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Review

Review on Roles of *Streptococcus agalactiae* in Bovine Mastitis

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Abstract

Streptococcus agalactiae continues to be a major cause of subclinical mastitis in dairy cattle and a source of economic loss for the industry. It is considered to be a costly disease of dairy animals and losses mainly occur through discarded milk, reduction in milk yield, premature culling of animals, and replacements. Streptococcus agalactiae is one of the etiological agents of bovine mastitis. The disease causes considerable direct and indirect economic losses to the livestock sector. Streptococcus agalactiae is well known worldwide as a major contagious pathogen causing bovine subclinical mastitis, which may substantially impact on the quantity and quality of milk produced. This pathogen can survive for long periods only within the mammary gland. This form of mastitis is characterized by a change in milk composition with no signs of gross inflammation or milk abnormalities. Special diagnostic tests can detect changes in milk composition. Diagnosis of subclinical infection is more problematic since the milk appears normal but usually has an elevated somatic cell count (SCC). Diagnosis of subclinical mastitis can be made in various ways, including direct measurement of the SCC level or indirectly by performing a California Mastitis Test (CMT) on suspected quarters. Streptococcus agalactiae is exquisitely sensitive to intramammary therapy using a variety of commercially available antibiotics. Treating Streptococcus agalactiae mastitis will be considered profitable if the dairy producer is faced with losing a market for milk. This review describes the importance of Streptococcus agalactiae infections in dairy industries in losses of milk production and quality of milk.

Keywords: Bovine, Mastitis, Subclinical, *Streptococcus agalactiae*.

Introduction

Streptococcus agalactiae (also called Group B *Streptococcus* or GBS) is a Gram-positive cocci (round bacteria) that have a tendency to form chains. It is a beta-hemolytic, catalase-negative, facultative anaerobic bacterium. GBS readily grows on blood agar plates as colonies surrounded by a narrow beta-hemolytic zone. GBS is characterized by the presence of Lancefield classification group B antigens in the cell wall (Lancefield grouping), which can be directly detected in intact bacteria using a latex agglutination test (29).

This streptococcus is the most common pathogen of dairy cows and causes huge direct and indirect losses. This pathogen often causes chronic mastitis and reduced milk production, with or without clinical symptoms. Mastitis is an inflammatory response caused by infection of the mammary tissue that may occur in many animal species raised for milk production (30). The occurrence of mastitis directly affects the quality of milk and leads to changes in its chemical and physical properties. The main changes observed in milk are an increase in somatic cells (SCC), clumping formation, or unfavorable color changes (23).

Clinical mastitis can lead to greater losses when cases occur early in lactation. Cows that have had multiple lactations tend to lose more milk production after clinical mastitis than cows that have had their first lactation. Clinical mastitis also shortens the lactation period and increases the likelihood of elimination. This bacterium remains the leading cause of subclinical mastitis in dairy cows and a source of economic loss to the industry. This is one of the serious health problems faced by dairy cows. It is recognized that the impact on the dairy industry has resulted in severe reductions in production and economic losses. It is an occupational disease and its prevention and control depend on factors such as good management practices on dairy farms (18).

This infection is recognized worldwide as an important infectious agent causing subclinical mastitis in cattle and can have a significant impact on the quantity and quality of milk production. This pathogen can only survive in the breast for a long time. It is a highly contagious obligate parasite of the bovine mammary gland. It is generally a moderate and persistent infection with a low self-healing rate. Unidentified infected cattle serve as infection reservoirs because they are not selected for treatment, quarantine, or culling. For obligate intramammary pathogens such as *Streptococcus agalactiae*, bovine udders are thought to be the only useful source of this microorganism in milk (28).

Morphologically, *Streptococcus agalactiae* is a Gram-positive bacterium that has a short lifespan in the environment. As an obligate pathogen of the breast, it can survive indefinitely in the mammary gland (22).

