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Review Article

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Review on Dairy Cow Mastitis and Its Economic Impact

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Abstract

Bovine mastitis is the most prevalent and costly disease, affecting dairy farms worldwide. It is inflammation of the mammary gland, can have an infectious or non-infectious etiology and it's general feature is categorized as acute or chronic on the basis of duration and, it is also divided into clinical mastitis and sub clinical mastitis on the basis of symptoms. Mastitis which is caused by bacteria causes a great loss or reduction of productivity and culling of animals at an unacceptable age. The two types of mastitis are contagious and environmental mastitis. The disease is distributed throughout the world and endemic in Ethiopia. The occurrence of this disease depends up on the complex interaction of the three epidemiological components: host, agent and environment. Thus for any control program to be successful, it should be geared towards correcting mastitis problems associated with these three factors. Diagnostic methods include: based on clinical examination and history, California Mastitis Test, somatic cell count, measurement of pH, and bacteriological examination. Administration of specially formulated dry cow treatments will help to prevent new infections during the dry period and also will eliminate many existing infections present at drying off. Practices such as good nutrition, proper milking, keeping the hygiene, and the culling of chronically infected cows can help to control mastitis.

Keywords: Bovine, California mastitis test, Control, Mastitis, Somatic cell count, Treatment

1. Introduction

In Ethiopia, livestock represents a major national resource and form an integral part of the agricultural production system. The country has the largest livestock population in Africa with estimated 65million heads of cattle and cows representing the largest proportion of indigenous cattle of the country (CSA, 2020a). Milk produced from these animals provides an important dietary source for the majority of Rural as well as a considerable number of the Urban and Peri-urban population. However, milk production often does not satisfy the country's requirements due to a multitude factor, out of which disease of the mammary glands known as mastitis is among the various factors contributing to reduced milk production (Fekadu, 1995).

Bovine mastitis is an inflammation of mammary glands caused by a wide range of pathogens epidemiologically classified as contagious and environmental. It is a complex and multifactorial disease resulting from the interaction of three major factors: the animal, pathogens, and environmental and management factors (Radostits *et al.*, 2007; Cervinkova *et al*., 2013). It can be presented with visible or invisible inflammatory responses of the udder. Mastitis with visible symptoms is called clinical mastitis(CM), whereas mastitis without visible symptoms is called subclinical mastitis (SCM) (FAO, 2014).

Bovine mastitis is a serious problem which affects the basic income of the farmers depleting their dairy sources. Worldwide, mastitis is associated with economic losses of $35 billion every year. It adversely affects milk production whereby losses due to subclinical mastitis are more severe than those due to clinical cases (Muhamed Mubarack*et al*., 2011).

Mastitis is considered to be one of the most common and substantial production diseases of dairy livestock worldwide (Ruegg & Erskine, 2015). The disease results in decreased production, discarded milk and medical treatments as well as a higher level of premature culling of affected animals. The economic loss due to the disease is considerable and can be crucial, especially for small-scale dairy farmers in developing countries (FAO, 2014). It causes milk wastage due to pathogenic contamination, antimicrobials used for treatment or adulteration in appearance, and treatment expenditure and indirectly it causes pre-mature culling, decreased quality and quality of the harvested milk, expenditure on prevention and health problems associated with the diseaseand the zoonotic potential (du Preez, 2000; Gruet *et al*., 2001; Bradley, 2002; Petrovski *et al*., 2006).The objectives of the review were: To overview the etiology, epidemiology, diagnosis, treatment and control of bovine mastitis and To highlight the economic impact of bovine mastitis.

I chose this title since this disease is one of the most frequent and costly diseases within the dairy industry. Also in Ethiopia, bovine mastitis is one of the foremost frequently encountered diseases of dairy cows. In addition to that this financially devastating disease hasn't been studied and understood in appropriate way in our nation.

2. Literature review

2.1 Definition

The term mastitis by and large refers to an inflammation of the mammary gland, regardless of the cause. The classic meaning of the word mastitis is derived from the Greek word "Matos" meaning breast or udder and the suffix"itis" meaning inflammation. It tood efined as an inflammation of the mammary gland, nearly constantly due to the impactsof bacterial or mycotic pathogens. It is characterized by a physical, chemical and usually bacteriological change within the milk, as well as pathological changes within the glandular tissue (Pretorious Crista, 2008).

