



# Review on Bovine Mastitis and its Status in Ethiopia

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## Abstract

The objectives of this paper to review on bovine mastitis and its status in Ethiopia. Bovine mastitis an inflammation of the mammary gland, is the most common disease of dairy cattle causing economic losses due to reduced yield and poor quality of milk. The causes of mastitis may be either- infectious or non-infectious agents. The etiological agents include a variety of gram-positive and gram-negative bacteria. The infectious ones are microbes such, as bacteria, fungi, yeasts and viruses. Mastitis can also be classified as clinical or subclinical intramammary inflammation according to symptoms. Although, depending on the primary reservoir and mode of transmission this pathology can be contagious or environmental. Early mastitis detection and identification of the causative agent is crucial for control and treatment. The diagnostic methods include clinical examination of mastitis, Electrical conductivity, California mastitis test, Somatic cell count, Culture methods, PCR-based methods, Biosensors for mastitis detection, Protein-based diagnostics were used frequently. Several therapeutic strategies for treating mastitis have been tested, including Antibiotic therapy, Bacteriophage therapy for mastitis, Animal-derived antimicrobials. The main treatments are intramammary antibiotic therapy, parenteral antimicrobial therapy, and supportive and dry cow therapies. Practices such as good nutrition, proper milking hygiene and the culling of chronically infected cows can help. Ensuring that cows have clean, dry bedding decreases the risk of infection. Most dairy farms in Ethiopia are not registered and therefore, information on the exact number and distribution of dairy farms is lacking. However, reports indicated that the number of farms is increasing yearly. Although, it is not commensurate with human population growth in the country. Subclinical mastitis which is highly prevalent and economically important should gain attention. In this regard, awareness should be created on the importance of this type of mastitis for farmers.



## Introduction

Bovine mastitis, an inflammatory condition affecting the parenchyma of the mammary gland, causes severe morbidity and mortality in dairy cows. Mastitis is caused by complex and multifactorial agents, and its occurrence is determined by variables such as the animal, environment, and pathogen (Muturi, 2020) [31]. Mastitis is caused by a diverse range of microorganisms. Among the infectious agents, bacterial infections pose a significant threat to the mammary gland [18].

Mastitis has two distinct forms [11,13]. Clinical and subclinical mastitis based on symptoms. Clinical mastitis is defined by a quick onset of udder redness and swelling [9]. Milk from an afflicted quarter is changed, comprising flakes or clots and having a runny viscosity. Cows may appear lethargic, have a poor appetite, and typically have a fever. The somatic cell count is higher than normal, which is less than 200,000 cells/mL. Clinical mastitis can be further classified as per-acute, acute, or sub-acute based on the severity of the inflammation. Clinical Mastitis in cows is diagnosed based on the presence of strangely looking milk [31].

In contrast, subclinical mastitis is distinguished by the absence of obvious indications in the milk or udder [6]. The diagnosis of subclinical infection is more difficult since the milk seems normal but contains an increased somatic cell count. Subclinical mastitis can be diagnosed in a variety of techniques, including directly measuring the Somatic Cell Count (SCC) level or indirectly using a California Mastitis Test (CMT) on suspected quarters [15].

However, depending on the underlying reservoir and route of transmission, this pathology may be infectious or environmental [11,13]. They are often contagious and widely dispersed in dairy animals' environments, increasing the occurrence of intra-mammary infections [18]. Mastitis is caused by the presence of infectious bacteria such as *Staphylococcus aureus*, *Streptococcus agalactiae*, *Mycoplasma spp.*, and *Corynebacterium bovis* [19].

Environmental mastitis, on the other hand, can be linked to intramammary infections caused by microorganisms originating in the milking cow's surroundings. The finest examples of environmental pathogens include bacteria such as *Escherichia coli*, *Streptococcus dysgalactiae*, *Streptococcus uberis*, and *Klebsiella spp.* The majority of environmental mastitis produced by these infections is symptomatic and short-lived [4,25].

Early detection of mastitis and identification of the causal agent are critical for effective control and therapy. The initial methods used for detection are (1) estimation of SCC, an indication of inflammation, (2) measurement of biomarkers associated with the onset of the disease (e.g., the enzymes N-acetyl- $\beta$ -D-glucosaminidase and lactate dehydrogenase), and (3) identification of the causative microorganisms, which often involves culturing. These approaches have limits, and new assays that are quick, sensitive, and reliable are needed. There have been significant advances in the identification of nucleic acid markers and other novel biomarkers, as well as the creation of sensor-based systems [3,4,29].