Streptococcus agalactiae can only grow and multiply in the udder, but can survive for short periods on hands, milking machine parts, and teat skin. Infected cows are always a source of new infections. Transmission occurs mechanically via the above-mentioned objects or through the mouth of suckling cows. It can be introduced into uninfected herds by purchasing infected cows or using contaminated milking equipment at fairs, auctions, etc. Infection usually does not cause life-threatening illness, and there are usually few or no obvious clinical signs of mastitis (14).

Based on the composition of the capsular polysaccharide, the historical classification of this bacterium has consisted of nine distinct serotypes (Ia, Ib, II, III, IV, V, VI, VII, VIII). Each serotype is associated with specific virulence factors that play a role in invading host cells. The synthesis of proteins enables the bacterium to evade the immune system and reduces the likelihood of opsonization by phagocytic cells. These mechanisms collectively contribute to the bacterium's ability to cause harm or hinder the udder of cows, resulting in a decrease in milk production (25)

Mastitis, a condition affecting dairy cows, is caused by *Streptococcus agalactiae*. Typically, this intramammary infection in cattle is chronic and subclinical, occasionally manifesting as clinical mastitis. The consequences of this infection are detrimental to the dairy industry, resulting in financial losses from decreased milk production and quality, increased expenses for treatment, and animal welfare concerns that lead to the removal of infected animals (2). So, the objective of this review is to focus on the damage of the disease to dairy cattle and the loss of milk due to a bacterial disease called *Streptococcus agalactiae* and its economic importance in dairy industries.

Literature Review

Characteristics of Streptococcus agalactiae

Group B streptococcus, also known as *Streptococcus agalactiae* or GBS, is a round bacterium that tends to form chains. It is a gram-positive coccus and a facultative anaerobe, producing beta-hemolysis and lacking catalase activity. On blood agar plates, GBS colonies display a narrow zone of β-hemolysis. A distinguishing feature of GBS is the presence of Lancefield group B antigen in its cell wall, which can be detected using latex agglutination tests (29)

The pathogen responsible for bovine mastitis, an inflammation of the udder in dairy cows, is a commonly occurring infection in veterinary medicine. The species, known as *Streptococcus agalactiae* or GBS, derives its name from "agalactiae," meaning "no milk," which alludes to its ability to cause this condition. GBS is a widely recognized and prevalent causative agent of both clinical and subclinical mastitis in bovines, leading to prolonged periods of infection. Bacterial cells are shed in milk from infected quarters and transmission to uninfected quarters and cows usually occurs during the milking period (17).

Gram-positive coccus, also referred to as *Streptococcus agalactiae* or GBS is responsible for causing mastitis in dairy cows. This infection typically manifests as a chronic and subclinical condition in cattle, with occasional bouts of clinical mastitis. The occurrence of mastitis, which triggers an inflammatory response in the mammary gland, is a major concern for dairy farmers due to its negative impact on milk production, treatment expenses, labor requirements, discarding of milk during treatment, potential mortality, and premature culling of affected cows (20)

Obligations

Streptococcus agalactiae is a highly contagious obligate parasite of the bovine mammary gland. Contagious mastitis pathogens such as S. *agalactiae* cause a low-grade, persistent infection that generally does not have a high self-cure rate. Cattle that are unidentified as infected function as reservoirs of infection because they are not selected for treatment, segregation, or culling. Management programs for subclinical mastitis in general, and S. *agalactiae* in particular, are effective to control infections throughout the herd. The economics of such programs are generally very favorable when response is measured by changes in the incidence of clinical disease, the prevalence of herd infection, or by SCC, which is a crude measure of prevalence (28).

In bovine mammary glands, S. agalactiae can survive indefinitely by forming biofilms and is heavily associated with subclinical mastitis. *Streptococcus agalactiae* is recognized by Lancefield classification as Group B Streptococcus (GBS). This group includes nine historically known serotypes (Ia, Ib, II, III, IV, V, VI, VII, VIII) and a further (IX) of more recent identification. Serotype III was the most frequently occurring serotype among GBS isolates recovered from the milk of the dairy cow population investigated. (21).

