Review Article

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# Mastitis in Dairy Cows: Current Knowledge

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## Abstract

According to the global dairy industry, mastitis is the costliest production disease affecting dairy herds. Many different microorganisms, including dominant and pathogenic microorganisms like *Streptococcus uberis, Corynebacterium bovis, Escherichia coli,* and *Staphylococcus aureus*, *Mycoplasma species*, fungi, yeast, and chlamydia are the cause of it. The clinical mastitis symptoms include changes in the milk, like flakes and clots, and indications of mammary gland inflammation, like swelling, heat, pain, and edema. The term "Subclinical mastitis" is the term used to describe inflammation of the mammary gland when there is no noticeable lesion in the udder or its secretion. However, pathogenic microorganisms are still present, leading to a reduction in milk production. The milk secretion also includes bacteria and the composition of the milk changes. Choosing animal breeds resistant to disease and incorporate this trait into farm herds is an effective way to reduce the issues brought on by infectious diseases Thus, the need for medication, which will lower environmental and product contamination levels, will be reduced. This review aims to summarize the state of knowledge regarding the causes, pathophysiology, manifestations, treatment, and avoidance of bovine mastitis.

**Keywords:** Dairy Cows, Mastitis, Somatic Cell, Clinical Mastitis.

## Introduction

Mastitis, a costly and dangerous illness, significantly impacts public health and the dairy industry, leading to a loss of milk yield, treatment costs, milk discarding, and a reduction in both the quality and quantity of milk. (1, 2). Research has demonstrated that mastitis significantly reduces productivity, impacts the quality and quantity of milk produced, and leads to the culling of animals at an unacceptably young age. (3). The primary indicators of clinical mastitis (CM) are alterations in the milk, such as flakes and clots, and signs of mammary gland inflammation, such as edema, swelling, heat, and pain. Subclinical (SCM) mastitis is defined as mammary gland inflammation with a high concentration of somatic cells in the milk, decreased milk production, the presence of bacteria in the secretion, and altered composition, but without the presence of a visible lesion in the udder or as its secretion carrying pathogenic microorganisms (4, 5). As dominant and pathogenic microorganisms, *Streptococcus uberis, Corynebacterium bovis, Escherichia coli,* and *Staphylococcus aureus Mycoplasma species* represent the majority of microorganisms that cause mastitis (6, 7, 8). Hoque (2020) (9) identified *streptococci* as a primary mastitis pathogen that significantly affects the well-being, milk quality, and productivity of cows. During milking, the main means of transmission are contaminated milking machines, milkers' hands, and their clothes (10). This review aims to provide an overview of the current understanding of the causes, pathophysiology, manifestations, treatment, and prevention of bovine mastitis.

### Etiology

Bacterial infections of the mammary gland is the most common reason of mastitis (11, 12). However, other non-bacterial agents, such as mycoplasmas, archaea, viruses, yeasts, and algae, have also been linked to mastitis in dairy cows (13). Contagious pathogens such as *Staph. aureus, Str. agalactiae, Str. dysgalactiae,* and *Coryn. bovis Mycoplasma spp*. are primarily found in the udder of dairy cows (14). The opportunistic invaders, known as environmental bacteria, originate from the cow's surroundings and are not tailored to thrive in their host. Environmental pathogens that have been associated with the disease include *Str. dysgalactiae, K. pneumoniae, K. oxytoca, E. coli*, and *Ente. aerogenes* (14, 15).

**Types of Mastitis**: Figure 1 (16) shows the mode of transmission of pathogens.

### 1-Contagious Mastitis

Contagious mastitis is spread from cow to cow during milking time through contaminated washcloths, milking equipment, and the hands of the milker (17). Infected cows are the primary sources of the disease. The type and quantity of bacteria exposed to cows, physical barriers, and both innate and acquired defense mechanisms influence the frequency of contagious mastitis. Staph. aureus, Str. pneumoniae, and Str. dysagalactiae are the bacteria that are known to be the primary cause of contagious mastitis in cows (18, 19, 20).