2.2 Etiology

The causes of mastitis may be either- infectious or non- infectious agents. The infectious ones are microbes, fungi, yeasts and viruses. The non-infectious causes are injury and bruising/ rough milking(Tyler and Ensminger, 2006).

Mastitis-causing pathogens can be grouped into Gram-positive and Gram-negative based on their Gram-staining characteristics or major or minor pathogens based on potential harm they cause to the host or contagious or environmental based on their mode of transmission(Radostits *et al*., 2000).

Reports indicate that more than 137 microbes are incriminated as etiological agents of mastitis (Petzer, 2004). The microbial causes of mastitis include a wide variety of micro-organisms (aerobic and anaerobic bacteria, mycoplasmas, yeasts and fungi). The most important microorganisms of bovine mastitis are *streptococci*, *staphylococci*, *Escherichia coli* and other *coliforms* (Radostits *et al*., 2000).

2.2.1 Bacterial cause

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

***Staphylococcus* spp:** *Staphylococcus* spp. is gram-positive bacteria that are common causes of mastitis. Within the mastitis diagnostic, *Staphylococcus* spp. is often divided into coagulase-negative (CNS) and coagulase-positive (CPS) *staphylococci.* S. *aureus* is a CPS and one of the most common causes of mastitis. This species is contagious and can cause everything from subclinical to severe clinical mastitis (Ruegg & Erskine, 2015). AndCoagulase negative *staphylococcus* consists of a large group of different species that commonly cause subclinical or mild clinical mastitis (Ruegg & Erskine, 2015). *S. hyicus* and *S. epidermidis* was the most common CNS in subclinical mastitis (Sharma *et al*., 2012).

***Streptococcus* spp**: *Streptococcus spp*. Is a genus of gram-positive bacteria where *S. dysgalactiae*, S. *agalactiae* and S. *uberis* are the most important mastitis pathogens (Chirico *et al*., 1997).

***E. coli* and *Klebsiella* spp**:*E. coli* and *Klebsiella* spp. Are gram-negative bacteria that often cause severe acute clinical mastitis, although development of mild and moderate clinical mastitis is also common,and subclinical infections can also occur (Oliveira *et al*., 2013).

2.2.2 Viral mastitis

Viruses are isolated from cows affected with bovine mastitis, although they are not regarded as common etiological factors. Some viruses, such as bovine *herpesvirus* (BHV), BHV4, foot-and-mouth disease virus and *parainfluenza*3, have been associated with clinical bovine mastitis without isolation of bacterial pathogens (Wellenberg *et al*., 2002).

2.2.3 Fungal cause

Fungal infection of bovine mammary tissue is attributable to super infection by certain fungal species as consequence to strict mastitis control programmes that render natural udder immunity quiescent. Contamination of teat dips, intramammary infusions and moldy surroundings play significant role. The important mycotic mastitogens are *Aspergillus fumigatus* and *Candida albicans* (Radostits *et al*., 2007).

2.2.4 Other causes

Conditions that affect the milking process will increase the milking time and may predispose the udder to mastitis. Milk machine faults are responsible and the severe forms can predispose to mastitis and/or the development of black spot. Injury and bruising are non- infectious mastitis causes (Tyler and Ensminger, 2006).

2.3 Types of Mastitis

Classification of bovine mastitis depends on pathogens involved, visibilityof clinical signs and degrees of severity, udder tissue harm and amount of irritationproduced(Argaw, 2016).

Types of bovine mastitis based on causative agents

2.3.1 Environmental Mastitis

Environmental bacteria are present in the cows environment like *Streptococcus* species (*Streptococcus uberis*, *Streptococcus dysagalactia*) and environmental coliforms like *Escherciacoli*, *Klebsiella* species, *Enterobacter* species (Quinn *et al*., 2004). Environmental mastitis is caused by bacteria such as coli form bacteria (e.g. *E. coli*) of which the main cause is a contaminated environment e.g., manure. Dairy cows may lie down in an enclosed area with a lot of manure present; therefore the coli form like bacteria can get easy access to the udder and teat canal (Pretorious, 2008). The majority of infections caused by environmental pathogens are clinical and of short duration (Harmon, 1994).

2.3.2 Contagious Mastitis

Contagious mastitis is caused by bacteria which are spread from infected quarter to other quarters or from infected cow to healthy cows. The most common contagious mastitis pathogens are *Staphylococcus aureus* and *Streptococcus agalactia*. *Mycoplasma bovis* is less common cause of contagious mastitis (Radostits *et al*., 2007).