The discrimination of the different serotypes depends on type-specific capsular polysaccharides that constitute also a virulence factor through which GBS eludes the host immune response (27). However, the expression of specific polysaccharides at the extracellular level is not the only invasion mechanism used by *Streptococcus agalactiae*. Indeed, analogously to other microorganisms, *Streptococcus agalactiae* can produce biofilm, a polysaccharide matrix that allows bacteria to hide from the immune system, favoring its persistence when environmental conditions are adverse (1).

Cause Sub-clinical Mastitis

In clinical mastitis, all five cardinal signs of udder inflammation (redness, heat, swelling, pain, and loss of milk production) are present, while the subclinical form is bereft of any manifestation of inflammation. Since there is no gross swelling of quarters or abnormality of milk, sub-clinical mastitis is recognized by laboratory examination of milk or animal-side tests. Subclinical mastitis is from an economical point of view, considered as the most important type of mastitis because of the higher prevalence and devastating long-term effects of chronic infections compared to clinical mastitis. Production losses in Ethiopian crossbreeds due to subclinical mastitis have been estimated at 38 USD per lactation per cow. However, because of a lack of clinical symptoms and a quality control system, few farmers in parts of the country are aware of the subclinical form of mastitis and its consequences (18).

This form of mastitis is characterized by a change in milk composition with no signs of gross inflammation or milk abnormalities. Special diagnostic tests can detect changes in milk composition. Subclinical mastitis is always related to low milk production, changes to milk consistency (density), reduced possibility of adequate milk processing, low protein, and high risk for milk hygiene since it may even contain pathogenic organisms (24).

Diagnosis of subclinical infection is more problematic since the milk appears normal but usually has an elevated somatic cell count. Diagnosis of subclinical mastitis can be made in a variety of ways including direct measurement of the SCC level or indirectly by performing a CMT on suspected quarters. Milk culture of suspected quarters or cows (composite samples) will identify the presence of mastitis pathogens but will not provide a measure of the degree of inflammation associated with the infection. Individual cow SCC will provide a determination of the level of infection within the herd. For diagnosing mastitis, a physical examination of the udder should be done to observe any deviation from the normal shape, size, and color consistency (10).

Milk Production Losses

There is a substantial loss in milk production in both clinical and subclinical mastitis. *Streptococcus agalactiae* infection in dairy cattle plays an important role in reducing the production of quality milk and milk products. Milk from cows with subclinical mastitis decreases the quality of cheese and other manufactured milk products. Changes in milk composition result in the reduced nutritional value of milk, increased processing problems, and off-flavors. Mastitis has been contributing to reduced milk production and is a major source of economic loss to the dairy industry through reduced milk yield and quality, cost of drugs and veterinary treatment, discarded milk, and forced culling. In addition to its economic impact, *Streptococcus agalactiae* is the major etiologic agent of invasive neonatal infections in humans in industrialized countries, causing sepsis, pneumonia, meningitis, Osteomyelitis, and soft tissue infections (3).

Direct losses in breeding caused by mastitis include drug and disease management costs, losses of milk that must be discarded, farmer time, mortality among sick animals, and costs associated with the relapse. The shortage of herds, lower animal welfare and hence, reduced production, as well as a decrease in milk quality are considered indirect losses (19).

Exposure of uninfected mammary quarters to contagious pathogens is limited to the milking process. In contrast, exposure of uninfected quarters to environmental pathogens can occur at any time during the life of the cow, including milking time, between milking, during the dry period, and before first calving in heifers. *Streptococcus agalactiae* is primarily occurring within the cow’s udder (6)

Milk Quality Losses

Streptococcus agalactiae is an important mastitis pathogen because of its highly contagious nature and its ability to degrade milk quality. The economic impact of *Streptococcus agalactiae* mastitis is primarily due to lost milk production and degradation of milk quality. Infection does not usually cause life-threatening illness and often shows few or no obvious clinical signs of mastitis. Increased bacteria and somatic cell counts can cause a loss of quality bonus, decreased milk quality in general, and loss of the farm’s milk market (9)