Mastitis is a worldwide disease that has a significant impact on animal health, quality, quantity, and the economics of milk supply. It has been shown to produce significant productivity losses, as well as significant financial losses, due to its impact on milk yield quantity and quality, veterinary costs, milk condem-

nation due to antibiotic residues, early culling of mastitis cows, and occasional deaths. Furthermore, mastitis has a significant zoonotic impact due to the discharge of harmful bacteria and toxins into breastfeeding cow milk. The purpose of this research is to provide an overview of bovine mastitis and its situation in Ethiopia.

## Bovine mastitis

### Etiology:

Mastitis can be caused by either infectious or noninfectious sources. Microbes that cause infection include bacteria, fungus, yeasts, and viruses. Noninfectious reasons include injury and bruising/rough milking (Tyler & Ensminger, 2006). Bovine Mastitis can be caused by physical or chemical sources, however bacteria are responsible for the vast majority of cases, which are contagious [12,31].

The principal contagious pathogens include *Staphylococcus aureus*, *Streptococcus agalactiae*, and *Mycoplasma spp.*, whereas minor contagious pathogens include *Corynebacterium bovis* and others. Coliform bacteria (*Escherichia coli*, *Klebsiella spp.*, *Enterobacter spp.*, and *Citrobacter spp.*) and environmental streptococci (*Strep. dysgalactiae*, *Strep. uberis*) are among the most common pathogens found in the environment [27,31].

### Epidemiology

#### Geographical distribution:

Mastitis has been reported in nearly all domestic mammals and has a global geographical spread. All dairy herds have cows with subclinical mastitis; however, the proportion of sick cows varies between 5- 75%, with quarters ranging from 2-40% globally [16,30]. Climatic circumstances, seasonal variation, animal population density and housing, and husbandry practices all have the potential to influence incidence and etiology [3].

#### Risk factors:

Bovine mastitis is an inflammation of the mammary glands caused by a variety of infections classed as infectious and environmental. It is a complicated and multifaceted disease caused by the interplay of three key elements: the animal, infections, and environmental and management factors [25].

#### Pathogen factor

**Staphylococcus species:** are gram-positive bacteria that are a prevalent cause of mastitis. *Staphylococcus spp.* is commonly classified as Coagulase-Negative (CNS) or Coagulase-Positive (CPS) staphylococci in the diagnosis of mastitis. *S. aureus* is a CPS and one of the leading causes of mastitis. This species is infectious and can cause mastitis ranging from asymptomatic to severe (Ruegg and Erskine, 2015) [7].

**Strep agalactia:** is a gram-positive bacterium that causes infectious mastitis [3]. It can be detected in both the bovine gastrointestinal tract and the surroundings of dairy cows. According to a recent study [17], maintaining udder and milking hygiene is not enough to control *Strep. Agalactiae* infection, as it can also be transmitted through milking machines and contaminated drinking water. Additionally, fecal and environmental management must be considered.

**Mycoplasma species:** is a highly contagious microorganism, however not as much as *Streptococcus agalactiae* or *Staphylococcus aureus*. *Mycoplasma*, on the other hand, produces

secretory tissue damage, including abscess, lymph node, and gland fibrosis [27]. *Mycoplasma* species are another cause of infectious mastitis. Jørgensen et al. [17] found that newly purchased animals can introduce *Mycoplasma mastitis* to the herd and spread it during milking. *Mycoplasma bovis* is the primary species that can cause significant consequences such as sudden onset, decreased milk supply, rapid transmission, and lack of response to treatment [13].

**Klebsiella pneumonia:** Can cause severe mastitis because it reacts poorly to routinely used mastitis treatment regimens and progresses quickly to toxic shock, leading in death [27].

**Escherichia coli:** is the most prevalent gram-negative pathogen. It enters the udder via teat, multiplies, and triggers inflammatory responses in dairy cows. It can be found in the surroundings around dairy cows, such as the herd's bedding, particularly in damp conditions. Mastitis produced by *E. coli* is typically symptomatic and transitory. The symptoms vary from modest with only local indicators (red and swollen udder) to severe with systemic signs (fever). Severe clinical mastitis induced by *E. coli* can cause irreparable tissue damage in the mammary gland and complete cessation of milk output, sometimes even resulting in dairy cow death [5].

**Fungal:** Fungal infection of cow mammary tissue is caused by superinfection by certain fungal species as a result of rigorous mastitis control programs that suppress natural udder immunity. Teat dips, intramammary infusions, and moldy surroundings all contribute significantly to contamination. *Aspergillus fumigatus* and *Candida albicans* are two major mycotic mastitogens [24,25].

