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University of Gondar

Mastitis: *Economic Significance, Effects on the Quality of Milk & Milk Products*

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MASTITIS: *ECONOMIC SIGNIFICANCE, EFFECTS ON THE QUALITY OF MILK & MILK PRODUCTS*

- **Definition:** Mastitis is an inflammation of the mammary gland caused by microorganisms, usually bacteria, that invade the udder, multiply, and produce toxins that are harmful to the mammary gland.

MASTITIS…Continued

- It can also occur as a result of chemical, mechanical, or thermal injury that leads the white blood cells (leucocytes), to be released into the mammary gland.
- The mammary gland does not produce any milk. The udder sac is hard, tight, and firm.

Mastitis-causing bacteria

- Bacteria that are known to cause mastitis include:

✓*Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus agalactiae*, *Streptococcus uberis*, *Brucella melitensis*, *Corynebacterium bovis*, *Mycoplasma* (various species), *Escherichia coli*, (*E. coli*), *Klebsiella pneumoniae*, and others.

Identification/diagnosis

- This disease can be identified by abnormalities in the udder such as swelling, heat, redness, hardness or pain. Other indications of mastitis may be abnormalities in milk such as a watery appearance, flakes, clots, or pus.

Types of Mastitis

i. Clinical Mastitis: visible signs of mastitis which include:

- *Mild signs* flakes or clots in the milk, may have slight swelling of infected quarter.
- *Severe signs* secretion abnormal, hot, swollen quarter or udder; cow may have a fever, rapid pulse, loss of appetite, dehydration and depression; death may occur.

ii. Subclinical Mastitis:

- no visible signs of the disease
- Somatic cell count (SCC) of the milk will be elevated.
- Bacteriological culturing of milk will detect bacteria in the milk.
- Causes the greatest financial loss to dairy farmers through lowered milk production.
- For every clinical case of mastitis, there will be 15 to 40 sub-clinical cases.

Somatic Cell Count (SCC)

✓The number of leukocytes or white blood cells per milliliter of milk.

Normal milk will have less than 200,000 cells per milliliter.

✓An elevated SCC is an indication of inflammation in the udder.

✓Bulk tank SCC gives an indication of the level of sub-clinical mastitis and the loss of milk production in a herd due to mastitis.

Transmission and prevention

- Mastitis is most often transmitted by contact with the milking machine, and through contaminated hands or materials.
- A good milking routine is vital. This usually consists of applying a pre-milking teat dip or spray, such as an iodine spray, and wiping teats dry prior to milking. The milking machine is then applied.

Transmission …Continued

- After milking, the teats can be cleaned again to remove the growth medium for bacteria.
- A post milking product such as iodine-propelyne glycol dip is used, to act as a disinfectant and a barrier between the open teat and the bacteria in the air.

Transmission …Continued

❖To prevent mastitis, application of hygienic methods is important including;

✓Apply dry cow therapy, eg. Benzyl penicillin

✓Treatment of acute cases

✓Prevent new infection

Transmission …Continued

❖The following activities can minimize new infection of mastitis cases;

- Wash the udder before milking
- Control of the proper function of milking machine
- Dipping of all teats after each milking with mild des infectants
- Disinfection of milking machines

Transmission …Continued

- Keep cows in clean straw
- Proper drainage
- Frequent removal of dung and urine
- Adequate scrapping and cleaning of the floor
- Adequate fly control
- Frequent tail clipping

Treatment

- Treatment is possible with long-acting antibiotics, but milk from such cows is not marketable until drug residues have left the cow's system.
- Antibiotics may be systemic (injected into the body), or they may be forced upwards into the teat through the teat canal (intramammary infusion).

Treatment…Continued

- Cows being treated may be marked with tape to alert dairy workers, and their milk is syphoned 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.

Control

- ✓ 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.

Economic Loss of Mastitis

- Mastitis is considered to be the most frequent and most costly production disease in dairy herds of developed countries.
- Economic loss to mastitis in the United States is estimated to be approximately $185/cow annually. If we assume the same milk price and this value is multiplied by the total number of milking cows (9.5 million head), the total annual cost of mastitis is about $1.8 billion.

