Technical bulletin No.12

MASTITIS
CAUSES, PREVENTION AND CONTROL

S. B. Barbuddhe
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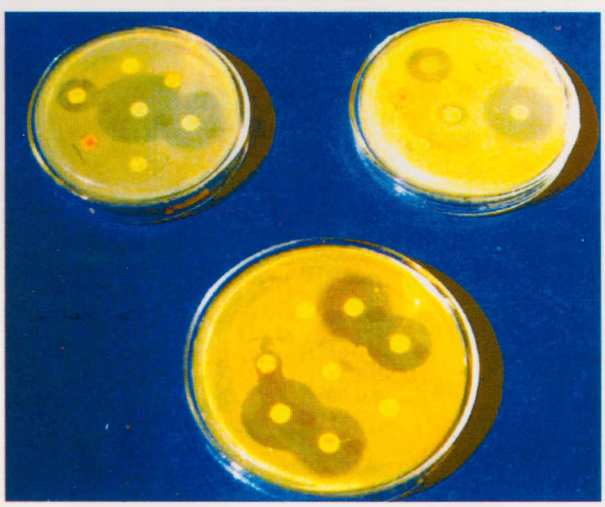

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(Indian Council of Agricultural Research)
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INTRODUCTION

What is mastitis?

Mastitis or inflammation of mammary gland or udder is an economically important condition in milking animals. Mastitis is a disease that affects a large number of dairy cattle throughout the world. It may affect one or all quarters of the udder. It is manifested in the form of swelling of the affected quarters, change in milk colour and composition. If one quarter is affected 25% milk yield is lost permanently. It may also spread to other quarters also, hence it causes major economic losses to the farmer. High yielding animals are more prone to this condition, if not milked properly. The milk from infected udders contributes to high microbial counts of milk, which in turn is not suitable for preparation of milk products. Mastitic organisms are also pathogenic for human beings. Mastitis control is a prerequisite to any of the clean milk production programmes.

Subclinical form of mastitis is considered world-wide to be the most persistent and widespread complex of diseases of importance to milk hygiene. Subclinical form occurs 20-50 times more frequently than the clinical forms and cause greater losses, although it cannot be recognized unless applying particular methods of examination.

Sources and causative agents

There are a great number of microorganisms on and in cow udders. There are 137 species and subspecies of microbes that can be associated with the mammary gland of the cow. Several of them are part of the normal flora and, with few exceptions, do not cause mastitis. On the contrary, they may protect udders from infection caused by pathogenic bacteria.

Mastitis may be of bacterial or fungal origin. Several other microorganisms may, however, cause infection in the mammary glands. The most common, those that cause about 90% of mastitis infections, are given in Table 1. There are contagious microorganisms and environmental microorganisms. Infected cows are the main source of contagious microorganisms, which survive and proliferate on the skin and on teat wounds. They consist of *Streptococcus agalactiae, Staphylococcus aureus* and *Streptococcus dysgalactiae*. Environmental microorganisms (*Escherichia coli* and other coliforms, *Streptococcus uberis*) do not remain on the teat. Of late, *Listeria monocytogenes* has been identified as a cause of bovine mastitis. The main sources of the infection of mastitic pathogens are the infected mammary gland, teat lesions, outer skin and the milking person, utensils. In Goa mastitis cases are mostly due to *Pseudomonas aeruginosa, Staphylococcus aureus* and *Streptococcus sp.*

The reservoir for the main mastitic pathogens is the infected mammary gland. The organisms multiply and secrete into the

milk and spread readily in the surrounding environment.

Mastitis is a difficult problem to comprehend because it is a disease caused by many factors. Microorganisms are responsible for the infection, but for them to enter the mammary glands and establish themselves to the point that they cause an infection, a multitude of factors may be involved. There are many such factors (e.g. hygiene, housing, climate, milking machines, feed, genetics) acting simultaneously.