2.3.3 Opportunistic mastitis

This type of mastitis is caused by opportunistic pathogens that exist on the teat skin. Normal flora, considered non-pathogenic can invade the udder, stimulate host immune system and cause subclinical or mild clinical mastitis (Kulkarni and Kaliwal, 2013). Coagulase negative staphylococci such as S. *epidermidis*, S. *saprophyticus*, S. *simulans* and S. *chromogenes* are good examples of pathogens causing this type of mastitis (Pyörälä and Taponen, 2009; El-Jakee *et al*., 2013; Hosseinzadeh and Dastmalchi Saei, 2014).

Types of bovine mastitis based on clinical manifestation

2.3.4 Subclinical mastitis

This is a hidden form of mastitis with no observable signs of illness or any visible changes to the milk produced. Subclinical mastitis (SCM) is very challenging form of mastitis in most of the developing countries where farmers sell their milk without considering the level of somatic cell counts (SCC). Normally, farmers are unaware about SCM in their farms neither have technical know-how to diagnose the disease. Occurrence of SCM may be 40 times more compare to clinical mastitis (CM) in a farm (Shaheen *et al*., 2016). This form of mastitis has huge influence in decreasing quality and quantity of milk produced (Batavani *et al*., 2007; Ogola *et al*., 2007). Wide ranges of pathogens have been isolated from apparently health milking cows (Dieser *et al*., 2014).

2.3.5 Clinical mastitis

Clinical mastitis can be recognized by its clear observable signs such as swelling, udder redness, pain, induration, hotness, sudden reduced milk production and alteration of milk secretion that may become watery with flakes, clots or bloody milk (Qadri *et al*., 2015). Clinical bovine mastitis can be categorized in different form depending on the severity of clinical symptoms (Hossain *et al*., 2017). Peracute: characterized by high inflammation with systematic signs of fever, depression, shivering and loss of appetite followed by reduction in milk production and changes in milk composition. Acute form: characterized by udder inflammation with mild systematic signs like mild fever and depression. subacute form: characterized by mild udder inflammation without systematic signs (Hamadani *et al*., 2013).

The most important bacteria that cause clinical mastitis are *Staphylococcusaureus*, *Escherchiacoli*, *klebsilla* spp, *Streptococcusuberis* and *Streptococcus dysgalactiae (*Hogain *et al*., 1990*)*.

2.3.6 Chronic mastitis

This type of mastitis is characterized by prolonged period of infection time which can be extended to months or year. Usually mastitis persists in the infected animal for months or can persist from one lactation to another. Chronic mastitis can persist as subclinical that erupt into clinical form from time to time. Changes in udder formation and milk composition can be observed for longer period of time. Many types of bacteria can invade and persist within the udder of an infected cow (Dogan *et al*., 2006).

2.4Epidemiology of Bovine Mastitis

2.4.1 Risk Factors

There are plenty of/abundant predisposing factors that can impact development of mastitis at individual and herd level in dairy cattle. The factors may be physiological, hereditary, pathological or environmental (Sordillo, 2005).

Many factors influence the incidence of mastitis, such as production stages of a cow, lactation number, herd management, husbandry environment temperature, humidity, seasons, breeds and milking characteristics (Bedane *et al*., 1994; Biffa *et al*., 2005).

Host factor

For contagious pathogens, adult lactating cattle are most at risk for infection, either while lactating or during the dry period. Stage of lactation is one of the intrinsic factors that determine the level of infection. Particularly, the early stage of lactation is more prone to mastitis occurrence than the remaining stage of lactation (Rahmeto *et al*., 2016). Age of cow is also a factor that is associated with the case of mastitis where commonly aged cows are more liable to mastitis than others (Mahantesh and Basappa, 2014).

Parity: parity has a direct relationship with mastitis occurrence. The presence of mastitis increases with increasing parity number. The likelihood of mastitis is higher in multiparous cows having more calving compared with primiparous cows. This might partly be associated with the position of the udder in older cows that let exposure of the teat and udder to injury and pathogens easily so that makes it to be the most susceptible one to mammary infections (Rahmeto *et al*., 2016).