Economic Loss …Continued

- This is approximately 10% of the total value of farm milk sales, and about two-thirds of this loss is due to reduced milk production in subclinically infected cows.
- The average production loss per lactation for one infected quarter is about 1,600 pounds.

Economic Loss …Continued

- Other losses are due to discarded abnormal milk and milk withheld from cows treated with antibiotic, costs of early replacement of affected cows, reduced sale value of culled cows, costs of drugs and veterinary services, and increased labor costs.

Economic Loss …Continued

- These estimates do not include additional costs arising from mastitis-associated problems related to antibiotic residues in human foods, milk quality control, dairy manufacturing, nutritional quality of milk, degrading of milk supplies due to high bacteria or somatic cell counts, and interference with genetic improvement of dairy animals.

The estimated costs of these factors are shown below (Table 1).

Source of Loss	Loss per Cow ($)	Percent of Total(%)
Reduced Production	121.00	66.0
Discarded Milk	10.45	5.7
Replacement Cost	41.73	22.6
Extra Labor	1.14	1
Treatment	7.36	4.1
Veterinary Services	2.72	1.5
TOTAL	**184.40**	**100.0**

***Assumptions: One-third of cows infected in an average of 1.5 quarters; milk loss 856 pounds per infected quarter; milk price $12.07 per hundred weight.**
(Source: Current Concepts in Bovine Mastitis. National Mastitis Council, 1996).

Economics of Mastitis Control

- When analyzing the cost of mastitis control, consider first the cost in lost production. The bulk tank SCC is a good place to start. Table 2 below estimates expected losses and prevalence of infection for elevated bulk tank SCC.

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Economics …Continued

- Consider as well the possible savings when mastitis is effectively managed. The value of increased milk sales from reduced mastitis more than offset the costs of an effective control program. (Table 3.)

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Economics …Continued

Table 2. Estimated infection prevalence and losses in milk production associated with elevated bulk tank SCC.

Bulk Tank SCC (1,000's/ ml) in Herd	Percent Infected Quarters	Percent Production Loss*
200	6	0
500	16	6
1000	32	18
1500	48	29

***Production loss calculated as a percent of production expected at 200,000 cells ml.**

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Economics …Continued

Table 3. Estimated annual savings from an effective mastitis control program (based on Table1 above).

Source of Saving	Amount of Saving
Production per cow	$121.08
Clinical mastitis reduced 40%	
Discarded milk $10.45 x 40%	4.18
Total Return	$125.26
Mastitis Control Costs (per cow annually)	
Teat dip	$10.00
Dry cow medication	$4.00
Paper towels	$10.00
Total Cost	$24.00
Net Return to mastitis control (per cow annually)	$101.26

(Source: Current Concepts of Bovine Mastitis. National Mastitis Council, 1996).

Effects on Milk Production, Composition and Quality

- Mastitis reduces milk yield and alters milk composition. The magnitude of these changes in individual cows varies with the severity and duration of the infection and the causative microorganisms.

Economics …Continued

- Mastitis is almost always caused by bacteria. These microorganisms produce toxins that can directly damage milk-producing tissue of the mammary gland, and the presence of bacteria initiates inflammation within the mammary tissue in an attempt to eliminate the invading microorganisms.

Economics …Continued

- The inflammation contributes to decreased milk production and is primarily responsible for the compositional changes observed in milk from infected quarters and cows.
- In general, compositional changes involve an increase in blood components present in milk and a decrease in normal milk constituents.

i. Production

- The Dairy Herd Improvement Association (DHIA) has adopted a SCC scoring system that divides the SCC of compositive milk into 10 categories from 0 to 9 known as linear scores.

Production …Continued

- The DHIA programs determine the SCC on each milking cow each month and report either the SCC or the linear score. Linear scores can be used to estimate production losses, but the average linear score for the lactation most accurately reflects reduced milk yield. Cows with higher lactation average SCC scores produce less milk (Table 4).