2-**Environmental Mastitis**

When a cow is exposed to a contaminated environment, microorganisms that typically reside in the udder or on the skin's surface enter the teat canal and cause environmental mastitis. The environment (bedding, flooring, anddroppings) harbors the bacteria that cause environmental mastitis (*Str. uberis, Str. dysagalactiae, coliforms,* etc.), which can infect cows at any time during their lives. This covers the time during and following milking, as well as the dry season and the first calving in heifers (21).

**3-Summer Mastitis**

The third type of mastitis, known as summer mastitis, can cause severe and agonizing damage to the udder of dry cows and heifers. It is imperative to put down the cow right away because the damaged quarter cannot be salvaged. An infection is more likely to strike cows housed in fly-infested environments with easily damaged teats. The hot, sore, swollen quarter and foul-smelling, viscous discharge are signs of summer mastitis (3). According to the Clinical Symptoms, the Mastitis classify to:

**1-Clinical Mastitis**

The disease is characterized by the presence of severe irritability symptoms, including swelling, heat, redness, and pain. This can be accomplished with the help of obvious clots or discolorations in the milk, which are frequently combined with a mildly swollen udder, and occasionally with fever, an absence of appetite, etc. Per-acute mastitis, another subtype of clinical mastitis, is characterized by extreme irritation, altered milk composition, and decreased milk yield; systemic symptoms include fever, depression, shivering, anorexia, and weight loss.Although sub-acute mastitis has minimal mammary gland irritation and no systemic symptoms, acute mastitis shares many of the same symptoms as per-acute mastitis, including fever and moderate depression (22). (see Figure 1).

**2-Subclinical Mastitis**

There are signs of a serious infection or something wrong with the milk, and the composition of the milk changes (SCC, leukocytes, epithelial cells, changes in milk pH, and ion concentration), but there are no clinical symptoms at the same time. When a healthy lactating mammary gland has one million cells per milliliter of milk, it is considered to have subclinical mastitis (23).(See Figure 1).

**3- Chronic Mastitis**

This inflammatory process, which lasts for months, can continue from one lactation to the next. Despite being subclinical, it occasionally flares up in a short-lived acute or subacute form. One-quarter of the milk is smaller than the other due to gland fibrosis and atrophy, which are clinically, characterized by variations in milk, such as clots or flakes (24).(See Figure 1)

