TBC	7.03±0.28	6.79±0.19	6.88±0.25	0.001
TCC	4.75±0.20	4.63±0.13	4.68±0.17	0.019
YMC	4.63±0.15	4.54±0.08	4.58±0.12	0.016

SD= Standard divation

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study was conducted in both rural and urban areas of Dale district, Sidama region, with the overall objective of assessing milk production practices, chemical composition, and the microbial quality of raw cow milk.

In the study area, local-breed dairy cattle were found to be more prevalent than crossbred ones. Artificial insemination (AI) was commonly used for breeding by many smallholder farmers. In rural areas, milk was produced both for household consumption and for sale, whereas in urban areas, the primary purpose of milk production was for marketing. Daily milk yield and lactation length differed between rural and urban settings, as well as between local and crossbred cows. Housing conditions also varied; rural dairy cows were kept in barns separate from family dwellings, typically with muddy floors, while urban farmers used concrete-floored barns. In rural areas, manure was utilized as natural fertilizer for crops like Enset and coffee, while in urban areas, it was not used for this purpose and required additional effort and cost for removal. Barns in rural areas were generally cleaned once a day, and river water was the main source of water for dairy animals. Although udder washing was not a widespread practice, hand washing before milking was commonly observed. A majority of respondents did not filter milk and preferred to preserve it in cool places. All participants reported cleaning their milking equipment before use, and most washed their hands both before and after milking. However, a significant portion did not regularly wash the cow's udder.Key constraints to dairy production in the study area included a shortage of animal feed, lack of grazing land, and the high cost of feed. Challenges related to milk quality included limited awareness of hygienic handling practices, inadequate access to clean water for sanitation, lack of cooling facilities during storage and transport, and the absence of an effective milk quality control system. Overall, the study revealed differences in milk composition and microbiological quality between rural and urban milk samples. While certain good production practices were evident—particularly in comparison to other districts—there remains a clear need to improve hygiene, especially regarding udder cleaning using individual towels and warm water. As indicated, some unsanitary practices continue to negatively affect the quality of milk produced in the region.

5.2. Recommendation

- Based on the findings of this study, the hygienic condition and microbial quality of raw cow milk in the study area were found to be below acceptable standards. Therefore, the following recommendations are proposed to improve milk safety and quality

- Dairy producers should regularly clean udders, hands, and milking equipment before every milking session to minimize contamination.
- Provide continuous education and training to dairy farmers on best practices for hygienic milk production, handling, and storage.
- Sanitary measures should be implemented at every stage from production to final consumption—to ensure the delivery of safe and high-quality milk and milk products.
- Encourage the installation and use of proper milk cooling systems at the producer level to maintain milk quality during storage and transport.
- Emphasize the importance of washing hands and cleaning the udder before milking, as these are critical control points in preventing contamination.
- Investigate the quality and sources of water used in dairy operations in Dale district, as poor water quality may significantly contribute to milk contamination.

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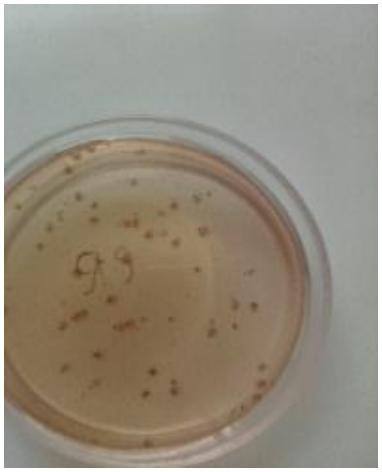
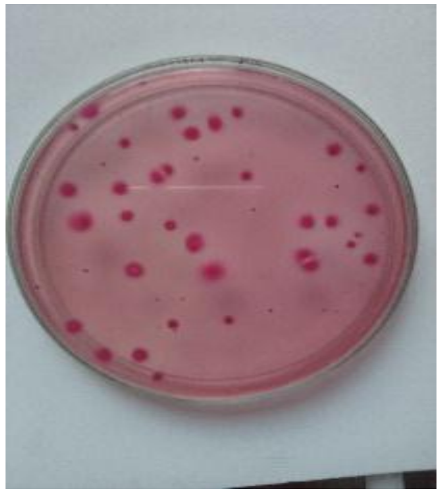
APPENDEX

