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A Review on Mastitis in Dairy Animals

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A B S T R A C T

Mastitis is a disease that affects a large number of dairy animals throughout the world. In most countries surveys of the incidence of mastitis, irrespective of cause show comparable figure as about of 40% morbidity rate amongst dairy cows and a quarter infection rates as measured by an indirect test of about 25%. Mastitis is caused by several species of common bacteria, fungi, mycoplasmas and algae. Most mastitis is of bacterial origin, with just a few of species of bacteria accounting for most cases. Mastitis causes considerable changes in milk and milk protein. Annual losses in the dairy industry due to mastitis was almost 2.37 thousand crore rupees in India. Out of this, sub-clinical mastitis accounted for approximately 70% of the loss. Many different control measures of bovine mastitis include hygienic management procedures, antibiotic treatments, teat dipping sealants, and intramammary devises. The use of animals that are resistant to mastitis reduces the need to apply drugs, with consequent decrease in the levels of contamination of products and the environment.

Introduction

In dairy cattle, there are two very essential aspects that all livestock who are engaged in the activity of the dairy industry should take into account, milk production and mastitis. The most important activity is the production of milk and occurrence mastitis is the most outstanding condition.

Mastitis is an inflammatory condition of the mammary tissue resulting in several metabolic and physiological changes, trauma, and more frequently it is caused by environmental or contagious pathogenic microorganisms (Oviedo-Boyso *et al.*, 2007), including Gram-positive and Gram-negative bacteria, algae and mycoplasmas (Zadoks *et al.*, 2011). Mastitis has been known to cause a great deal of loss or reduction of productivity, to influence the quality and quantity of milk yield and to cause culling of animals at an unacceptable age. Most estimates have shown a 30% reduction in productivity per affected quarter and a 15% reduction in production per cow/lactation, making the disease one of the most costly and serious problems affecting the dairy industry worldwide. Moreover, a single quarter infected for one lactation may reduce milk production of the cow to 10% to 12% in that lactation (Radostits *et al.*, 2007).

Mastitis is a complex, multi factorial disease and continues to be the most costly disease of dairy animals. Bovine mastitis results in a great deal of economic losses, mostly because of the reduction of milk yield, decreased milk quality, and higher production costs, medication costs, discarded milk during and shortly after treatment, loss of milking days, reduced milk price, increased labour and increased recruitment costs due to culling. And therefore the objectives of this review paper are to highlight the effect of mastitis on productivity of dairy animals and to review several major aspects of mastitis and its economic importance.

Prevalence of mastitis in dairy cows

The prevalence of mastitis in Asia is increasing in parallel with the development of new, high-milk-producing breeds of cows and buffaloes. Other factors have been identified that contribute to increased spread of the disease, including: lack of awareness; delay in disease detection in the absence of visible signs of abnormal milk; unhygienic milking practices; and delayed and incomplete treatment of clinical and chronic mastitis (Sharma *et al.,* 2012). Mastitis is a disease that affects a large number of dairy cows throughout the world. In most countries surveys of the incidence of mastitis, irrespective of cause show comparable figure as about of 40% morbidity rate amongst dairy cows & a quarter infection rates as measured by an indirect test of about 25% (Radostits *et al.,* 2007). An annual basis 3 of every 10 dairy cows have clinically apparent inflammation of the mammary gland of the affected cattle, 7% are culled and 1% dies as a sequence of the disease (Smith, 1996).

Sub clinical mastitis is 15 to 40 times more prevalent than clinical mastitis (Kaur and Chawla, 2002). According to Cynthia (2005) the cases of SCM varied from 15 to 75%, whereas the involvement of quarters having SCM varied between 5 and 40 %. Five states, namely Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, and Maharashtra had estimates of 53.52%, 51.18%, 39.58 %, 62.49 % and 35.11 % respectively. Meta-analysis of state-wise prevalence data showed that Punjab and Haryana had harmonized prevalence of subclinical mastitis on cow-basis (Bangae *et al.,* 2014). According to Busato *et al.,* (2000) the prevalence of sub clinical mastitis at the quarter level were 21.2% for lactation period of 7 to 100 days and 34.5% for 01 to 305 days post partum in organic certified dairy farms. According to Varshney and Narsh (2004) prevalence of subclinical form of mastitis was found to be more common in India (varying from 10-50% in cows and 5-20% in buffaloes) when compared to clinical mastitis (1-10%).