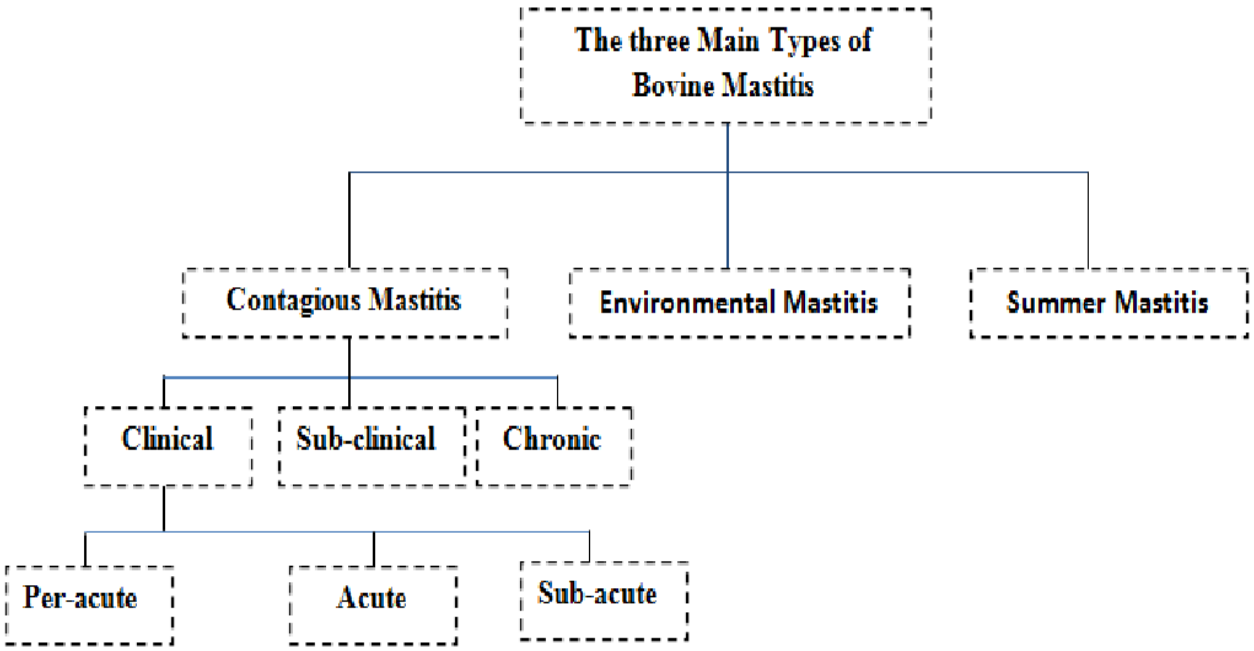


**Figure 1: Three Main Types of Bovine Mastitis (25).**

**Risk Factors**

**1 -Pathogen Factor**

The following are the pathogen risk factors: ability to resist milk flushing out of the glands (ability to adhere or attach to and invade or internalize into mammary epithelial cells); zoonotic (transmit from cow to human or vice versa); number (large and small); virulence (highly, moderately, or less virulent); frequency of exposure (frequently exposes to pathogens); and resistance to antimicrobials (26). (See Figure 2).

**2-Host Factor**

It includes the animal's age, breed, lactation stage, and milk yield. The number of contaminated quarters increases with age, reaching a maximum of seven years. In the early two months of lactation, most new infections, particularly environmental infections, occur, but for heifers, the incidence is significantly higher in the first month following calving. High-yielding cows are generally considered more susceptible to mastitis and teat injury (3, 27), (Figure 2).

**3-Environment factor**

The herds' management practices and the surrounding environment have a significant impact on the animals' health and welfare. Maintaining the herd's comfort and cleanliness can help prevent mastitis and lessen its severity (28). High stocking density, dirty flooring, wet bedding, insufficient ventilation, and a hot, humid atmosphere can all promote the growth of mastitis pathogens and increase cow exposure, which in turn raises the risk of mastitis developing (29).(See Figure 2).