#### Host factor

Mastitis susceptibility and resistance in dairy cows can be genetically determined. Selection for greater milk output has been demonstrated to be deleterious to the mammary gland's health [35]. The disease consequently mostly affects high-production cows reared under intense agricultural circumstances [18].

Physiological factors include stress, milk stasis, mammary regression, variable leucocyte udder barrier activity, perparturient edema, lactation stage, and udder makeup. Secretion and age [14].

**Udder structure:** The anatomy of the udder also influences susceptibility to infection. Cattle with big funnel-shaped teats, pendular-shaped udders, and blind quarters after calving are more likely to develop subclinical mastitis [5,32]. Animals with pendulous udders had a higher incidence of mastitis than cows with non-pendulous udders, and there was a relationship between the two groups. This is due to increased exposure to environmental diseases and hazardous compounds (Terefe, 2018).

**Environment factor:** Animal health and wellbeing are significantly influenced by herd management strategies and environmental circumstances. Keeping the herd clean and comfortable helps lessen the occurrence and severity of mastitis [33]. High stocking density, polluted floors, moist bedding, poor ventilation, and a hot and humid climate can all contribute to the proliferation of mastitis pathogens and increased exposure in cows, resulting in a higher incidence of mastitis [5].

#### Mode of transmission:

Bovine mastitis spreads in two ways: infectious and environmental [24]. The contagious bacteria that move from an ill cow

to a healthy cow during milking via the hands, towels, and/or milking machine, which serve as bacterial reservoirs [26].

In contrast, environmental mastitis develops in the environment, such as bedding, manure, or water. Even before being used, bedding may contain a high concentration of microorganisms. Frequently, bedding is polluted with manure, which contains everything bacteria require: moisture, warmth, and nutrients. Water can become contaminated with bacteria from manure or build in a milking machine, especially if the houses do not have the proper slope and the cleaning water temperature is too low [18].

#### Clinical sign

Mastitis is a mammary gland inflammation that can be Clinical (CM) or Subclinical (SCM), infectious or not [19]. The clinical form of mastitis is characterized by morphological changes in the udder as well as chemical and physical changes in the milk, whereas the subclinical form of mastitis occurs without any visible signs of inflammation and is more common than clinical mastitis, causing the greatest economic loss in most dairy herds [12].

Subclinical Mastitis, on the other hand, is the most expensive disease in the majority of herds and is frequently defined as the presence of a microbe in conjunction with an elevated Somatic Cell Count (SCC) in the milk. Various SCC cut-off positions for definition [15].

#### Diagnosis

##### Clinical examination of mastitis:

A clinical examination was performed to identify the prevalence of clinical mastitis. Udder was evaluated for visual abnormalities, symmetry, size, consistency, lesions, and ticks [7]. Clinical Mastitis is defined by disease in the udder, which manifests as inflammation symptoms such as swelling, discomfort, redness, and heat in the event of acute Mastitis. Chronic Mastitis is characterized by udder stiffness, teat obstruction, atrophy or fibrosis, and abscess formation. Acute Mastitis was also identified by changes in milk color and the presence of flakes and clots [4,15].

##### Electrical conductivity:

Mastitis causes inflammation and tissue damage, which results in the infiltration of blood components into milk, altering the quantities of milk from infection-free udders. Mastitis-infected milk contains more salt and chloride ions, making it a better electrical conductor. As a result, milk's electrical conductivity increases as Na and Cl levels rise and K and lactose levels fall [20].

##### California mastitis test:

The California Mastitis Test (CMT), also known as the rapid mastitis test, the Schalm test, or the Mastitis-N-K test, is regarded as the most reliable, simple, fast, user-friendly, and cost-effective cow-side test for detecting subclinical mastitis. The test is based on the reaction of a detergent containing CMT reagent with cell DNA and a pH indicator (Bromo cresol is purple), which changes color in response to an increase in milk pH from the typical 6.6 to 6.8 or higher [20].

##### Somatic cell count (SCC):

The assessment of SCC is commonly used to check udder

health. SC is a normal constituent of milk, and only when it becomes excessive does the problem arise. When paired with bacteriological culture findings, the factor of greatest importance can be identified. When SCCs are increased, they are made up of primary leukocytes. During inflammation, SCC increases significantly due to the migration of PMN into milk. A healthy cow's udder quarter should have a count of less than 100,000 cells/mL [24].