Production …Continued

- Production losses in older cows are about double those of first lactation cows.
- Determining the exact amount of milk lost at a specific SCC or linear score or for any one cow is not possible.
- However, the fact remains that elevated SCC results in major losses to dairy producers, and elevated SCC is almost always due to the presence of intramammary infection.

ii. Composition

- Changes in milk composition accompany the increase in SCC following infection of the mammary gland.
- These comparisons frequently are made between high and low SCC milk from opposite quarters of the same cow to reduce cow to cow variation.

Composition …Continued

- Elevated SCC is associated with a decrease in the content of lactose and fat in milk because of a reduced ability of the mammary gland to produce these components.
- Some studies have shown no change in fat percentage, yet total fat production declines with the decrease in milk production.

Composition …Continued

- Although there may be little change in the total protein content as a result of subclinical mastitis, there are marked and significant changes in the types of proteins present.

Composition …Continued

- The major milk protein is casein. This protein has high nutritional qualities and is very important in cheese manufacturing. Casein content of milk with a high SCC is reduced, but lower quality whey proteins increase in concentration, resulting in a similar total protein content.

Composition …Continued

- The lower quality whey proteins are blood serum proteins such as serum albumin, immunoglobulins, and transferrin, which increase in milk as a result of the destruction of membranes that normally prevent blood serum proteins from entering milk.

Composition …Continued

- Sodium and chloride increase in high SCC milk due to increased passage of these minerals from blood into milk. Potassium, normally the predominant mineral in milk, declines due to its passage out of milk to lymph between damaged secretory cells.

Composition …Continued

- Most of the calcium in milk is associated with casein, and disruption of casein synthesis results in reduced calcium levels in milk from mastitic cows.
- These alterations in mineral content affect the pH and conductivity of milk. The pH of normal milk is generally around 6.6, but may increase to 6.9 or higher in milk from mastitic quarters.

Composition …Continued

- Other important compositional changes include increases in enzymes originating from damaged mammary tissue, the blood stream, or milk somatic cells. Many of these enzymes negatively impact milk quality.
- An increase in the enzyme lipase can raise the content of free fatty acids, which produce off-flavors in milk from mastitic cows.

Composition …Continued

- An additional example is the enzyme plasmin, which may double in concentration in high SCC milk. Plasmin attacks casein and can markedly reduce the casein content, resulting in lower yields of cheese and other manufactured products and off-flavors in milk.

iii. Quality

- Mastitis not only reduces dairy producer profits but also results in important and costly losses to processors due to poor quality milk. Reduced quality is detected with herd milk at 400,000 cells/ml.
- A variety of dairy products are affected, including cheeses, powdered milk, fermented products, and fluid milk. Progressive milk plants pay on milk quality for obvious reasons, but quality premiums also pay big dividends to producers.

Mastitis effect on milk quality and milk products

- There are a number of functions that can be disrupted during intra-mammary infection.
- It depends on the following factors:-

A. Severity of the infection
B. Extent of the infection
C. Alteration of the metabolic activity of milk producing cells

Mastitis effect cont.

D. Interference with precursors availability for milk synthesis
E. Disruption of epithelial integrity, by opening up Para cellular pathway
F. Decomposition of the milk constituents

- The increased permeability of blood-milk barrier in the affected quarter leads to

  - decreased vol. of milk composition conc.

Mastitis effect cont.

- Or decreased in milk production may be due to
  - Demand for energy of immune system against infection
  - Decreased appetite associated with inflammation

Mastitis has effect on different components of milk compositions.

1. Effect on protein composition

Mastitis effect cont.

- Increase in proteins of blood serum is possibly due to

A. Disruption to integration of mammary epith.

B. Decrease in casein conc. Due to post secretion degradation of casein by proteinase,

- which has important implication on cheese manufacturing

Mastitis effect cont.

2. Effects on Fat content

- Decrease in fat concentration or
- Increase in fat concentration
- Increase in conc. Indicating decrease lactose synthesis
- Decrease in conc. Is due to lower volume of milk secretion

Mastitis effect cont.

