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Staphylococcal Mastitis in Goats

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ARTICLE ID: 57

Introduction

Mastitis, an inflammatory condition affecting the udders of goats and sheep, is often associated with bacterial infections and can significantly impact both the health and production potential of these animals. This disease is common among dairy breeds, affecting both lactating and non-lactating animals. *Staphylococcus aureus* (*S. aureus*) and non-aureus staphylococci (NAS) especially coagulase-negative staphylococci (CNS) are the primary pathogens responsible for mastitis in goats and sheep. *Staphylococcus aureus* and NAS cause both clinical and subclinical forms of the disease, leading to substantial financial losses for farmers. Clinical mastitis presents with noticeable signs such as swollen udders, changes in milk quality, and elevated somatic cell counts (SCC). The disease can manifest in acute, subacute, or chronic forms, with chronic cases often leading to persistent infections and fibrosis of udder that may require culling. Subclinical mastitis, though less apparent, also causes a rise in SCC, significantly reducing both milk production and quality. *S. aureus* is recognized as a primary pathogen in staphylococcal mastitis due to its ability to evade the host's immune defenses and establish persistent infections. Its pathogenicity is attributed to various virulence factors, such as toxins and enzymes, which damage mammary tissue and support bacterial survival. In contrast, CNS, including species like *S. epidermidis* and *S. simulans*, are often considered secondary pathogens. However, these bacteria can still significantly impact milk quality and animal health.

Antimicrobial therapy has traditionally been the primary approach for managing staphylococcal mastitis in small ruminants. However, the increasing occurrence of antibiotic-resistant bacteria is diminishing the effectiveness of antibiotics, making it essential to explore

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alternative control strategies. Despite the growing recognition of staphylococcal mastitis as a critical issue, there remains a substantial gap in comprehensive understanding and practical management methods tailored specifically for goats and sheep. The aim of this article is to enhance the understanding of staphylococcal mastitis in sheep and goats by examining its pathophysiology, epidemiology, and the challenges posed by *S. aureus* and CNS infections. Additionally, it addresses the shortcomings of current control measures and emphasizes the need for innovative and sustainable solutions to effectively reduce the impact of staphylococcal mastitis in small ruminants.

Etiology

- ***S. aureus* Mastitis:** Mastitis caused by *S. aureus* can be seen in various forms, including the more common subclinical and chronic types, which are associated with elevated somatic cell counts (SCC) and reduced milk production. A more severe peracute form typically occurs during early lactation, leading to gangrene in the udder. In cases of acute mastitis, goats can become severely ill very rapidly due to the sudden onset of intense inflammation, pain, and systemic symptoms. Key signs of acute mastitis include fever, loss of appetite, shock, and localized inflammatory changes in both the udder and milk. Subacute mastitis, the most frequently observed form of clinical mastitis, is marked by visible changes in the milk, such as small clots, along with mild inflammation of the udder.
- **Non *S. aureus* (NAS) Mastitis:** The NAS group consists of over 50 distinct species of coagulase-negative staphylococci, along with a few coagulase-positive and variable species. Despite the diversity within this group, around 15–20 species are commonly linked to mastitis. The most frequently isolated species include *S. chromogenes*, *S. simulans*, *S. xylosus*, *S. haemolyticus*, and *S. epidermidis*. Although less virulent than *S. aureus*, these bacteria can still lead to persistent, often subclinical infections that negatively impact the milk yield and quality in dairy animals including goats and sheep.

Virulence Factors

- **Biofilm Formation:** Biofilm plays a crucial role in the virulence of staphylococci by forming a protective barrier through its structure. This shield-like matrix, resembling slime, is composed of exopolysaccharides that protect the bacteria from the host's immune defenses. The biofilm enables staphylococci to adhere to and colonize the inner

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mammary tissue and the epithelium of the mammary gland. The initial attachment occurs through a polysaccharide/adhesin capsular antigen. As the bacterial cells multiply and mature, they form a dense biofilm complex. Once fully developed, the production of polysaccharide intercellular adhesin begins, a key component of the biofilm matrix that enhances the bacteria's resistance to the goat's innate immune system.