#### **Culture methods:**

Culture-based approaches are considered the gold standard for identifying mastitis pathogens. The results are based on incubating a known volume of milk on culture plates for at least 18 hours at defined temperatures to stimulate growth. After the growth phase, Colony Forming Units (CFU) are counted, and the colony phenotype is examined to determine the agent. When necessary, additional biochemical testing can be performed. Most pathogens can thrive on a wide range of accessible culture media, either aerobically (the vast majority) or anaerobically (*Mycoplasma* sp.). Culture plates are commercially available and reasonably priced. Specific culture media can be used to encourage the growth of certain bacteria. Pathogen detection can be done with milk from the bulk tank or at the cow/quarter level [22,23].

#### **PCR-based methods:**

The application of molecular methods in veterinary diagnostics is not a novel strategy. These approaches have the ability to detect pathogens with greater sensitivity and specificity. The introduction of PCR technology and its various expansions, such as multiplex PCR, real-time PCR, and LAMP, has increased the speed and sensitivity of diagnosis. These DNA-based diagnostic tools have significantly improved dairy farm management. The genetic sequences of diverse diseases serve as the foundation for nucleic acid-based detection [3].

#### **Biosensors for mastitis detection:**

Biosensors for mastitis detection have been created for on-site testing in an effort to develop less time-consuming approaches to standard diagnostic methods. Recent breakthroughs in nanotechnology and biotechnology have resulted in the development of analytical tools known as biosensors, which can convert biological substances in a sample to electrical signals. These signals can detect the presence of specific cells and markers with high sensitivity when properly tuned and amplified. The biological element known as the bioreceptor interacts with a physical transducer known as the sensor, generating a measurable signal that is converted into data. The most often utilized recognition components in sensing bacterial contamination are single-stranded oligonucleotides, antibodies, and enzymes, followed by peptide nucleic acids, bacteriophages, and artificial binding proteins [20,22].

#### **Protein-based diagnostics:**

Advances in proteomics have also resulted in faster and more accurate identification of bovine mastitis. It is often used to identify and quantify the proteins expressed in any biological sample, which can lead to a better understanding of their function and role in that condition. It is based on the idea that any change in the protein or proteome makeup of an organism or biological fluid indicates a diseased or pathological condition. The most often utilized procedures are two-dimensional gel electrophoresis and mass spectroscopy [3].

## **Treatment**

### **Antibiotic therapy:**

Antibiotics are routinely used to prevent mastitis during the dry season. Dry cow therapy with antimicrobials is permitted as a preventive approach for livestock species. The choice of antibiotics for clinical mastitis treatment should be based on history, etiology, antibiotic sensitivity profile, and, most significantly, suggested therapeutic principles [26].

### **Bacteriophage therapy for mastitis:**

Bacteriophage therapy is an alternative treatment for mastitis that uses pathogen-specific bacteriophages to cure a bacterial infection. Bacteriophages are viruses that can infiltrate and kill bacteria [28]. Phages have been shown to be predictors of novel antibacterial drugs for veterinary uses. Certain studies indicate that phage therapy may have an advantage against *E.coli* and *S.aureus*-induced mastitis infection [11]. Still, more study is needed to determine the therapeutic potential of bacteriophages for mastitis-associated bacterial infections [13].

### **Animal-derived antimicrobials:**

Immunomodulators, such as lactoferrin, are naturally produced by mammals and have been identified as possible non-antibiotic antimicrobial agents for the treatment and prevention of cow mastitis. Lactoferrin is a glycoprotein found in various bodily secretions, including saliva, tears, bronchial mucus, and milk (Dabele *et al.*, 2021).

### **Prevention and control**

Practices such as appropriate nutrition, proper milking cleanliness, and culling chronically ill cows can help. Ensuring cows have clean, dry bedding reduces the risk of illness and transfer. Dairy staff should wear gloves during milking, and machines should be cleaned on a regular basis to reduce the risk of transmission. As previously stated, mastitis is caused by a complicated combination of three epidemiological components: host, agent, and environment. To be effective, any control program should be aimed at resolving mastitis issues caused by these three causes [14].

### **Monitoring of udder health:**

Cow-side assays, such as the strip-cup test for clinical mastitis, the CMT for sub-clinical mastitis, automated electronic cell counts, and the NAGase test, provide for the monitoring of dairy cow udder health [14].

### **Good management:**

Practices such as adequate nutrition, proper milking cleanliness, and culling chronically ill cows can be beneficial. Ensuring cows have clean, dry bedding reduces the risk of illness and transfer. Dairy staff should wear rubber gloves during milking, and machines should be cleaned on a regular basis to reduce the risk of transmission. A proper milking schedule is essential. This usually entails using a milking teat dip or spray, such as iodine spray, and wiping the teats dry before milking. The milking machine is then used. After milking, the teats can be thoroughly cleaned to remove any bacterial growth media. A post-milking treatment, such as iodine-propylene glycol dip, is used to disinfect and protect the open teat from microorganisms in the air. Mastitis can develop after milking because the teat pores seal after 15 minutes if the animal sits in an unsanitary environment with manure and urine [21,30].