The factors which contribute to the causation of mastitis include-

- Contamination with milker's hands, contaminated floors, utensils and clothes.
- Presence of high population density of the causative bacteria in milking shed.
- Damage to the teat sphincter
- Udder infected with FMD, Pox virus.
- Physical trauma that may accelerate the growth of these causative bacteria.
- Sawdust and shaving used as bedding, which are harboring *E. coli.*
- Edema and congestion of udder during parturition.
- Poorly designed housing, uneven faulty surface
- Dirty milking machine

Environmental Factors

Climate

Climate may have a direct or indirect influence on the onset of mastitis. Exposure to intense cold, draughts, excessive humidity or heat predisposes cattle to mastitis. A particular type of mastitis often called summer mastitis, is caused by biting insects that contaminate the udder with the bacteria. Climate may also have an indirect influence. For example, muddy conditions outdoors caused by abundant rainfall will increase the number of microorganisms and thus increase risks of infection.

Housing

The mere fact of keeping cows indoors increases the incidence of mastitis. When cows are inside, the risk of udder injury increases. There are also microorganisms whose populations are less concentrated outdoors. It would appear that mastitis is less common with loose housing systems than with tied housing systems.

Draughts, excessive humidity and frequent changes in temperature in a barn are factors that lead to increased incidence of mastitis.

Bedding

Whether with loose or tied housing systems, bedding plays an important role in the incidence of mastitis. This is easy to understand when considering the mastitis-infected milk that reaches the ground, the humidity that favours the development of microbes on bedding and that cows often spend 14 hours out of 24 in contact with their bedding. Inadequate bedding in loose-housed herds, particularly large herds, may lead to serious situations in the case of contagious mastitis.

Stress

In the stressed environment, the immune system of animal is less efficient, therefore resistance to microbial infestations is less. Therefore, the more stress there is, the greater the chance of mastitis.

The following are some sources of stress:

- Excessive density of animals. Proximity of cows encourage microbial exchanges and tense relations between animals;
- Irregular management, unpredictable behaviour on the part of the farmer;
- Noise

Genetic factors

Hereditary factors may influence susceptibility to mastitis. The different dairy cattle breeds are not equally susceptible to mastitis. High yielding cows are more likely to be affected. Selective breeding that focuses solely on milk production is undoubtedly an important factor in higher rates of mastitis. According to different sources, hereditary factors account for 12% to 20% of susceptibility to mastitis in a single breed. Genetically, there is a correlation between the percentage of milk fat and the incidence of clinical mastitis.

Nutritional Factors

Two practices that increase the risks of mastitis are rapid changes in diet and excess or imbalance in the different components of rations. Excessive nitrogen or protein in feed is often mentioned as one of the factors causing mastitis. It is recommended that reduced quantities of concentrates be given to a cow with mastitis. A high energy content in rations increased the incidence of mastitis in first lactation cows whereas it had the opposite effect on the other cows.

Silage and hay

Poor quality silage has a very negative effect on the immune system. The overheated proteins and sugars may kill the white blood cells protecting the udder. Cows fed with hay and grain have greater resistance in every way to several pathogens than cows fed with silage. In some cases, *Pseudomonas* and *Proteus* are the only microorganisms that survive the high temperatures produced in silage. Although rare, silage contaminated this way may then be a source of mastitis caused by these types of organisms. Mouldy hay and mycotoxins also harm white blood cells and therefore weaken the immune system.

Selenium and vitamin E

Maintaining an adequate level of selenium in the system helps to prevent mastitis, reduce the severity of infection and causes it to last for a shorter period of time. Selenium serves to reinforce the immune system response by increasing the release of leucocytes and increasing the efficiency of phagocytes. Selenium and vitamin E work together in the system. Thus, a vitamin E supplement of 1000 IU/day alone reduces the somatic cell count but not the incidence of mastitis. The role of selenium is considered to be most significant in the case of subclinical mastitis. Vitamin A deficient rations reduce immunity.

Human Factors

Integrated human factors with herd management influence causation of mastitis. Geographical position of the farm, treatment of dry cows, replacement cows produced on the farm, positive attitude towards milking, family enterprise result in low somatic count. Tied housing, obsolete milking equipment, short withdrawal period after antibiotic treatment are responsible for high bacterial count.