- **Antimicrobial Resistance**: Antimicrobial resistance remains a persistent challenge in managing staphylococcal mastitis. Antibiotic resistance is classified into two types: intrinsic (innate) and acquired. Among the most effective forms of intrinsic resistance is biofilm formation, which, as mentioned earlier, allows all strains to establish deeply embedded infections that are difficult to treat with antibiotics. Every strain associated with staphylococcal mastitis exhibits antibiotic resistance, linked to their pathogenic genotype and gene expression. A key mechanism in the development of acquired resistance is horizontal gene transfer, which plays a crucial role in the bacteria's adaptive processes.
- **Coagulase:** Coagulases are polypeptides tightly bound to the surface of *S. aureus* cells. They interact with blood prothrombin to form staphylothrombin, which catalyzes the conversion of fibrinogen, a plasma protein, into fibrin. The resulting fibrin facilitates the formation of blood clots, which serve as a protective barrier, shielding the bacteria from phagocytosis and other immune responses. In addition to influencing blood clotting, coagulase promotes the production of fibrinogen-binding proteins, enhancing bacterial aggregation. The simultaneous processes of clot formation and cell clumping further protect the bacteria by creating a fibrin coat that acts as an immune shield.
- **Staphylococcal Protein A:** Staphylococcal protein A (SpA) is a surface protein anchored to the cell wall of *S. aureus* that plays a key role in evading the host's adaptive immune system. As a virulence factor, SpA interferes with immune responses through multiple mechanisms. First, it binds to the Fcγ region of IgG antibodies, preventing the immune system from recognizing and targeting the bacteria for elimination. Additionally, SpA binds to the Fab domain of IgM, creating cross-links between B-cell receptors. This cross-linking trigger programmed cell death in B lymphocytes as they develop, impairing the host's ability to mount an effective adaptive immune response. As a result, SpA significantly compromises the host's immune defenses.

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Pathogenesis

Mastitis begins its destructive course when pathogens, like *Staphylococcus aureus*, find a way to breach the defenses such as the skin covering the teats, sealed teat canal, and immune cells of the milk ducts. The most common entry point is the teat canal. Although usually sealed tightly, this small opening can become vulnerable due to poor hygiene, injuries, or improper milking. Once inside, the bacteria slip through the milk ducts, bypassing the initial defenses. Once the bacteria reach the glandular tissue, they begin to multiply and establish a foothold. The animal's immune system detects the invasion and responds by deploying neutrophils to the site of infection. These immune cells work rapidly to engulf and destroy the bacteria. However, in the process of fighting the infection, the immune response inadvertently damages the udder's tissues, leading to inflammation. This explains the characteristic symptoms of mastitis—swelling, heat, and pain in the affected udder. In acute or clinical cases, the immune system and bacteria engage in a noticeable and intense battle. Affected goats show clear signs of distress, such as swollen udders and abnormal milk, which may contain blood, pus, or clots. The toxins released by the bacteria further damage the milk-producing tissues, while the milk ducts become obstructed, exacerbating the condition. In chronic mastitis, bacteria can hide or persist within small pockets inside the udder, making the infection less obvious. While outward symptoms may not be immediately noticeable, the ongoing presence of the bacteria leads to continuous, low-level inflammation. Despite the goats appearing healthy, milk production often declines over time, and the overall quality of the milk deteriorates.

Diagnosis

The California Mastitis Test (CMT) offers a quick, convenient, and cost-effective method for detecting subclinical mastitis in sheep and goats directly on the farm. It serves as an excellent screening tool due to its simplicity, affordability, and ability to provide immediate results, making it highly practical for routine monitoring and early detection of mastitis. Elevated somatic cell counts (SCC) are a key indicator of udder health, signaling potential infection and inflammation. In goats, an SCC exceeding 1,000,000 cells/mL is often a strong indicator of mastitis. Confirming staphylococcal mastitis requires the isolation and identification of *Staphylococcus* species from milk samples collected from goats showing symptoms or suspected of infection.