Major causative agents: contagious and environmental pathogens

Mastitis is caused by several species of common bacteria, fungi, mycoplasmas and algae (Batavani *et al.,* 2007). Most mastitis is of bacterial origin, with just a few of species of bacteria accounting for most cases. Mastitis pathogens are categorized as contagious or environmental (Kivaria, 2006). Contagious pathogens live and multiply on and in the cow's mammary gland and are spread from cow to cow, primarily during milking.

Contagious pathogens causing mastitis includes *Staphylococcus aureus*, *Streptococcus agalactiae*, *Mycoplasma* spp. and *Corynebacterium bovis* (Radostis *et al.,* 2000).

Environmental mastitis can be defined broadly as those intra-mammary infections (IMI) caused by pathogens whose primary reservoir is the environment in which the cow lives (Smith *et al.,* 1985). The most frequently isolated environmental pathogens are Streptococci, other than *S. agalactiae*, commonly referred to as environmental streptococci (usually *S. uberis* and *S. disgalactiae*) and gram-negative bacteria such as Escherichia coli, *Klebsiella* spp. and *Enterobacter* spp. (Hogan *et al.,* 1999).

Mycotic infections are another important cause of mastitis. In an unpublished study, mentioned in a paper from Kivaria and Noordhuizen (2007), it was established that 90% of small-scale dairy farmers in Tanzania were unaware of the causal factors of mastitis and so did not know how to prevent the disease. Many available studies in developing countries had the aim of conducting microbiological investigations to understand each pathogens role in causing mastitis in different areas.

It is important to remember that contagious mastitis prevalence is considerably influenced by the milking procedures followed by milkers. Thus correct milking procedures such as milking mastitic cows last, and proper sanitation of utensils, milker's hands and udder before milking could help to improve the situation. The frequency of isolation of coliforms (*E. coli*, *Enterococcus faecalis*, etc.) and other micro-organisms causing environmental mastitis is usually directly influenced by unhygienic housing conditions (Mekonnen and Tesafaye, 2010). Many studies from Asian countries have reported that *S. aureus* is the chief aetiological agent of mastitis in cattle and buffaloes (Sharma *et al.*, 2007; Rahman *et al.*, 2010; Ali *et al.*, 2011).

Effect of mastitis on milk composition

Mastitis causes considerable changes in milk (Table 1). Casein, the major milk protein of high nutritional quality, declines and lower quality whey proteins increase which adversely affects the quality of dairy products such as cheese. Serum albumin, immunoglobulins, transferrin and other serum proteins pass into milk because of increased vascular permeability. Jones (2006) has reported that with higher SCC, the concentrations of serum albumin and immunoglobins are increased which reduces heat stability of mastitis milk and pasteurization gives lower grade scores after storage. Also there is a decrease in calcium absorption from blood into milk, resulting impaired coagulation characteristics of mastitis milk. Haenlein *et al.,* (1973) reported a significant decrease in casein content when SCC in milk exceeded 500,000/ ml. The milk proteins breakdown can occur in milk from animals with clinical or sub clinical mastitis due to the presence of proteolytic activity by more than 2- fold during mastitis. Plasmin and enzymes derived from somatic cells can cause extensive damage to casein in the udder before milk removal. Mastitis increases conductivity of milk and sodium and chloride concentrations are elevated. Potassium, normally the predominant mineral in milk, declines and because most of the calcium in milk is associated with casein, the disruption of casein contributes to lowered calcium in milk. The reduced lactose concentration is one important factor for impaired acidification properties of milk with elevated SCC, after adding starter cultures (Schallibaum, 2001). Jones (2006) compared various components of normal milk with that of mastitis milk having high SCC, as described in Table 1.