Average herd, treatment of dry cows, tendency to seek out information, elimination of cows that are too susceptible are ideal for high milk yield.

Types of Mastitis

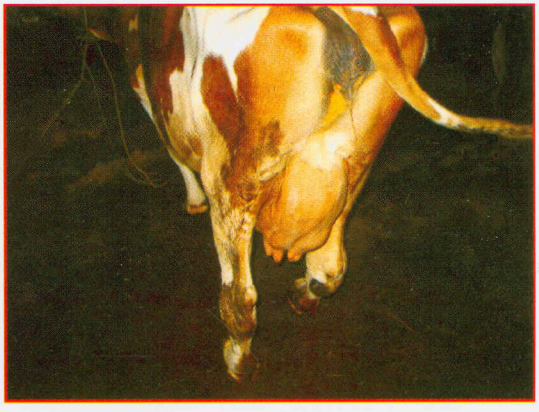
Since mastitis is a disease that has different levels of intensity and which may be caused by different organisms, there exists a complete jargon to describe the disease. It is therefore important to be able to recognize the different types of mastitis in order to decide what preventive measures to use as well as what treatment (Table 1).

To infect a quarter, a microorganism must first enter the quarter and the cow must be unable to get rid of it before it multiplies. Following is a typical scenario that leads to mastitis infection.

1. Contact with the microbe: The number of microorganisms multiplies near the orifice (or sphincter) of one or several teats. This is where hygiene and milking habits play an important role in preventing microbes from entering the quarter.

2. Entry of microbe into the teats: Entry may be forced by the milking machine, particularly at the end of milking. Injured teats (injuries, keratin injured inside teat) or teats whose openings are too large may be easily invaded.

3. Immune response of the cow: the cow's first line of defense is to send white blood cells (leucocytes) to eliminate the microbes that have penetrated the teat. If the response is insufficient, the microbes multiply and the cow shows other immune responses such as fever. The effectiveness of the cow's immune system depends on many factors.



Clinical Cases of Mastitis

Table 1. Main microorganisms involved in mammary infections, their characteristics and prevention

Species	Main Source	Living Conditions	Propagation Factors	Symptoms	Preventive Treatment
Streptococcus agalactiae	Infected cows	Infected quarter and udder only	Using same rag for cleaning udders	Mild fever for about 24 hours.	Wash udders after milking, reduces problem by 50%
Staphylococcus aureus	Infected cows	On abnormal udder and teat, milkers, vagina, tonsils	Transmitted by hands or rags, enters during milking	Often quite acute for a few days after calving. Quarter swells and turns purple. Quickly affects entire system. In chronic state, udder hardens, aqueous secretion, eventual atrophy of the quarter. Intermediate form with granular secretion.	Cull infected cows
Streptococcus dysgalacti	Infected cows	Infected quarter, injuries		Pronounced swelling of one or more quarters. Milk highly abnormal. High fever in serious cases.	
Streptococcus uberis	Contaminated environment	On cow's skin, mouth, ground	Neglected udder washing, insufficient drying, lack of bedding	Pronounced swelling of one or more quarters. High fever in serious cases. Affects mostly dry cows.	Wash udders only, dry well with disposable paper towels for each cow.
E. coli	Contaminated environment	Ground, bedding (sawdust and shavings), manure, water	Dirty calving stall, lack of bedding, inadequate udder washing	Often very serious. May lead to loss of quarter or even death. Thin yellow secretions, with granular texture resembling bran.	
Corynebacterium pyogenes	Certain insects	Humid valleys, wooded areas		Pronounced systematic reaction due to toxins caused by bacteria. Often more than one quarter affected. They become hard, produce thick smelly secretion like cheese.	

Table 2. Different types of mastitis.