Breed: breed of a cow is also another factor that determines presence or absence as well as the level of mastitis. Mostly high producing cows are more exposed to mastitis than low-level milk producers (Zygmunt *et al*., 2015). Studies conducted in Ethiopia generally show an increasing trend in the prevalence of Mastitis with increasing exotic blood levels. Accordingly, the prevalence is the highest in pure breeds followed by crosses; and indigenous zebu being less frequently affected than others. The increase in prevalence in exotic breeds as opposed to local indigenous zebus could be the indigenous zebu are low in milk production and Higher yielding cows are more susceptible to Mastitis.(Radostits *et al*., 2007).

Lactation stage: stage of lactation affect Mastitis prevalence significantly as a research conducted in Ethiopia implies. Early stage and the period of involution (late stage) of the mammary glands were the most susceptible stages. This is possibly due to absence of dry cow therapy regime that is considered major factor contributing to high prevalence at early lactation (Biffa *et al*., 2005).

Pathogenic factor

Includes bacterial viability, colonizing ability & susceptibility to antibiotics. Bacteria viability means the ability of the organism to survive in the cows' immediate environment, that its resistance to environmental influence including cleaning, disinfection procedures is characteristics of each species of bacteria. The causes of contagious mastitis are relatively vulnerable to the external environment than the cause of environmental mastitis. Colonizing ability; means the ability of the organism to colonize the teat duct, then to adhere to mammary epithelium & set up mastitis reaction. Susceptibility to antibiotics; means inherent or acquired resistance to antibiotics therapy usually due to excess exposure to the agent (Radostits *et al*., 2007).

Management and environmental factors

Previously identified environmental and farm management risk factors that have significant role in the occurrence of bovine mastitis included increased herd size and number of lactating cows, intensive or semi intensive rearing system, cow hygiene, poor farm hygiene and inappropriate milking techniques (Suleiman *et al*., 2013; Iraguha *et al*., 2015; Sarba and Tola, 2017).

2.4.2 Sources of Mastitis

Mastitis is a multi-etiologic disease. The source of mastitis infection may be regarded as contagious or environmental. Contagious pathogens except some that invade the cow's udder after bacteremia are spread during milking. Most other species are opportunistic invaders from the cow's environment. The primary reservoir of infection is the mammary gland; transmission occurs at milking. Environmental pathogens are commonly known to cause clinical mastitis in most dairy herds. The bedding used for housing cattle is the primary source of environmental pathogens in addition to other contaminated fomites as well as skin and teat lesions and vector parasites (Erskine, 2020).

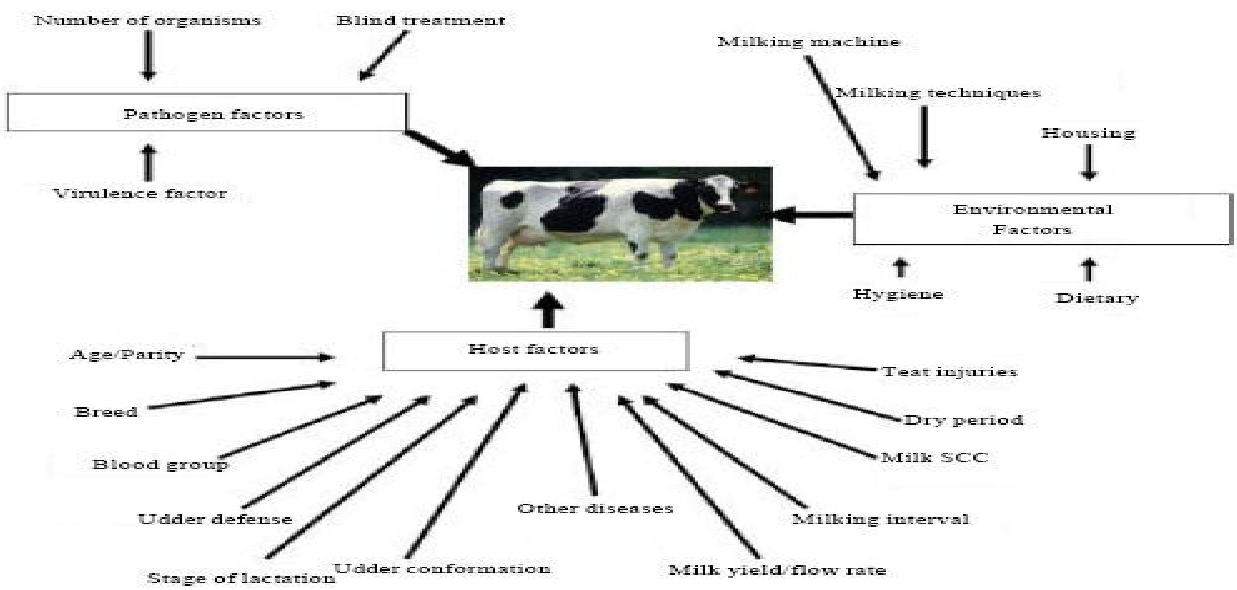

Figure 1: Risk factors for bovine mastitis (Sharma *et al*., 2012)