Figure 6 Data collecting

Figure 7 compostional analysis of milk

Figure 8 media preparation during maicrobial culture





TPC **TCC** **Yeast and Mould**

Figure 9 cultured media in labratory

Questionnaire

Part I: General characteristics of the respondent

1. Gender of household head A) Male B) Female

2. Marital statuses: A) married, B) Divorced, C) Single, D) Widowed

3. Respondents' age A) 18-25 B) 26-33 C) 34-41 D) 42-49 E) 50 and above

4. Educational status of the household A) Illiterate B) Read and write C) primary school D) high school E) Diploma holder, F) Degree holder and above

5. What is your source of income? (Tick first column as appropriate)

S.N. Income sources of the family	Tick
1 Dairy farming and crop production	
2 Dairy farming and Other livestock	
3 Dairy farming and Other	

6. Total farm size of the household (hac)

A) Grazing land ______ (hac) B) Cropland (both annual and perennial)____________ (hac)

C) Improved forage land_____________ (hac) D) Fallow land __________________(hac)

E) Woodland_______________ (hac) F) Total land holding __________ (hac)

7. Which crops do you produce? A) Maize B) Barley C) Wheat

D) Sorghum E) Other specify………………

Part II Dairy cattle production system

1. How many dairy cows do you have?

A) 1-5 B) 6-10 C) 11-15 D) 16-20 E) >20

2. What motivated you to engage in dairy production system enterprises or the Sector?

A) To expand income, B) for unemployment, C) for consumption, D) for business profit

3. What are the purposes of milk production?

A) For consumption B) For market C) for processing D) other (specify)

4. What is your breeding system?

A) Natural breeding….. B) Artificial insemination….. C) Both….

5. If a natural bull, where is the source of the bull? A) Own growth B) Rental C) Extension serve

6. If Artificial, where is the source of semen?

A) Government extension, B) Private, C) Other (specifics

7. How much liter on average do you get?

Cow no	Local cow Li / per day	Cross cow Li / per day
1		
2		
3		
Average		

8. How long do you milk your cow (lactation period)?

No	cow	5-6 months	7-8month	9-11month	Above 12month		
1	Local breed						
2	Cross breed						

Part III Hygienic information

A. Milking procedure and frequency

1. How do you initiate the milking operation?

A. Allow calves to suckle before milking. B. Allow calves for suckling before and after milking, C. Other (Specify)………………

2. Method of milking? A Hand milking B) Machine milking

3. What is your milking frequency? A) once/day B) twice/day C) threex/day

4. Who participates during milking? A) Mother B) Father C) Son D) Hired a laborer

5. Who is responsible for hygienic and milking practice?

A) Men B) Women. C) Children D. Hired laborer (boy/girl) E) all F. Other (specify) ……………………..

6. Do you filter milk after milking? A. Yes B. No

7. If your answer is yes to Q no 6, what type of cloth do you use?

8. How do you keep milk after the milking operation?

A. Keep in the refrigerator. B. Keep in cold water. Keep at ambient temperature D. Other (Specify) ……………………

9. Milk consumption ways

A. Fresh raw milk B. Plain boiled and cooled milk C. Boiled milk with coffee D. Processed into traditional Ergo, E. Processed into Arera F) Other (Specify) ………………..

B. Person responsible for the milking operation)

1. Do you wash your hands during milking?

A) Yes…. B) No…

2. If your answer is yes to Question 1, when do you wash your hands?

A) Before milking, B) After milking, C) Both

3. Do you wash your wear before and after milking?

A) Yes B) No

4. Do you wear a hair cover during milking? A. Yes, always B. Yes, sometimes C. No

5. Do you check your health regularly? A. Yes B. No

6. If the answer to the question above is yes, on what interval A? Once a year , B. Twice a year , C. Other (specify)

C. Cow hygienic

1. Do you wash your cow's udder during milking? A) Yes… B) No..

2. If your answer is yes to Q no 1, when do you wash?

A) Both before and after milking, B) Before milking only, C) No washing at all

3. How do you clean the udder?

A) Wash with water and dry with a common towel. B) Wash with water and dry with an individual towel . C. Allow the calf to suckle and dry with a common towel after suckling. D) Dry with an individual towel after suckling. E) Udder not washes at all F. Other (specify) …………..