Bagri *et al.,* 2018 conducted an experiment on 80 lactating cows at dairy farm and were screened against subclinical mastitis (Table 2), the Milk samples were analysed by using ultrasonic ekomilk milk analyzer Instrument. Chemical properties of milk samples were significantly affected ($p>0.05$) with severity of mastitis. The pH and acidity significantly increased in subclinical mastitis milk samples as compared to normal milk samples whereas a significant decreases were recorded in the fat, protein, lactose, solid not fat (SNF) and total solids percent in subclinical mastitis milk samples as compared to normal milk samples of non- affected cows from mastitis disease.

Types of Mastitis

Mastitis may be classified as clinical or sub clinical depending on the degree of inflammation (Philpot and Nickerson, 1991).

Clinical Mastitis

Clinical mastitis can be defined as farmer observed abnormality in the milk and/or the udder. It is inflammation of the mammary gland with grossly visible changes in the udder and milk. It is characterized by abnormalities such as discoloration of milk, redness, increased temperature, pain and disturbance of function (Radostits *et al.*, 2007). Clinical forms of mastitis may further be classified according to the severity of the inflammatory response as mild, acute, per acute or chronic. Clinical mastitis occur in all dairy herds, even in well managed herds as judged by somatic cell count level and cows with a high level of milk production, may be suffering from a high incidence of clinical mastitis (Hogain *et al.*, 1990). The most important bacteria that cause clinical mastitis are *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella spp, Streptococcus uberis and Streptococcus dysgalactiae*.

Sub Clinical Mastitis

Sub clinical mastic refers to inflammation of the mammary gland in the absence of visible gross lesions in the udder or its secretion with the presence of pathogenic microorganisms and unusual number of somatic cells in the milk (Radostits *et al.*, 2007; Harmon, 1994).

Environmental mastitis

This type of mastitis 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).

Diagnosis of mastitis

Clinical examination

Individual udder quarters are examined for abnormal type of size, consistency, symmetry, fibrosis, inflammation signs by thorough inspection and palpation. Milk is examined for the detection of abnormalities such as discoloration, blood ting, wateriness, clots, flakes and pus (Radostits *et al.,* 2000).

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 PNM 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).

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). The procedure is either to use a tube containing 10cc milk add 2ccnormal sodium solution & shake & observe the result or to deposit 5 drops of milk on slide, add 1 drop of sodium hydroxide, shake for 15sec. & read on a black back ground in the tube precipitation is manifested by a gelatinous appearance on the slide by the formation of floccules (Chipper, 2000).

California Mastitis Test (CMT)

CMT is simple, inexpensive, rapid screening test for mastitis. This test is based on a gelling reaction between the nucleic acid of the cells and reagent (Andrews *et al.*, 1992).

Bacteriological 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 and 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).

Table.1 Comparison of values (%) of normal milk with that of mastitis milk having high somatic cell count (SSC)

Constituent	Normal milk	Mastitis milk with high SCC
Fat	3.5	3.2
Lactose	4.9	4.4
Total protein	3.61	3.56
Total casein	2.8	2.3
Whey protein	0.8	1.3
Serum albumin	0.02	0.07
Lactoferrin	0.02	0.1
Immunoglobulin	0.1	0.60
Sodium	0.057	0.105
Chloride	0.091	0.147

Source: Jones (2006)

Table.2 Comparison of values (%) of normal milk with that of mastitis milk having high somatic cell count (SSC)

Parameters	Average value of 20 samples of normal milk	Average value of 20 samples of sub clinical mastitis milk
pH	6.37	6.69
Acidity	0.13	0.17
Fat (%)	3.82	3.21
Protein (%)	3.63	3.40
Lactose (%)	4.83	4.62
Solid not fat (%)	9.74	8.1
Total solids (%)	13.54	11.32
Significant at 5% level		

Source: Bagri *et al.*, 2018

Zoonotic importance

With mastitis there is the danger that the bacterial contamination of milk from affected cows may render it unsuitable for human consumption by causing food poisoning, or interfere with manufacturing process or, in rare cases provide a mechanism of spread of disease to humans. TB, Streptococcal & brucellosis may be spread in this way (Radostits *et al.,* 2007).