2.4.3 Occurrence

Mastitis is a worldwide problem affecting mainly lactating animals but during their dry periods as well. It affects a wide range of hosts; different breeds, age, parity, lactation stage, and milk yield categories (Rebeka *et al*., 2019).Bacteria are by far the most common causes of mastitis. Chief pathogens include *Streptococcus agalactiae and Staphylococcus aureus* is the bacteria which cause mastitis disease that affects a large number of dairy cows throughout the world (Radostits, 2007).

2.4.4 Prevalence of Bovine Mastitis

Numbers of studies have been conducted to demonstrate the prevalence of bovine mastitis in eastern part of the African continent. In Ethiopia, the farm level prevalence of bovine mastitis has been reported to be 74%, cow level prevalence has been shown to be 42-71% while quarter level prevalence ranged between 28 to 44% (Mekibib *et al*., 2010; Biressaw and Tesfaye, 2015; Abebe *et al*., 2016; Mekonnin *et al*., 2016). In Kenya, cow level prevalence was between 56-82% while quarter level prevalence was estimated as high as 87.4% (Ondiek *et al*., 2013; Gitau *et al*., 2014; Nkoroi and Maitho, 2014). Epidemiological survey on bovine mastitis conducted in Tanzania mainland revealed high prevalence of both clinical and subclinical mastitis (Mdegela *et al*., 2005; Karimuribo *et al*., 2005; Karimuribo *et al*., 2006; Kivaria *et al*., 2007).

Table1: Prevalence of Clinical mastitis in different parts of Ethiopia.

Place	Prevalence	Authors
Gondar town and surrounding areas	25.22%	Almaw *et al.*, 2009
Aawassa	42.5%	Abebe *et al.*, 2010
Holeta	71.0%	Mekibib *et al.*,2010
Bahir Dar and its Enviroment	28.2%	Bitew *et al.*,2010
Asella	66.1%	Bedada and Hiko (2011)

2.5 Transmission

There are two fundamental modes of transmission for bovine mastitis: contagious and environmental. Contagious transmission too called cow-to-cow transmission since; cows with mastitis are the most source of disease. Spread of the microbes that cause the disease fundamentally happens during milking, e.g. through the milkers' hands, udder cloths, or the milking machine (Zadoks *et al*., 2011). And those Environmental mastitis begins within the environment, e.g. in bedding, manureor water and its transferred from the environment to teats between milking's (Gurjar *et al*., 2012).

2.6 Pathogenesis

Inflammation of the mammary gland predominantly occurs via the teat canal except in the case of tuberculosis, leptospirosis and brucellosis where the method of spread may be haematogenous. The development of mastitis can be explained in terms of three stages as invasion, infection and inflammation. The invasive stage refers to the time in which pathogens move from the teat end to the milk through the teat canal. The infection stage is the stage in which the pathogens multiply rapidly and invade the mammary tissue. The stage of inflammation is the stage with varying degrees of clinical abnormalities of the udder and with systemic effects from mild to per acute as well as gross and subclinical abnormalities of the milk (Radostits *et al*., 2007). The inflammatory response is initiated when bacteria enter the mammary gland and this is the body's second line of defense. These bacteria multiply and produce toxins, enzymes, and cell-wall components which stimulate the production of numerous mediators of inflammation by inflammatory cells. The magnitude of the inflammatory response may be influenced by the causative pathogen, stage of lactation, age, immune status of the cow, genetics, and nutritional status (Harmon, 1994).

Polymorphonuclear Neutrophil (PMN) leukocytes and phagocytes move from bone marrow towards the invading bacteria and are attracted in large numbers by chemical messengers (chemotactic agents) from damaged tissues. Masses of PMN may pass between milk producing cells into the lumen of the alveolus, thus increasing the somatic cell count (SCC) as well as damaging secretory cells. Somatic cells consist mainly of PMN (white blood cells). At the infection site, PMN surround the bacteria and release enzymes which can destroy the organisms. The leukocytes in milk may also release specific substances that attract more leukocytes to the area to fight the infection. Numbers of somatic cells remain in large concentrations after bacteria are eliminated until healing of the gland occurs. Clots formed by the aggregation of leukocytes and blood clotting factors may block small ducts and prevent complete milk removal. Damage to epithelial cells and blockage of small ducts can result in the formation of scar tissue in some cases, with a permanent loss of function of that portion of the gland (Harmon, 1994).