3. Effect on lactose content

- Mastitis causes decrease in concentration of milk lactose
- It's due to damage in the alveolar epithelial cells
- Level of lactose conc. are dependent on the severity of damage to the tight junction.

Mastitis effect cont.

4. Effect on mineral content

- Milk contains a high conc. of potassium relative to sodium
- Conc. Of many minerals altered during mastitis which plays significant role in determining the manufacturing quality of milk
- Potassium is most abundant mineral in milk
- Conc. Decreases due to leakage through Para cellular pathway

Mastitis effect cont.

- Na. found in blood in high quantities, so Leakage in to the milk Increases in the milk above normal
- Conc. Of Cl in the milk from cow with subclinical mastitis are elevated
- Due to the influx of blood constituents in to the milk during infection.

DAIRY SANITATION: Sanitation in farm and in dairy processing industries

- In today's competitive environment, quality milk bonuses are becoming increasingly more lucrative
- Subsequently, cooperatives are employing higher/quality standards for determining milk quality.
- To implement such things and keep its sanitation, it is essential to consider in many perspectives;

Dairy water supplies

- Water is used for all cleaning purposes in a milk processing plant.
- An adequate supply of water of satisfactory bacteriological and chemical quality is therefore required.
- Water of good bacteriological quality is important to protect public health and to avoid contamination and possible deterioration in the quality of milk and milk products.

Bacteriological quality

- The bacterial flora of most water supplies consists mainly of Gram negative rods.
- Many of these may be proteolytic and lipolytic and will cause spoilage of milk and milk products if processing and storage conditions are not correct.
- Coliform bacteria, and in particular *Escherichia coli* type 1 which is largely of human and animal intestinal origin, are particularly undesirable in water.

Bacteriological quality

- Their presence may indicate pollution of water by sewage and the possible presence of pathogenic bacteria
- The bacteriological quality of water varies with its source and it may also vary with the season of the year and variations in rainfall.
- Water of satisfactory bacteriological quality should meet the following requirements:

Bacteriological quality

- Total bacterial count at 37°C should not exceed 200 per ml
- Coli-aerogenes (coliforms) bacteria should be absent in 1 ml
- Nutrient gelatine count (proteolytic bacteria) at 21°C for three days should not exceed 500 per ml.

Chemical quality

- Rain water is relatively pure and contains only traces of dissolved chemicals.
- The chemical impurities of a water supply are related to the topography and geology of the area from which it is obtained.
- Water may contain inorganic salts of calcium, magnesium and sodium as well as iron, copper, lead and zinc nitrate.
- The hardness of water is due mainly to the presence of inorganic salts of calcium and magnesium.

Chemical quality

There are two kinds of water hardness,

- temporary and permanent;
- Temporary hardness is due to the carbonates and bicarbonates of calcium and magnesium.
- These salts are easily precipitated or removed by heating.
- Permanent hardness is mainly due to the sulphates, chlorides and nitrates of calcium and magnesium.
- In the presence of certain alkalis these salts are converted into insoluble deposits and for this reason specific constituents, e.g. polyphosphates and salts

Chemical quality

of gluconic acid are incorporated into a detergent to minimize the precipitation.

- It is usual to express water hardness in terms of equivalent calcium carbonate in ppm.
- Water supplies are classified as soft, moderately hard, hard and very hard if the total hardness (expressed as calcium carbonate) is 0--60, 60--120, 120--180 and over 180 ppm, respectively.

Chemical quality

- Deposits of calcium and magnesium salts on the surfaces of milk processing equipment reduces heat transfer efficiency and provides a nucleus for deposits of other materials present in milk.
- Hardness is also objectionable as it leads to waste of soaps and detergents
- Suggested chemical standards for water supplies are:
- Total hardness (as $CaCO3$) -- less than 50 ppm
- Chloride (as NaCl) -- less than 50 ppm
- PH -- 6.5 to 7.5

Chemical quality

- Lead -- 0.1 ppm maximum
- Iron (as Fe) -- 1 ppm maximum
- Cyanide -- 0.01 ppm maximum.
- The presence of heavy metals such as copper and iron in a dairy water supply is particularly objectionable as they can act as catalysts in the oxidation of milk fat leading to off-flavours in products such as butter and cream.
- Processing equipment should be clean and the processing room should be well lit and ventilated, clean and tidy.
- However, sanitation of processing equipment means more than having the equipment looking clean and tidy.