Types of Mastitis	Characteristic Symptoms or Definition
Hyperacute clinical	Swollen, red, painful quarter, milk passes with difficulty. Fever over 41°C. Cow has no appetite, shivers and loses weight quickly. Lactation often stops.
Acute clinical	Inflammation of the teat, fever above 39 °c, weak and dejected animal, lack of appetite. Drastic drop in milk yield, often follows calving and, less seriously, after cow goes dry.
Subacute clinical	No apparent change in udder, presence of flaky particles in milk, especially in initial ejection. Subject appears healthy.
Subclinical	No symptoms. 15 to 40 per cent more incidence than clinical cases. Milk appears normal. Only change is detection of pathogenic agent in analysis and increased somatic cell count. Mostly caused by *Staphylococcus aureus.*
Chronic	Repeated but mild clinical attacks, generally without fever. Lumpy milk, quarters sometimes swollen. Quarter may become hard (fibrous indurations). Antibiotic treatments often do not work.
Contagious	Mastitis caused by bacteria such as *Staphylococcus aureus* and *Streptococcus agalactiae,* of which infected cows are the main source.
Environmental	Mastitis caused by bacteria such as coliforms (e.g. *E. coli),* of which the main source is a contaminated environment, i.e. manure.

Diagnosis of mastitis

To diagnose mastitis, it is necessary to learn how to distinguish between the symptoms of the various types of mastitis infection (Tables 1 and 2). The key points to remember are as follows:

Monitor the milk: routine examination of the milk using a filter cup to extract the first three squirts before washing (before milking) is undoubtedly the best way to diagnose mastitis. The presence of lumps, flakes, blood, etc. must be watched for. Milk that is hotter than normal may be a good indication of a *Staphylococcus aureus* infection.

Palpate the udder: particularly after milking, when it is easy to detect swelling, and fibrous, hard or injured tissue.

Subclinical cases may go unnoticed and therefore testing of milk with California mastitis test (CMT) or any other spot test is necessary. Bacteriological examination of CMT positive samples should be carried out.

Diagnosis of mastitis is based on bacteriological and cytological methods of examination. For bacteriological examination, milk samples need to be collected under aseptic conditions and should be preserved under refrigeration.

Somatic Cell Count

When swelling occurs, the cow's immune system reacts by sending leucocytes to destroy the foreign bodies. The somatic cell count in the milk may thus indicate if a cow is fighting infection. For normal milk with a cell count of 50,000 cells per ml, there may by 20% leucocytes and 80% epithelial cells, whereas mastitis infected milk with a cell count of over 500,000 cells per ml, contains 90 to 95% leucocytic cells.

Facilities for diagnosis of mastitis are available at ICAR Research Complex for Goa, Ela, Old Goa and Disease Investigation Laboratory, Dept. of Animal Husbandry and Veterinary Services, Tonca, Caranzalem.

Prevention and control

Mastitis control also entails a good understanding of the factors that encourage its incidence and the microorganisms that cause it. Mastitis control must be concentrated on the prevention aspects, which depends mainly on the whole hygienic management and absence of stress conditions. Specific control measures need to be taken according to the respective cause and the extent of losses. Specific control measures include -

1. Correction of milking technique
2. Teat disinfection (e.g. teat dipping) following milking.
3. Antibiotic treatment at drying off
4. Culling of animals with therapy - resistant mastitis.

Milking Process

Clean milking habits are important to avoid the spreading of germs or their proliferation. The purpose of hygiene is to prevent the transmission of germs from one teat to another on one cow or from one cow to another.

Udder washing

Washing the udder is hygienic and it has a stimulating effect on milk flow. Adequate washing is especially important to prevent environmental mastitis, caused by coliforms and other microbes from contaminated environments. Badly washed udders contribute to the transmission of microbes rather than to their destruction.

Foremilking

Removing a little milk by hand before machine milking serves to stimulate milk let down and to obtain a milk sample containing a high microbial count.

Milking order

It is important to milk infected cows last. If possible, milking order should be as follows: first lactation cows, normal cows, cows with a high cell count and then infected cows.

It is important to milk twice a day, even with cows that do not produce a lot. The longer the milk remains in the udder, the greater the risk of infection. The first squirts of milk must not go on the ground

as this will contaminate the bedding and floor.