The profitability of the dairy industry is driven by both the quantity and the quality of the milk produced. Although milk has often been described in the popular media as nature's most perfect food, it cannot escape consumer scrutiny for quality and wholesomeness. *Streptococcus agalactiae* subclinical mastitis leads to slight changes in the properties of milk; however, it may contain pathogens that cause the disease. Due to its often-latent course, subclinical mastitis leads to greater losses than clinical mastitis and poses a greater risk of spreading among individuals in a given herd. Lower-quality milk is characterized by a shorter shelf life after pasteurization among other factors and may also be associated with a lower quality of products such as cheeses obtained using traditional methods (11)

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. (12)

The milk protein breakdown can occur in milk from animals with clinical or subclinical mastitis due to the presence of proteolytic activity during mastitis. Plasmin and enzymes derived from somatic cells can cause extensive damage to casein in the udder before milk removal. Mastitis increases the 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 (12).

Economic Importance of Streptococcus agalactiae

Streptococcus agalactiae is the most common and costly disease in the dairy industry and is of worldwide relevance in causing bovine mastitis. Next to the financial losses due to low milk yield and quality, the veterinary treatment, medication, and increased personnel expenses. Mastitis is an important issue of animal welfare and the main reason for dairy cow culling. Mastitis-infected cows can show a wide range of symptoms: swelling, heat, and pain of the udder, milk with abnormal appearance, increased body temperature, lethargy, and anorexia. Bovine mastitis can be classified into three classes according to the inflammation degree: clinical, subclinical, and chronic. Clinical mastitis is characterized by visible abnormalities of cow and milk, which is not the case for subclinical mastitis (23).

The subclinical mastitis is economically more relevant due to its higher frequency and capacity to reduce milk yields. If acute mastitis is not successfully cured, it can become chronic and lead to reduced fertility. *Streptococcus agalactiae* are well-known pathogens that induce chronic mastitis. Treatment and prophylaxis of mastitis are the most common reasons for antibiotic usage in dairy cows bearing the risk of enhanced selection in favor of AMR. Additional factors must be considered when assessing the impact of subclinical mastitis. These costs include the loss of functional udder parenchyma, reduced milk quality, and the real, but nebulous, cost of maintaining reservoirs of contagious udder pathogens. On most farms, the largest cost of mastitis is the decreased milk production associated with subclinical infection (13).

Treating Streptococcus agalactiae

Antibiotic therapy is the main strategy for mastitis treatment. The milk ducts and alveoli of the mammary gland are primary targets of the antimicrobial therapy against *Streptococcus agalactiae* mastitis. Antibiotics such as penicillin, oxacillin, and ampicillin are the most effective and most applied antibiotic classes to treat mastitis caused by *Streptococcus agalactiae*. Antimicrobial treatment is usually administered by intramammary syringe or parenterally by intramuscular injection. Both application forms are comparably effective. The intramammary infusion should be preferred instead of muscular application because it needs significantly fewer drugs and it avoids the systemic distribution of antibiotics within the cow (7).

The most common treatment of streptococcal mastitis is β- lactam antibiotic therapy. The extensive use of antibiotics in dairy husbandry generates an increased risk of emerging AMR microorganisms that may then enter the food chain and affect human health (16).

Treating Mastitis in Lactating Cows

Most mastitis occurs in lactating cows, often soon after calving, with the abnormal milk having to be discarded. Conventional treatment is to use antibiotic therapy. Although alternatives including herbal and homeopathic approaches assume some importance. The use of antibiotics to treat mastitis is contentious in itself with the methods varying internationally. The udder should be washed thoroughly in a sanitizing solution with individual paper towels and after milking, the teats should be immersed in the appropriate teat-dip solution. The teat cup assembly, milk pipes, and other utensils should be cleaned and sanitized between each milking. After milking, the sphincter muscle surrounding the teat canal remains dilated for a varying period, facilitating invasion of the teat canal by bacteria. Thus, teat dips are most effective when applied immediately after the milking machine is removed. Cows are also exposed to mastitis organisms via the milking machine when milked after a cow is affected with clinical or subclinical mastitis (26).