Water softeners

- Chemicals and zeolites or resins are used to soften water.
- Temporary hardness may be removed by the addition of lime or sodium hydroxide to the water.
- while permanent hardness is removed by the addition of sodium carbonate and sodium hydroxide.
- Thorough cleaning and sanitising of all dairy equipment is an essential part of milk processing.
- Water alone is inadequate for cleaning and sanitising and, therefore, chemical agents must be used.

Water softeners

- Cleaning and sanitising dairy equipment is necessary to prevent:
  - Accumulation of undesirable micro-organisms in the equipment
  - Development of bad smells in the equipment which pass on to the product
  - Loss of efficiency in a dirty separator
  - Possible corrosion of metal parts due to lactic acid
  - Mould growth on wooden surfaces leading to mould contamination of the product and discolouration of the churn surface
  - Contamination of the product with pathogens.

Cont….

The cleanliness of equipment can be classified at four levels:

1. Physical cleanliness, where all visible dirt has been removed.

2. Chemical cleanliness, where, in addition to all visible dirt, microscopically small residues have been removed.

3. Sanitation, where, in addition to being chemically clean, the equipment has been treated to inactivate or remove micro-organisms present on its surface.

4. Sterilisation, where, in addition to being sanitised, the equipment has been treated to destroy all micro-organisms present on the equipment.

Cont…

- Sanitation and sterilisation are easier to achieve if the equipment is initially at least physically clean.
- Therefore, the equipment is normally cleaned before sanitation or sterilisation.

Chemicals used for cleaning

- Detergents are chemical agents that assist in the cleaning process by dissolving the deposited dirt, thereby making its removal easier.
- Sodium salts are the commonest and cheapest detergents.
-

Cont ….

- Sodium hydroxide, sodium carbonate and sodium tripolyphosphate are commonly used.
- Synthetic detergents, such as alkyl benzyl sulphate, and biological detergents are also used

Sterilisers

- Chemical sterilisers are agents which, when added to water at a specific concentration, reduce the number of micro-organisms on previously cleaned surfaces to very low levels.
- The active sterilising ingredient is usually iodine, chlorine, nitric acid or quaternary ammonium compounds..

Cleaning procedure

- Before using any detergent or steriliser, remove as much of the dairy or food product as possible from the surface of the equipment.

1. Prewash the equipment with clean, cold water. This removes much of the dirt and should be

- carried out immediately after the product has been removed.
- Wash the equipment with warm water (50°C) to remove fatty material.
- If the equipment is washed thoroughly with water, much less detergent is required in later stages.

Cont…

- Organic sterilisers such as chloramine-T, halane and isocyanuric acids are also used

2. Wash the equipment with a detergent solution, following the manufacturer's instructions.

- The equipment should be cleaned thoroughly at this stage to ensure that it is chemically clean.
- The equipment should be scrubbed thoroughly using the detergent solution.
- Detergent cleaning also reduces bacterial numbers on the equipment.

Cont…

3. Drain the detergent solution. It may be retained for washing other items of equipment, provided its strength is maintained.

- Rinse the equipment at least three times with clean cold water to remove all traces of the detergent.
- If not removed, traces of detergent may be incorporated in subsequent batches of dairy product.
- Rinsing three times with small volumes of water removes detergent residues much more effectively than rinsing once with a large volume of water.

Cont…

4. Sanitise the equipment using one of the compounds mentioned above.

- Chlorine compounds are particularly corrosive and should only be used in accordance with the manufacturer's instructions.
- Rinse the equipment again with clean water to remove all residues of the sanitising agent.
- In the absence of a suitable chemical steriliser, the equipment can be scalded with water at 80°C.

5. Once washed and rinsed the equipment should be stored in a clean, dry, dust-free area.


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