4. Type of water used for washing the udder

A) Cold B) Warm C) Both alternatively

D. storing and transportation Equipment and its hygienic

1. Do you wash equipment before milking? A) Yes B) No

2. What types of water are used for wash equipment before milking?

A) Cold water B) Hot water C) Both alternatively

3. How do you clean milk handling material before and after milking?

A) Wash only B) smoking only C) wash with plant leaves D) Both

4. Smoke milk handling equipment

A. Yes B. No

5. What type of plant do you use to smoke?

A) Use of Olea Africana stems (Ejersa), C) Premnaresinosa (Tetessa),

B) Balanitesaegyptica (BadeSaokole), D) Terminallabrownii (Biressa),

E) Combretum mole (Rukesa). F) Other-----------------------

6. Type of container to transport milk to market

A) Pots B). Plastic D) Traditional containers C) others…………………

7. Type of container to store milk.

A) Pots B). Plastic C) Traditional Containers.

8. How do you preserve your milk?

A) Cooling it in the smoking equipment at an available temperature

B) Not preserved at all, but consumed or sold as soon as it is milked

C) By putting it in the fridge

D) Other specify----------------

9. Which Milking equipment do you use?

A. Pots B. Plastic C Traditional Containers D). Others…

10. What is your churning material?

A) Traditional (baarree) B) Plastic (jerry-can) C) Pot

11. Always treat wash water before use for hygienic practices

A. Yes

B. No

C. Sometimes

12. If Q11 is yes or sometimes, what is the method of treatment?

A. Chemical

B. Physical (boiling)

C. Others (specify)

PART IV: Housing and manure management system

1. Housing type A) Separate house (fenced) B) Share with family house

2. What type of Materials are used to construct the barn floor?

A. Concrete B. Cement C. Muddy soil

4. What type of bedding materials are used?

A) Grass and/or cereal straw B) Sawdust C) No bedding materials at all.

5. Barn cleaning frequency? A. Once /a day B. Twice/ a day

C. Once /a 2-day D. Once/ a Week

6. How to manage manure? A) Used for fertilizer. B) used for biogas, C) used for energy by drying

Part V: Seasonal Feed resources and feeding System.

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

A) Free grazing (full-time) B) Stall feeding

C) Stall feeding with limited grazing

2. What are the major feed resources in the area?

Season	Natural pasture	Crop residues/straw	Hay	Fodder trees/forages	Crop after math	Industrial by-products	other
Dry Season							
Wet Season							

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

A) Own farm produced B) Purchased C) Both farm produced and Purchase

Part: Watering Management

1. Source of water for your farm activity

   A) River B) Pond C) Pipe water D) Other (specify)

2. What is the frequency of watering your dairy animals? Frequency (code):

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

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

Part: General constraint to Dairy Cow Production

1. What are the major constraints that affect livestock productin your area? (Strictly rank them according to their importance to you.)

No Constraints	Rank 1, 2, 3 …9in the order of severity
1 Feed shortage	
2 Drought	
3 Disease & parasite	
4 Market problem	
5 Lack of improved breed	
6 Lack of veterinary service	
7 Lack of extension service	
8 Water scarcity	
9 Shortage of grazing land	
10 Others, mention (No rank)	

3. Have you been provide with extension services? A) Yes… B) No…

4. Have you ever taken any dairy training related to improve your hygienic practice?

A) Yes … B) No…

5. If yes, specify the type of training and the organization responsible for the training/ who and type of training

____

____

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

A) Government actors veterinarian B) Private actors veterinarian

C). Shop or market D) other———————————

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

No	Dis	Tick	Sign
1			
2			

3			

Part: Milk quality Characteristics

1. What are the quality characteristics of milk? A) Color white /yellowish color/golden color B) Odor/smelling C) Other (specific)

2. Do you know adulterated milk? A) Yes B) No

3. What is source of milk adulteration? A) Addition of water B) Flour C) other (specific)

4. What are the constraints of clean milk production? A) Lack of awareness
B) Lack of Clean Water C) Lack of clean environment D) Other specify

APPENDEX III. Check List for Group Discussion

1. What is the purpose of dairy cows in the area?
2. What are the opportunities do you have for dairy cow production?
3. Discuss the source of information for selection of dairy cows if you undertake selection of dairy cows.
5. Tell us how milk is use processed and marketed.
6. Mention where you sell milk and milk products.
7. What are the major production constraints for dairy cows? Please discuss in detail.