Postmilking teat dipping

Using a disinfectant teat dip after each milking is a means of diminishing by about 50% the risk of infection by contagious microorganisms like *Streptococcus agalactiae* and *Staphylococcus aureus*. Teat dipping prevents populations of these microbes from developing sufficiently between milkings. Teat dipping also discourages flies. It is important that the teat dip contain up to 10% of emollients to increase the suppleness of the teat.

It is obviously important to clean and disinfect equipment after milking. Cider or corn vinegar and peroxide can be used as alternatives to phosphoric acid and chlorine.

Hygiene and Safety

Indoors

Abundant bedding prevents injury to the udder, limits exposure to cold damp floors and limits contact of the udder with manure. Adding lime to the bedding can help in a stable where environmental mastitis is a problem but can also irritate the udder, the teats and the lungs when airborne.

It is important to prevent the cows from injuring their udders. The floors should not be slippery when the cows are let outdoors and there should be separators between the cows. Disinfecting the stable twice a year is a good practice.

Outdoors

There should not be any mudholes around the buildings or any place the cows have access to. Along the same lines, watering areas should not be allowed to become mucky. Ideally they should be located on higher ground or gravel or cement platforms used under the drinking areas. There should be no barbed wire left lying around or in areas where the cows could injure themselves. Overpopulation in the stable and fields, particularly with loose housing, should also be avoided, as it increases stress on the animals and risk of contagious mastitis being transmitted.

Feed

Changes in feed must be done slowly. Excesses must be avoided, particularly concentrates and nonprotein nitrogen feed. A 1.4 to 1.8 calcium to phosphorous ratio must be maintained, even during the dry period. Selenium and vitamin E supplements may be a good choice if the ration does not provide the necessary minimum.

Culling and Replacement

Replacement: Do not buy infected animals; have them tested before purchasing them and examine the udders. It is better to buy only heifers (heifers generally do not have mastitis) or produce your own replacement animals.

Culling: Cull animals that are severely or repeatedly affected by mastitis. Cows with injured teats that do not heal should be put at the top of the list of animals to cull.

Drying off Periods

It is well known that mastitis often affects cows that have recently gone dry. These animals should not be overfed, particularly during dry periods. First lactation cows in particular must also be supervised since they are twice as likely to develop mastitis during the dry period than the others.

CURATIVE MEASURES

There is a vast range of curative methods that may be used as an alternative to antibiotics: homeopathy, phytotherapy, etc. The advantage of homeopathy over antibiotics is that milking may be continued. The other alternative products used must not go in the bulk milk because tests for detecting antibiotics in milk may react positively to certain products like some essential oils.

When a treatment is being administered it is important to modify other practices:

- Infected cows must be fed prudently. Concentrates must be reduced and extra fibres and laxatives must be included.
- Avoid exposing infected animals to cold and draughts;
- Milk gently by hand 3 to 6 times a day.

In all cases, it is important to immediately contact a veterinarian if there is no rapid improvement.

HOMEOPATHY

Preventive homeopathic treatments are administered using nosodes on an entire herd rather than on individual animals. Nosodes are fragments of pathogenic cells that increase the immune response. Nosode preparation is established according to the species of bacteria causing the problem in the herd.

An alternative to nosodes that is particularly effective for subclinical mastitis is to use in conjunction homeopathic remedies that have proven effective against mammary gland afflictions. Common preparations include Belladonna, Bryonia and Urtica Urens; Phytolacca and Sulphur, Silicea and Carbo vegetabilis .

Homeopathic treatments are administered through the mucous membrane. Homeopathy is less effective when the infection is caused by injury to the teat.

Treatment

a. Udder infusion: - It is convenient and efficient. Disposable tubes with water soluble ointment base need to be used. Emptying of udder is essential before infusion. For animal with clinical mastitis manual removal of congestion in the gland and inflammatory debris from the duct system should be done.

b. Parental treatment is advisable. In supportive therapy large quantity of isotonic fluid with glucose, antihistaminic drug is recommended.