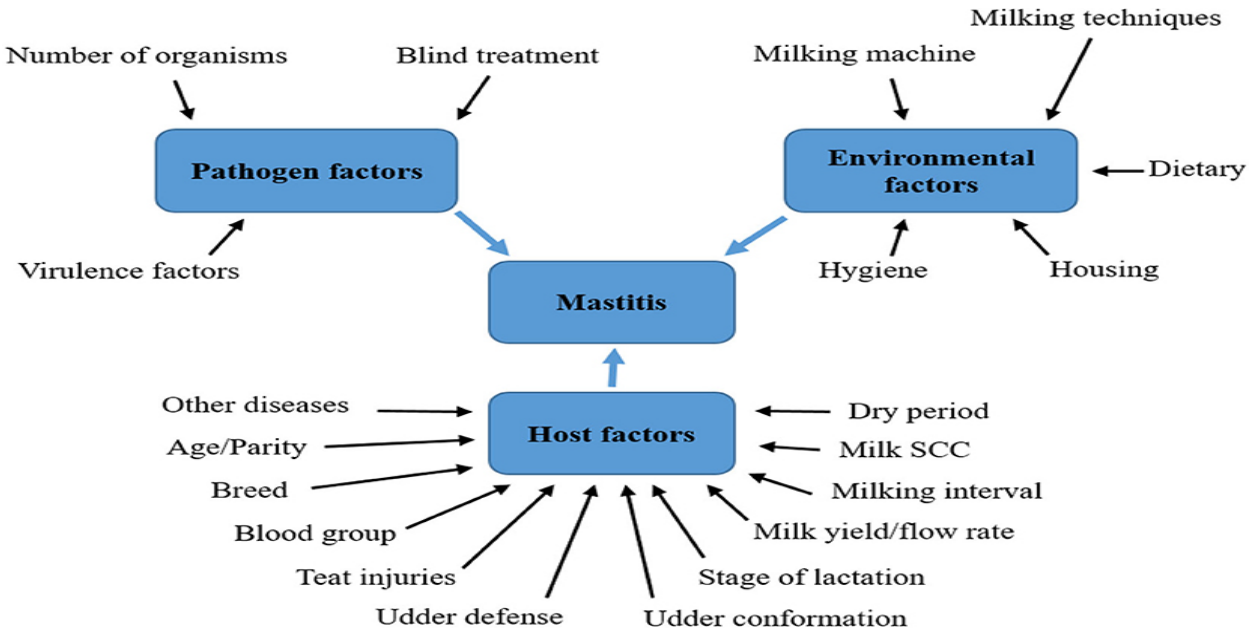


**Figure 2: Factors influencing the development of mastitis in dairy cows (30).**

## Methods of Transmission

### 1-Contagious Transmission

Since cows with mastitis are the primary source of infection, contagious transmission is also known as cow-to-cow transmission. The main way the infection-causing bacteria spread is when they encounter udder cloths, milkers' hands, or the milking machine. This can be avoided by using separate towels and milking gloves. If the unit is cleaned before the subsequent milking, milking sick cows last or with a different unit will also stop the infection from spreading (25).

### 2- Environmental Transmission

Environmental factors, such as bedding, manure, or water, can cause environmental mastitis. Sometimes, the high bacterial count in bedding occurs even before its use. Manure, which contains all the nutrients, moisture, and heat bacteria require, frequently contaminates bedding. Manure-contaminated water can contaminate water, or it can build up in a milking machine, especially if the cleaning water is too cold or the hoses are not sloped properly (25).

## Pathogenesis

The bacteria enter and reach to the mammary gland through the teat canal. Microorganisms that invade the udder's tissue and harm the mammary gland can lead to an infection. The pathogenesis can be divided into three stages: invasion, infection, and inflammation. When the invasion stage occurs, an organism passes through the teat canal and out of the teat end. Pathogens enter the udder and move quickly to the teat

canal, where they infect and may release endotoxins, causing inflammation in the udder. Mammary gland inflammation brought on by an infection is a defining feature of clinical mastitis, which can be acute, acute, or chronic. The symptoms of both acute and peracute mastitis include edema, a painful and hot udder swell, and changes in the milk's appearance. In long-termcases , an abscess forms on the infected udder, gland atrophy, and gangrene develops (9, 31, 32).

**Clinical Finding**

**1-Clinical Mastitis**

In clinical cases, the enlargement of the mammary glands and physical alterations in the milk (such as the presence of clots) are visible to the unaided eye.Based on the pathogens, additional symptoms like fever and depression could appear. Early in lactation, milk production is significantly reduced due to clinical mastitis. In clinical cases, the afflicted quarters might not heal in time to produce milk during the ensuing lactation (33). It is typified by anomalies like milk discoloration, redness, elevated body temperature, discomfort, and disruption of function (27).

2- **Sub-clinical Mastitis**

This type of mastitis is extremely mild and progresses very slowly. Minimal and often frequent deviations from the udder's healthy conditions only result in a small amount of microscopic alterations in the milk and a decrease in milk yield. Flaky particles are frequently seen in milk, particularly during the first ejection. It is difficult to see the milk's physical alterations and the udder's pathological changes . Subclinical cases can result in a 30% decrease in milk production. (27).

**3- Chronic Mastitis**

The two most frequent bacteria that cause chronic mastitis are *Str. uberis* and coagulase-negative *Staph. aureus*. The milk has changed physically, as evidenced with yellowish fluid or whiteclots. Milk can occasionally appear green or yellow-green and smell bad. The udder becomes hard due to extensive fibrosis and the affected quarter becomes firm and nodular which may progress to be atrophic. A cow with chronic mastitis has a rapid increase in their somatic cell count (26).