All over the world attempts are being made to control bovine mastitis due to the huge effect on public health and the changed composition of milk from animals with mastitis. These may have a harmful influence on the suitability of milk for processing and the quality of the processed products made from it. Mastitis commonly results in some degree of permanent impairment of milk secretion capacity in the cow. As milk from cows with clinical mastitis is unmarketable and milk from cows with sub-clinical mastitis is of inferior quality, an increasing number of milk processing plants and companies are paying much less for milk with a high SCC, than for good quality milk (Norman Christopher, 2004).

Economic loss due to mastitis

Dua (2001) reported that, in India, economic loss due to mastitis was INR 6,053.21 crore, where majority of loss was found to be related to sub-clinical mastitis (70 to 80 per cent) which accounted around INR 4,365.32 crore. According to Varshney and Naresh (2004), incidence of subclinical form of mastitis was found to be more common in India (varying from 10-50% in cows and 5-20% in buffaloes) when compared to clinical mastitis (1-10%). Annual losses in the dairy industry due to mastitis was almost 2.37 thousand crore rupees in India. Out of this, sub-clinical mastitis accounted for approximately 70% of the loss. As per the data from NDRI, the estimated economic loss due to mastitis was to the tune of INR 7165.51 crore per annum. Sinha *et al.,* (2014) stated that economic loss due to sub-clinical mastitis in crossbred cows was INR 592.87 per lactation and loss due to decrease in milk production was INR 700.18.

Mastitis controlling measures

Vaccination, a very innovative idea, designed specifically towards characteristic structural subunits of invading organisms, has been extensively studied in recent years. Most mastitis vaccines fail to elicit long term immune responses. Many different control measures of bovine mastitis include hygienic management procedures, antibiotic treatments, teat dipping sealants, and intra mammary devises. However, the treatment for bovine mastitis relies heavily on antibiotic administration. The drawback of using antibiotics is that the milk may contain residuals and when not administered properly bacteria have the chance to mutate and become resistant to that particular antibiotic (Bradley, 2002). Moreover, in some cases, depending on the type of pathogens, using antibiotics alone is not sufficient to destroy the pathogen.

Along with adequate herd management and sanitary care, the selection of animals that are resistant to diseases and the incorporation of this trait in herds is a promising alternative to reduce the problems caused by infectious-contagious diseases. The use of animals that are resistant to a determined disease reduces the need to apply drugs, with consequent decrease in the levels of contamination of products and the environment. Therefore, the incorporation of genes that impart resistance through the selection of more resistant animals is a practice that should be encouraged.

One of the techniques employed to select disease resistant animals is the use of molecular markers in genetic improvement programs. Various strategies can be applied to identify these markers, among which studies of gene expression stand out. These studies generate knowledge about the biochemical and genetic mechanisms of resistance by clarifying the actions of the respective genes. In recent years, new methods to identify genes of interest by means of gene networks have become available (Chen *et al.,* 2008; Reverter and Fortes, 2013).

In conclusion the mastitis is a complex, multi factorial disease and continues to be the most costly disease of dairy animals and is the most prevalent production disease in dairy herds worldwide, it causes considerable changes in quality and quantity of milk. Bovine mastitis results in a great deal of economic losses, mostly because of the reduction of milk yield, decreased milk quality, and higher production costs, medication costs, discarded milk during and shortly after treatment, loss of milking days, reduced milk price, increased labour and increased recruitment costs due to culling. Many different control measures of bovine mastitis include hygienic management procedures, antibiotic treatments, teat dipping sealants, and intra mammary devises. Along with adequate herd management and sanitary care, the selection of animals that are resistant to diseases and the incorporation of this trait in herds is a promising alternative to reduce the problems caused by infectious-contagious diseases. There is lack of information on the economic impact of the disease in the majority of developing countries; lack of awareness among farmers concerning sub-clinical mastitis and the importance of udder health; and lack of specific national programmes to control mastitis in the majority of countries. All these imply a need for concerted future effort to control and minimize mastitis in dairy animals.

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