2.7 Clinical signs

Inflammation of the affected mammary tissue is characterized by gross abnormalities in the udder (swelling, heat, redness, pain). Persisting inflammation leads to tissue damage and replacement of the secretory tissues with non-productive connective tissues. There are changes in composition and appearance of milk. Abnormalities in milk may include flakes, clots or a watery appearance (Hillerton, 1999).

2.8 Diagnosis

2.8.1 Clinical examination of mastitis

Udder is examined for visible abnormalities, symmetry, size, consistency, presence of lesions and/or ticks. Clinical Mastitis was recognized by some pathology in udder, which is manifested by sign of inflammation like swelling, pain, redness and heat in case of acute Mastitis. Whereas, hardening of the udder, blockage of the teats, atrophy or fibrosis and abscess formation are manifested in chronic Mastitis. Acute Mastitis is also recognized by change in milk color, presence of flakes and clots (Moges *et al*., 2012).

2.8.2 Measurement of pH

Normal milk has pH between 6.5 and 6.7. This figure approximate to that of the blood (7.2-7.4) when infection is present that it tends toward alkalinity with the use of reagent (sodium hydroxide) (Andrews *et al*., 1992).

2.8.3 California mastitis test (CMT)

The California Mastitis Test (CMT) is performed according to the manufacturer's instruction. In brief, a small sample of milk (approximately ½ teaspoon) is collected from each quarter into a plastic paddle that has 4 shallow cups marked A, B, C and D. An equal amount of CMT reagent is added to the milk and the paddle rotated to mix the contents. After approximately 10 seconds, the score is read while continuing to rotate the paddle. Results are recorded as T (trace), 1, 2 or 3 based on the level of precipitation (coagulation) (Mellenberger and Carol, 2000).

Figure 2: California Mastitis Test (CMT)

2.8.4 Somatic Cell Count (SCC)

The determination of SCC is widely used to monitor udder health. SC is normal Constituent of milk & only when they become excessive indicates the problem. When combined with bacteriological culture results the factor of great importance can be determined. When SCC is elevated they consists primary leucocytes. During inflammation the major increases is SCC because of the influx of PMN into milk. The count in a healthy udder quarter of the cow should be fewer than 100,000 cells/ml (Hamann, 2002). A level >200,000 cells/ml indicates infection (Smith *et al*., 2001).

2.8.5 Bacteriological examination of Milk

The laboratory procedure of inoculating standard volume of hygienically collected milk agar culture medium has been the standard diagnostic method for bovine mastitis. The resulting bacterial growth is observed, quantified & tested. In fact use of milk culture is wide spread as a measure of determining udder health status. It has become the definitive standard diagnostic test (Radostits *et al*., 2007).

2.9 Treatments

The management of mastitis involves both preventive and therapeutic strategies, and is primarily based on antibiotic therapy (Benic *et al*., 2018).Treatment of peracute mastitis includes: stripping the gland frequently to remove organisms and toxins (at 1 or 2 hrs. intervals), injecting oxytocin to facilitate milk letdown, IV infusion or oral administration of fluids, administration of anti-inflammatory drugs, analgesics, antipyretics (given systemic), and/or antibiotics (systemic or intramammary).Treatment of acute mastitis includes: stripping frequently, administration of antibiotics (systemic or intramammary), administration of fluids if needed, and administration of anti-inflammatory drugs, analgesics, and/or antipyretics. Treatment of subacute mastitis includes intramammary antibiotic infusion and stripping the gland (after oxytocin injection). Treatment of Chronic Mastitis usually involves treating the clinical flareups, or culling the cow Treatment of subclinical mastitis is not economical during lactation, but rather is often done during the dry period with intramammary infusion of antibiotics from the herd(Preece *et al.,* 2000).

Successful treatment of clinical mastitis depends on several factors: antimicrobial treatment, causal agent identification, parity, stage of lactation, history of previous SCC, clinical mastitis and other systemic diseases (Steeneveld *et al*., 2011). Cows being treated may be marked with tape to alert dairy workers and their milk is siphoned off and discarded. Vaccinations for mastitis do exist, but as they only reduce the severity of the condition and do not prevent new infection they should be used in conjunction with a mastitis prevention program (Radostits *et al*., 2007).