**Diagnosis**

**Physical Examination of Udder**

It is necessary to examine the mammary gland to diagnose mastitis properly. It emphasizes the significance of precisely observing the udder's dimensions, consistency, form, and contour. To evaluate inflammation, hot, painful swelling, and loss of function, a thorough examination of the teat and teat orifices is necessary (34).

**Strip Cup Test**

The strip cup or strip plate test is commonly used in milking parlors to detect clinical mastitis in individual animals and herds. By squirting a few stripes of milk on a strip cup, milking machine operators visually inspect the fore milk for gross abnormalities related to herd health. These abnormalities typically

show up as blood, flakes, clots, and wateriness suggestive of mastitis (34).

**Somatic Cell Counting of Milk**

Indirect measurement of the quantity of somatic cells (SCC) in milk is possible with modern mastitis tests. The cells secreting through milk are called SCC; they are made up of 75% leukocytes and 25% epithelial cells. Approximately 90% of the neutrophils in milk migrate when there is inflammation or mastitis, and this causes an increase in somatic cell counts. SCC stands for somatic cell count, which is the measurement of SCC in milk samples. This cell count, especially leukocytes, increases dramatically in milk as the inflammatory process spreads throughout the udder tissue (35). As a result, SCC can be considered as an indicative test for mastitis early diagnosis, and any change in cell count can be linked to a strong pathogen. (36, 37, 38).

**California Mastitis Test**

This quick and affordable test can be used to screen dairy cows for mastitis to evaluate the health of their udders and the quality of their milk. The number of somatic cells in milk is determined by the test's use of a detergent combination that interacts with somatic cells and then releases nucleic acid to form a gel. The test measures the gel's viscosity and strength of rainfall. Because of its accuracy and speed, CMT is one of the best methods for assessing the health of udders, according to numerous studies (38, 39).

**Draminski mastitis detector**

The Draminski mastitis test have been promoted as a screening tool for subclinical mastitis in some countries. The Draminski mastitis test measures the electrical resistance of milk (40). The Draminski Mastitis Detector (DMD) is probably the most recent hand-held device used for monitoring mammary gland health status, developed by Mr. Janusz Dramiński, the president of Draminski Company, in 1989 with a principle based on the measure of milk electrical resistance. In brief, the infection damages the mammary gland cells, leading to an increase in $Na^+$ and $Cl^+$ and a decrease in $K^+$ and lactose concentrations, which can cause a decrease in the resistance of milk to the electrical current (41).

**Wisconsin mastitis test**

The Wisconsin Mastitis Test (WMT) is a well-known rapid screening test for mastitis-causing bacteria in bulk milk samples. The test is based on increased leukocytes followed by increased viscosity when the detergent reagent is mixed with the milk sample. In both tests (WMT and CMT), the same reagent is used, a 3% sodium lauryl sulfate solution. In a CMT, the resultant reaction is qualitatively estimated, while in WMT, the test result reaction is measured quantitatively (mm). These tests provide practical and inexpensive methods to detect subclinical mastitis in the dairy herd (42)**.**

**Bacterial culture methods**

In the diagnosis of mastitis, bacterial culture (BC) performed under globally recognized guidelines is the gold standard (43). The

foundation of BC involves cultivating an aliquot of milk from a quarter milk sample that was taken aseptically and then incubating the plate on an agar plate for 24 to 48 hours. Colony-forming units are indicators of viable microbial cells. Conventional microbiological schemes identify distinct species based on representatives of various colonies with distinct morphologies (44)**.**

**Modified White Side Test**

This test's foundation is milk's elevated leukocytic count. The test result for mastitis indicates the formation of white flakes, whereas the test result for normal milk indicates the formation of milky opaque fluid (45).

**PH Test**

Normal milk has a pH of 6.5-6.7, but because it is more alkaline when it has mastitis, the pH rises. The permeability of blood capillaries is increased by mammary gland inflammation, allowing alkaline blood constituents like sodium and bicarbonate ions to enter milk. As a result, the pH of the milk rises and can even surpass 7.0 in cases of severe clinical mastitis. The degree of quarter inflammation, which causes blood and extracellular fluid components to mix with secreted milk, is positively correlated with the rise in milk PH (46, 47, 48).