## Mastitis vaccines

Mastitis vaccines have been used with the goal of reducing the occurrence of mastitis in dairy production while maintaining business profitability. Killing entire cell vaccinations to deal with infective organisms on dairy farms is a typical approach, as is another disease vaccine. Many experiments have been conducted to develop a vaccination against mastitis, but only a few have reported satisfactory results. It is critical to develop a vaccination capable of defending against a wide variety of strains, as many strains can occur within a herd and a single cow [13].

Because of its endemic character, the enormous variety of microorganisms that can cause the disease, and the prevalence of these infections, bovine mastitis cannot be entirely eradicated [8]. As a result, different strategies/vaccines are required in different nations to address the unique needs of each country or part of the dairy business. Vaccination has recently emerged as a crucial component of mastitis control techniques, and the

execution of an effective control regimen is becoming increasingly critical [11].

## Status of bovine mastitis in Ethiopia

The majority of dairy farms in Ethiopia are not registered, so information on the exact number and distribution of dairy farms is limited. According to reports Yilma *et al.* [34], the number of farms is expanding on a regular basis, although not at the same rate as the country's human population expansion. The number of herds mentioned below is derived from prevalence studies conducted in various regions (Table 1). Most farms evaluated have similar average herd sizes, milk production, and farming procedures.

Furthermore, most farms are hand-milked, and cows are raised under zero-grazing conditions. However, discrepancies in mastitis prevalence between studies may be explained by differences in individual farm management, environment, and animal breed [10].

**Table 1:** The prevalence of Clinical Mastitis (CM) and Subclinical Mastitis (SCM) from different studies conducted in Ethiopian.

No	Study Area	Prevalence	Authors'
1	Borana Pastoral and Agro-Pastoral Settings of Yabello District, Borana Zone, Southern Ethiopia	59.1%	Bedane <i>et al.</i> , 2012
2	Hawassa milk shed, South Ethiopia	74.7%	Abebe <i>et al.</i> , [1]
3	In and around Jigjiga, Somali Region, Ethiopia	9.1%	Adane <i>et al.</i> , 2017
4	In and around Asosa Town	34.6%	Hora and Ebissa, [12]
5	West Hararghe zone, East Ethiopia	38.6%	Boggale <i>et al.</i> , 2018
6	West Wollega, Oromia, Ethiopia	39.67%	Kitila <i>et al.</i> , [19]
7	Toke Kutaye, Shelia, and dendi districts, west shewa zone, Oromia, Ethiopia	30.5%	Dabele <i>et al.</i> , 2021
8	Gamo zone, southern Ethiopia	17.1%	Belay <i>et al.</i> , [4]
9	Adawa and Enticho Towns, Tigray, Ethiopia	35.9%	Hailay <i>et al.</i> , 2023
10	South Wollo, Ethiopia.	28.4%	Adem <i>et al.</i> , [2]

## Conclusion and recommendations

Bovine mastitis is a truly important production disease due to its impact on the quality and quantity of milk production. The dairy industry suffers from substantial financial losses due to mastitis all over the world. The practice of hygienic methods during milking, milk collection, lactation and dry cow therapy, dietary supplements, and culling are likely to reduce but not control the incidence of both clinical and subclinical mastitis. The effects of mastitis on dairy cattle health and milk production highlight an urgent need to develop an effective strategy for prevention and control. Antibiotic therapy is a dynamic component in mastitis control programs. Therefore, it is of fundamental significance to detect what type of disease-causing organisms are predominant in each dairy farm and what type of medicines can be used to prevent and control mastitis. Antibiotic sensitivity tests are thus playing a key role in treating the mastitis case more effectively.

- ❖ Regular screening for early detection and treatment, follow-up of chronic cases, and control of subclinical Mastitis are recommended to alleviate the problem.
- ❖ Subclinical Mastitis which is highly prevalent and economically important should gain attention. In this regard, awareness should be created on the importance of this type of Mastitis to farmers.

## Author declaration

### Availability of data and materials

All the datasets generated or analyzed during this study are included in this manuscript.

### Competing interests

All authors have nothing to disclose in this work.

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### Authors' contributions

All authors contributed to data collection, study design, data interpretation, reference search, manuscript writing, and editing, and all authors have approved the submission of the final manuscript.

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