2.9.1 Antibiotics

These are chemical compounds (natural or synthetic) with anti-bacterial activity (bacteriostatic or bactericidal). Over the past few decades up to now, cows with mastitis (clinical or sub-clinical) are more likely to be treated with antibiotics. These are also used on many dairy farms worldwide as part of the prophylactic control of mastitis and are used when the cows are dried off. Their use increases the risk of the presence of antibiotic residues in the milk, which renders it unfit for processing. Antibiotic residues in the milk are not well tolerated by regulatory agencies, milk processors and consumers. Furthermore, increasing evidence of bacterial resistance against a vast range of antibiotics, also limit their sustainable use in mastitis control of dairy cattle (Pretorious Crista, 2008).

The main strategy to treat mastitis is by the use of antibiotics, such as penicillin, ampicillin, tetracyclin, gentamycin, etc., which can be given by intra-mammary infusion, intramuscular or intravenous injections (Hossain*et al*., 2017).

2.9.2 Dry cow therapy

The DCT is one of the best choices to control and inhibit progression of mastitis. Dry period is an important stage in lactation cycle; any infection during dry period will affect the next lactation, and therefore, it is very important to take care of the cow's health before the next milking cycle. Before drying off the cows, they were checked for any sign of mastitis; chronic mastitis cases, which are hard to detect by naked eyes, were checked via the California mastitis test (CMT) (Bhutto *et al*., 2010). Then, right after the last milking, intra-mammary injection of antibiotic was applied to cow udder through canal teat, followed by application of teat sealant, which simulates the keratin plug, providing a physical barrier to bacterial invasion and preventing milk leakage. DCT can eliminate existing IMI and prevent new infection during dry period; thus, a dry cow tube consists of long persisting antibiotics, as they can deliver better cure rates (Biggs, 2017; Ricci*et al*., 2017). An ideal treatment should be long enough to cure subclinical mastitis and short enough not to cause antibiotic resistance once the cow has calved. Dry cow period is the best time to cure mastitis; as there is no milk production during this period, the risk of incorporating antibiotic into the food chain is minimized, but caution should be taken even after calving (Biggs, 2017).

3. Mastitis prevention and control strategies

Five-point core plan for mastitis prevention and control include the following:

Disinfection of teats, adherence to hygienic practices in the milking procedures, removal of cows with chronic mastitis, dry cow therapy with antibiotics, and Treatment of clinical mastitis (Vliegher*et al*., 2018; Giesecke*et al*., 1994).

Additionally, in cow herds the measures used in prevention and control of mastitis are as follows:

Reduce introduction of new infections, shorten the duration of existing infections, maintenance of the normal udder health (Philpot and Nickerson, 1999). dry and clean storehouse for fodder, feeders, and mangers, supply of palatable water, disinfection of milking area, shoe dipping disinfecting solutions for visitors to check any entry of the pathogen, check spread of infection by sprinkling lime powder (Pieterse and Todorov, 2010). And Keeping dairy animals stress free that encourages the development of healthy immune system (Kumar*et al*., 2017).

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 and transmission. Dairy workers should wear gloves while milking and machines should be cleaned regularly to decrease the incidence of transmission(NMC, 1987).

The specific steps for an udder health management program devised to fulfill the three basic epidemiological principles (Radostits *et al*., 2007; Philpot and Nickerson, 1991) include:

Elimination of Existing Infections: This is achieved by such programs as proper milking hygiene and technique, teat dipping, dry cow therapy, treatment of clinical mastitis and culling.
Prevention of New Infections: Procedures such as good milking management, environmental and nutritional management, as well as breeding methods are employed to prevent new infections.
Monitoring of Udder Health: The applications of cow-side tests, for example the strip-cup test to detect clinical mastitis, the CMT for sub clinical mastitis enables one to monitor the udder health of dairy cows.

4. Impact of mastitis

Mastitis may be a serious issue that reduces milk production, affectsthe quality of milk, and leads to public health hazards, results within the death of animals and thus leads to financiallosses (FAO, 2014). Costs due to mastitis include reduced milk production, condemnation of milk due to abnormal color, odor and test and due to antibiotic residues after treatment, decreased quality of milk in terms of some desired substance of milk responsible in determining amount and quality of milk by-products, veterinary costs, culling of chronically infected cows and intermittent deaths (Rahmeto *et al*., 2016).Additionally, mastitis has a serious zoonotic potential related with shedding of pathogens and their toxins within the milk.