**Electrical Conductivity**

Because milk contains anions and cations, electrical conductivity (EC) has been used as a mastitis indicator for the past 40 years. A portable electrical conductivity meter can calculate the EC, which is measured in Simens/cm. Before conducting the test, the conductivity meter is cleaned with cotton, and three milliliters of milk are used. The reasons for the increase in electrical conductivity in infected areas are higher concentrations of sodium and chloride ions and lower concentrations of lactose and potassium in milk (45).

**Chloride Test**

Increased blood-milk barrier permeability causes content increases in the milk of mastitis-affected animals. Because of inflammatory exudates, normal milk has a chloride content of 0.08–0.14%, whereas mastitis milk has a chloride content of >0.14%. Therefore, one method for identifying mastitis may be electrical conductivity, a qualitative test that indicates the presence of higher chloride ions (45).

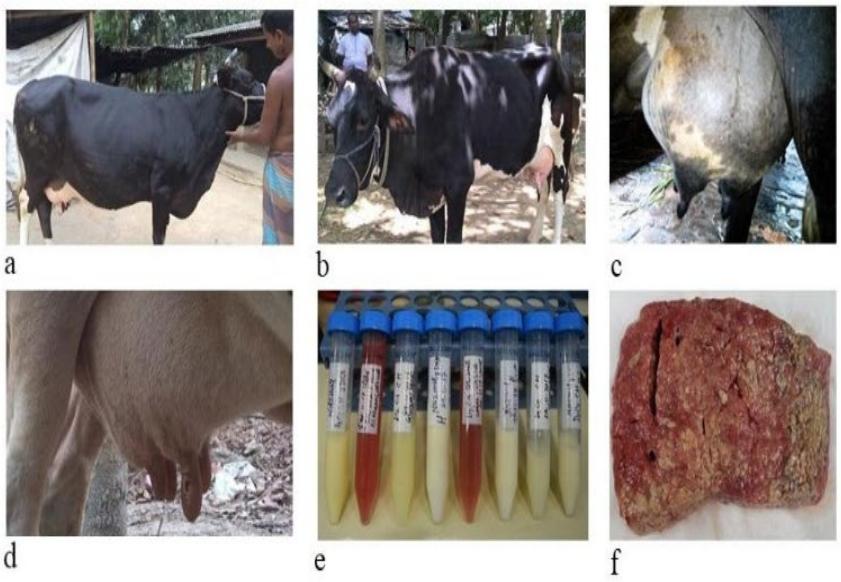


**Figure 3: Clinical features of bovine mastitis. (a) Cows suffering from clinical mastitis (CM) with no visible signs and abnormalities, (b) CM-affected cows with high fever, dullness, and depression, (c) typical signs of CM; swollen, hot, hard, or painful udder, (d) teat lesions in CM, (e) characteristics changes in milk; no normal milk; watery, serum, blood and pus and (f) gross histopathological changes in mammary tissues after CM (9).**

**Table 1: Interpretation of chloride test (45).**

| Color | Chloride content (%) | Interpretation of mastitis status |
|---|---|---|
| Yellow color | >0.14% | Positive |
| Brownish red | < 0.14% | Negative |

**Detection of through molecular techniques**

Polymerase chain reaction (PCR) is used to improve the diagnosis of pathogens, for which biochemical methods for species identification are known to be inaccurate (49). The idea underlying PCR is that DNA made up of nucleotides with distinct sequences is found in the nucleus of bacterial cells (20). Enzyme-linked immunosorbent assays (ELISA) have already been used to identify a number of biomarkers for the diagnosis of bovine mastitis pathogens, including heptoglobulin, NAGase, lactate dehydrogenase (LDH), and acute phase protein (9).