Treating Mastitis in Non-lactating Cow

The incidence of mastitis during the dry period can be considerably reduced by the effective use of antibiotics infused in each quarter of the udder at the last milking of lactation. Dry cow therapy is the best way to cure chronic and subclinical mastitis that is difficult to treat successfully during lactation. New mastitis infections occur particularly often during the cow dry-off period more often than at any other time point of lactation (5).

Control and Preventions of Bovine Streptococcus agalactiae

Prevention is the key in mastitis control. A control program should emphasize factors that reduce the rate of new infections. New infections are controlled by adopting measures like proper milking procedures, improved milking hygiene, dipping the teats after milking, culling of chronically infected cows and housing management. A combination of preventive measures and therapeutic use of antibiotics will markedly reduce the incidence of mastitis. Intra-mammary infusion of antimicrobials following the last milking of the lactation (dry cow therapy) can greatly reduce the cases of *Streptococcus agalactiae* mastitis by eliminating existing infections and controlling new infections early in the dry period. Pre-dipping teats with disinfectant solution has become the standard method for pre-milking teat disinfection. Pre-dipping was associated with the lowest bacterial burden in milk compared to other methods (8).

Management of *Streptococcus agalactiae* Mastitis

Infected cows should be rapidly detected and separated to avoid bacterial spreading within the herd. The bacterial contamination of the individual cow should be lowered by good milking practices such as teat disinfection and drying, as well as regular cleaning and checking of the milking machine (15)

Biosecurity protocols are important for the prevention of infectious disease transmission among farms. Maintaining a closed herd should be the goal of every biosecurity program. For pathogens that have been eradicated from a particular herd, such as *Streptococcus agalactiae*, biosecurity takes on additional relevance (3).

Culling can be an important component of the management of contagious pathogens. While most *S. agalactiae* infections can be cured with appropriate therapy, refractory cases should be culled to eliminate the reservoir of infection from within the herd (22).

Cloth towels provide excellent removal of organic matter and disinfectant from the teats and good stimulation of t he cow for milk letdown. Organic matter and disinfectant removal are important for quality milk production (4).

Conclusions and Recommendation

Streptococcus agalactiae is a gram-positive obligate pathogen that affects pre-milking heifers, as well as older cows in dairy herds. It is considered one of the major causes of economic losses to dairy producers. *Streptococci agalactiae* is at the forefront of subclinical mastitis of global mastitis cases. It belongs to one of the major pathogen groups inducing bovine mastitis. In the dairy industry, mastitis is the most common and costly disease. It not only negatively impacts economic profit due to milk losses and therapy costs, but it is an important animal health and welfare issue as well. Even after thousands of years and intensive research regarding mastitis, it is still an important economic and animal welfare issue and the most frequent and costly disease in dairy farming. The cases of mastitis can be reduced to an appreciable extent and production can be increased by adopting the following management measures on a priority basis:

- Use a simple screening test before purchasing, if positive avoid buying such animals.
- Treating cows during the dry period and lactating time is effective in the prevention of *Streptococcus agalactiae* infection.
- Education programs may reduce prevalence to levels at which regulatory programs may be initiated, especially regarding subclinical mastitis.

Declarations

Ethical Approval and Consent to Participate

The review was carried out with high regard for animal welfare and it was approved by Ambo University, College of Veterinary Medicine.

Data Availability

All contents of data are available in the Ambo University, Ethiopia archive, which is currently in the process of being available in its repository.

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Contribution by Authors

Wesenu Berhnau searching of articles, data extraction, and reviewing the manuscript and major supervision, and prepared all contents of the review..

Conflict of Interests

There is no conflict of interest.

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