4.1 Economic impact of mastitis

Mastitis is a worldwide problem highly affecting animal health, quality, quantity, and the economics of milk production. It has been known to cause large losses in productivity, and it can cause huge financial losses due to its impact on quantity and quality of milk yield, veterinary expenses, condemnation of milk due to antibiotic residues, culling of mastitis cows at an early age, and occasional deaths (Suriyasathaporn *et al*., 2000).Bovine mastitis is regarded as one of the most economically damaging diseases in the dairy industry globally (Skuce *et al*., 2016; Schlesser, 2017).

Mastitis costs are also classified into two main categories: Those occurring directly and indirectly (Kossaibati and Esslemont, 1997). Direct costs consist of veterinary services, diagnostics, treatments, additional labor requirements, and discarded milk (during the course of treatment).

Indirect costs are defined as those that are not always obvious to the milk producer, also known as hidden costs. Indirect losses due to subclinical mastitis (SCM) are not well recognized by many farmers, but include reduced milk yield, premature culling losses, and reduced quality premiums (Nielsen, 2009). It is generally accepted that SCM accounts for the majority of the economic costs of mastitis. Education on this matter is critical because unrecognized indirect losses would be a reason for the difficulty in implementing mastitis control measures. Mastitis can involve two main forms: Clinical and subclinical forms. From an economic perspective, for many cattle farms, SCM is thought to be the most economically important type of mastitis because of the long-term effect of chronic infections on total milk yield. It causes substantial damage to the milk secretory cells and results in reduced milk production, changes in milk composition and quality, and also a shortened lifespan of diseased animals (Halasa *et al*., 2007). The annual losses by bovine mastitis are estimated as $35 billion globally. In Ethiopia annual losses in the dairy industry due to mastitis was approximately $2 billion in which subclinical mastitis are responsible for approximately 70% of these dollars losses (Nesru *et al*., 1997).

In Ethiopia, preventive and therapeutics measures against mastitis cost on an average $ 37.96 per dairy cow annually. Mastitis not only decreases the productive performance of cows but it also reduces the reproductive performance (Radostits *et al*., 2007). Most estimates have shown a 30% reduction in productivity per affected quarter & a 15% reduction in production per cow lactation (Radostitis, 2007).

4.2 Zoonotic Importance

Bacterial contamination of milk from affected cows may render unsuitable for human consumption by causing food poisoning or interference with manufacturing process or in rare cases provides mechanism of spread of disease to humans. Zoonotic diseases potentially transmitted by raw cow milk include brucellosis, caseous lymphadenitis, leptospirosis, listeriosis, melioidosis, Q-Fever, Staphylococcal food poisoning, toxoplasmosis and tuberculosis (Mungube *et al*., 2005; Radostits *et al*., 2007).

5. Conclusion and recommendations

Mastitis is endemic in many regions of the world. It remains a serious economic and public health problem in a number of countries. Generally the economic losses associated with mastitis derive mainly from a decrease in milk production and to a lesser extent, from the culling of chronically infected cows, cost of veterinary treatment, and penalties on milk quality. Mastitis may be classified according two different criteria: either according to the clinical symptoms or depending on the mode of transmission:-Clinical symptoms (Clinical mastitis, Sub-Clinical mastitis, per acute mastitis, acute mastitis, sub-acute mastitis, chronic mastitis) and Mode of transmission **(**Contagious mastitis, environmental mastitis).This disease is associated with a lot of Risk Factors of Mastitis. Therefore, it is very important to support and implement control programmes so as to prevent further spread of the disease. Advances in knowledge and development/design of new control tools for mastitis disease including new diagnostics and vaccines provide an excellent prospect for improved control programmes.

Based on the fore mentioned conclusions the following recommendations were drawn:

- Strict hygiene should be kept with regard to milking practices, milkier hygiene and effective teat dipping, constant removal and disposal of manure and provision of adequate quality bedding.
- Procedures such as good milking, environmental, and nutritional management should be practiced to prevent new infections.
- Government should be involved in the control of the disease in integrated manner among the ministries of health, agricultures and other social associations to save economic loss due to the condemnations of the milk.

- Appropriate treatment and following the progress of the treatment should be done by the veterinarian in any types of clinics.

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