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Treatment & Prevention

Antibiotic therapy is the most common treatment for staphylococcal mastitis in goats, with its effectiveness influenced by factors such as the type of pathogen, drug resistance profile, and stage of the disease. Commonly used antibiotics include tetracyclines, macrolides, penicillins, and cephalosporins. However, treatment becomes more challenging with the emergence of methicillin-resistant *Staphylococcus aureus* (MRSA), which can resist multiple drugs. The widespread use of antibiotics has contributed to increasing resistance, particularly the rise of MRSA, reducing the effectiveness of many first-line drugs. This growing resistance underscores the need for combination therapies or alternative treatment strategies. Non-steroidal anti-inflammatory drugs (NSAIDs) can be used as supportive therapy to relieve the inflammation, pain, and discomfort caused by mastitis. By reducing inflammation, NSAIDs not only promote faster healing of the udder but also help restore normal milk production. Another potential treatment involves bacteriophages—viruses that specifically target *Staphylococcus* species. Bacteriophage therapy offers a promising alternative to antibiotics, particularly for managing antibiotic-resistant infections. However, its application in goats is still under experimental stage.

Maintaining good hygiene practices is essential to minimize the risk of staphylococcal mastitis in goats. Proper udder care and milking techniques can significantly reduce the occurrence of both clinical and subclinical mastitis. Before milking, ensure that the teats are thoroughly cleaned to remove dirt and bacteria. Pre-dipping the teats in an effective disinfectant solution further decreases the bacterial load on the teat surface. Regular cleaning and maintenance of milking equipment are crucial to prevent the buildup of bacterial biofilms. Well-maintained equipment, including clean rubber liners, minimizes the risk of cross-contamination and reduces the chance of teat injury. A holistic approach is essential to prevent staphylococcal mastitis, involving proper hygiene practices, effective herd management, vaccination, balanced nutrition, and stress mitigation. The integration of these strategies helps maintain udder health, boosts milk production, and enhances the overall efficiency and productivity of the herd.

Vaccines targeting *S. aureus* have been developed to reduce the frequency and severity of mastitis by boosting the animal's immune response. However, vaccine effectiveness may vary, and they are typically used alongside other preventive measures. Ongoing research aims

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to improve vaccines, focusing on multiple virulence factors or various *Staphylococcus* species. Despite challenges in developing vaccines due to *S. aureus*' ability to evade the host immune system, vaccination remains a valuable preventive tool.

Conclusion

In conclusion, staphylococcal mastitis remains a significant challenge in small ruminant farming, particularly in goats and sheep, due to its impact on both animal health and farm productivity. The disease can manifest in various forms, from subclinical and chronic infections to acute and peracute cases, with *Staphylococcus aureus* and coagulase-negative staphylococci (CNS) playing major roles. The complexity of the infection, compounded by the rise in antibiotic-resistant strains such as MRSA, highlights the need for more effective management strategies. Current treatment approaches primarily rely on antibiotic therapy, though increasing resistance necessitates alternative solutions, including combination therapies and bacteriophage treatments. Non-steroidal anti-inflammatory drugs (NSAIDs) offer additional support by alleviating inflammation and aiding recovery. Preventive measures, including proper hygiene, regular maintenance of milking equipment, and effective udder care, are crucial in minimizing the risk of mastitis. Vaccination against *S. aureus* has shown promise, but ongoing research is required to improve vaccine efficacy given the pathogen's ability to evade immune defenses. Ultimately, a comprehensive, integrated approach is essential for managing and preventing staphylococcal mastitis. This involves combining good hygiene practices, herd management, nutrition, stress reduction, and immunization to promote udder health, improve milk production, and enhance overall herd productivity. As research progresses, the development of more effective vaccines and sustainable treatment strategies will be critical in reducing the burden of mastitis in small ruminant farming.

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