Before antibiotic therapy, the sensitivity of the pathogens to particular antibiotics should be carried out.

c. The use of preparations containing disinfecting ingredients and added emollients is effective which promote the healing of teat lesions and prevent new infections. Glycerin (up to 10%) and lanolin (up to 3 %) are used as emollients.

d. Iodophors are important teat dips. Application of preparations containing 3000-5000 mg available iodine per kg, depending on the glycerin concentration, leads to reduction in bacterial numbers.

e. Culling of cows with therapy resistant udder diseases considerably reduces the risk of infection for the other animals. To improve the situation of udder health in a herd it is essential to ensure that exclusively healthy animals are used as herd replacements.

f. If machine milking is practiced then rinsing of the teat cups and dipping them in the disinfectant wash water between cows, by dipping a pair of each cluster in turn or hot water (170-180) for 10 sec. is effective. The back flushing of the milking tube and cups with cold water for about 15 minutes should be done. Milking machine pressure should be 37.5 cm Hg. Pulsation rate should be 40/minute.

Estrogenic compound in foods should be reduced. Young animals should be milked before older. Newly introduced animal should be milked separately.

Non-antibiotic control

Although we are concerned with alternative methods of mastitis control, it is worth mentioning some of the disadvantages of the currently recommended methods of disease control which necessitate the consideration of alternatives. Intramammary antibiotics are administered after clinical mastitis has been diagnosed, and although in many cases they are very effective and reduce the severity and duration of the disease, at least 5 d milk yield from the cow must be discarded because of antibiotic contamination.

Staphylococcal infections often result in a chronic subclinical disease, which causes a permanently elevated polymorphonuclear leucocyte (PMN) count in the milk, considerable loss of milk yield, and continual excretion of bacteria which can infect other cows. This condition is very resistant to antibiotic therapy with a bacteriological cure rate often as low as 15%.

There are two forms of control not involving antibiotics which are valuable or potentially so. The most obvious and potentially the most effective method is to stop organisms gaining entry to the udder. If this fails the next option for control is to inhibit or prevent bacterial multiplication by utilizing the defense mechanisms of the udder, so reducing the duration and severity of the disease.

The teat is tightly sealed in the inter-milking period, and the keratinous lining of the teat duct contains antimicrobial basic proteins and fatty acids which may kill bacteria entering the teat canal. With very few exceptions the transmission of infection between cows and quarters occurs during milking, via the milker, udder cloths or the milking machine.

Udders should be effectively washed before milking with a mild disinfectant and dried with a disposable paper towel. This reduces the transmission of bacteria from teats which have colonized orifices or lesions or have acquired contamination of the surface between milkings. A small quantity of milk should be drawn from each quarter or look for clinical signs of new infection. This identifies cows, which are a potential source of new infection. Extreme care needs to be exercised at this point since contaminated milker's hands or gloves are an excellent way of transferring bacteria not only from quarter to quarter in the same cow but between cows. The milking machine clusters can be disinfected between each cow to reduce further the chance of lateral spread, because of cost and time this is rarely practiced, and at best the clusters are disinfected only after a known infected cow has been milked.

Dipping of the teats in a mild disinfectant is widely practiced and reduces teat-end colonization by killing organisms which have contaminated the teat at milking.

The milking machine is another important vector in the spread of disease within a cow and between cows. One problem of milking machines is that milk from each quarter is mixed in the claw piece of the machine immediately after withdrawal from the udder and each teat can become bathed in milk from the other three quarters. Vacuum fluctuations in the system can cause an impact mechanism, which results in the bacteria being jetted through the teat canal during milking.

Various antimicrobial systems exits in the bovine udder, but with certain notable exceptions they are not very efficient. A large proportion of penetrations of bacteria result in multiplication; the consequent changes in the udder and milk constituting mastitis.

It is accepted that perhaps the most important defence mechanism of the udder is the PMN. These cells are not present in the healthy udder to protect it from infection but, following bacterial multiplication, they generally migrate in large numbers into the milk. The future may offer techniques which manipulate and improve the existing PMN defence mechanism of the udder to ensure a more rapid and complete kill of the bacteria which are already growing in the udder. These options would also have the benefit of not requiring the day-to-day attention of the farmer although they will not remove the need for good husbandry and hygienic milk production methods.