**Treatment**

Long-acting antibiotics, such as ampicillin, cephalosporin, oxytetracycline, and penicillin, can be used to treat mastitis. The penicillin-G formulation is used for mild to

moderate clinical cases; however, if longer therapy is required, intramural B-lactamase formulation works very well. In mild to severe clinical cases during lactation, parental and intramural administration of B-lactamase-resistant antibiotics, such as penethamate hydriodide, is beneficial. When treating subclinical infections in recently calved heifers, administering penicillin-G formulation or a B-lactamase-resistant intramammary antibiotic is simple and effective. Depending on the severity of the condition, supportive therapy such as a course of anti-inflammatory, antihistaminic, antipyretic, vitamins, and minerals should be administered (33).

**Prevention and Control**

There are several ways to control bovine mastitis for example, feeding practices, cleanliness, animal husbandry, and general health care can help to lower the risk of udder infections (50, 51).

Good farming practices and the use of antibacterial treatments aid in the effort to reduce the incidence of bacterial mastitis infection in herds (52).

In recent times, much research has been done on vaccination programs, even though most mastitis vaccines do not produce long-term immune (53). An effective way to prevent *Staph. aureus* infections using lysostaphin, a bactericidal enzyme developed from transgenic mice. A potential substitute for managing sanitary conditions that lower the need for medication use and subsequently lower levels of environmental and product contamination is the selection of disease-resistant animal breeds and the integration of this trait in farm herds. This is a good practice that should be promoted: incorporating genes that confer resistance through a selection of more resistant breeds (54).

## Conclusions

There are three primary classifications for cow mastitis: contagious, environmental, and summer mastitis, depending on the etiological agents and the causative agent. Mastitis the costliest production disease in dairy herds worldwide and the source of significant financial losses for the dairy industry, is a serious problem. The most serious kind of mastitis is subclinical because the afflicted animal appears to be producing normal milk and conceals the infection from others for an extended period. This makes it a crucial component of mastitis epidemiology. Mastitis has been reported to result in significant productivity loss or reduction, affect the quality and quantity of milk yield, and force the culling of animals at an unacceptably young age. The farm building needs enough ventilation and hygienic conditions to reduce the number of pathogens exposed to the mammary.

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## التهاب الضرع البقري في أبقار الألبان: المعرفة الحالية

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### الخلاصة

وفقا لصناعة الألبان العالمية، فإن التهاب الضرع هو أكثر أمراض الإنتاج تكلفة التي تصيب قطعان الألبان. العديد من الكائنات الحية الدقيقة المختلفة، بما في ذلك البكتيريا السائدة والممرضة مثل العقدية أوبيريس، والوتدية البقرية، وأنواع الميكوبلازما، والإشريكية القولونية، والمكورات العنقودية الذهبية، والفطريات والخميرة والكلاميديا هي السبب في ذلك. تشمل أعراض التهاب الضرع السريري تغيرات في الحليب، مثل الرقائق والجلطات، ومؤشرات التهاب الغدة اللبنية، مثل التورم والحرارة والألم والوذمة. التهاب الضرع تحت الإكلينيكي هو المصطلح المستخدم لوصف التهاب الغدة اللبنية عندما لا تكون هناك آفة ملحوظة في الضرع أو إفرازه. ومع ذلك، هناك كائنات دقيقة مسببة للأمراض، وهناك انخفاض في إنتاج الحليب، والإفراز يحتوي على بكتيريا، ويتغير تكوين الحليب. تتمثل إحدى الطرق الفعالة للحد من المشكلات التي تسببها الأمراض المعدية في اختيار سلالات حيوانية مقاومة للأمراض ودمج هذه السمة في قطعان المزارع. سيؤدي ذلك إلى تقليل الحاجة إلى الأدوية، مما سيؤدي بدوره إلى خفض مستويات التلوث البيئي وتلوث المنتجات. الهدف من هذه المراجعة هو تقديم ملخص لحالة المعرفة فيما يتعلق بالأسباب والفيزيولوجيا المرضية والمظاهر والعلاج وتجنب التهاب الضرع البقري.

**الكلمات المفتاحية:** أبقار الألبان، التهاب الضرع، الخلايا الجسدية، التهاب الضرع السريري.