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A Mini Review on Current Challenges and Opportunities in the Management of Bovine Mastitis

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Abstract

Bovine subclinical mastitis stands out as a significant challenge in the dairy industry, leading to substantial milk losses. The issue becomes more alarming as lactating cows frequently face severe infections caused by *Staphylococcus aureus* bacteria, resulting in detrimental udder damage. The conventional approach of combating such infections involves prolonged antibiotic treatments, contributing to the emergence of Antimicrobial Resistance (AMR) in cows. Compounding the issue, *S. aureus* bacteria can undergo modifications, transforming into the formidable Methicillin-Resistant *S. aureus* (MRSA). Addressing this pressing concern requires exploring alternative solutions, and one promising avenue lies in the realm of medicinal plants. Leveraging the inherent antibacterial properties of phytochemicals found in various medicinal plants could offer a sustainable and effective approach to managing bovine mastitis. Not only do these botanical remedies provide a potential solution to the challenges posed by conventional antibiotic treatments, but they also offer a more environmentally friendly and holistic approach to safeguarding the health of dairy cows and preserving milk production in the industry.

Keywords: Bovine Mastitis; Methicillin-Resistant *S. Aureus*; Antimicrobial Resistance; Herbal; Phytochemicals

Abbreviations: AMR: Anti-Microbial Resistance; MRSA: Methicillin-Resistant S. Aureus; SCC: Somatic Cell Count; IDF: International Dairy Federation; SCM: Subclinical Mastitis; EC: Electrical Conductivity; MCMT: Modified California Mastitis Test.

Introduction

Bovine mastitis, a pervasive concern in dairy farming, initiates inflammation within the udder's milk glands, prompting a nuanced categorization into clinical, sub-clinical, and chronic mastitis. Clinical mastitis, the overt expression of the ailment, manifests with discernible symptoms such as redness, swelling, fever, and noticeable changes in milk consistency. Further refinement into per-acute, acute, and sub-acute stages sheds light on the urgency of addressing this visible form promptly. Severe cases, fraught with potential fatality risks, underscore the critical need for timely intervention [1].

In contrast, sub-clinical mastitis operates in stealth, lacking overt signs but revealing it through insidious markers—diminished milk production and an elevated somatic cell count (SCC). This subtle nature underscores the economic impact, surpassing that of clinical cases, highlighting the hidden challenges faced by the dairy industry. Detecting and addressing sub-clinical mastitis pose unique challenges, emphasizing the importance of proactive monitoring strategies [2].

In navigating this intricate landscape, my insights underscore the multifaceted nature of bovine mastitis, necessitating vigilant monitoring and timely interventions to mitigate financial losses in the dairy industry. Additionally, understanding the diverse etiological agents, including contagious pathogens like *Streptococcus agalactiae* and environmental bacteria, emphasizes the pivotal role of hygiene and proactive measures in dairy management. As we grapple with this complex condition, proactive prevention and treatment strategies become imperative, aligning with a holistic approach to sustain the health and productivity of dairy herds in the long term [3].

Causes

In recent years, there has been a shift in the epidemiology of mastitis infections from *S. aureus* to *S. Uberis*, which is now the most common causative agent of mastitis in cows. While *S. Agalactiae*, one of the most harmful forms of the disease, has been practically eliminated from the dairy cow through the use of antibiotics, the presence of this bacteria in milk can be an indicator of poor management and biosecurity [4].

Mastitis infections caused by various Gram-negative bacteria are also common issues in dairy cattle, and their occurrence can be related to hygienic problems such as the use of dirty bedding materials. Therefore, mastitis is a multifactorial disease that can be caused by a variety of pathogens and can have consequences on both animal health and milk quality. While the importance of individual pathogens in the epidemiology of mastitis can vary, *S. Uberis* and *S. aureus* is currently the most common and important cause of the disease, and it's essential to take necessary precautions and measures to control and prevent mastitis infections in dairy herds [5].

Management practices should target the pre-calving period in heifers in order to reduce the probability of mastitis in later stages. Antibiotic therapy is effective against mastitis, but it has long-lasting adverse effects on udder health and milk production, resulting in profit loss. The main etiological agents responsible for mastitis infections can be classified into different groups of pathogens. These include contagious, environmental, opportunistic, and other organisms such as *Nocardia asteroides, Pseudomonas aeruginosa*, and *Streptococcus pneumonia, Streptococcus aureus* which are known to cause less common forms of mastitis that are often accompanied by fever symptoms in the host [6].

Economic Loss

Mastitis is a significant cause of economic loss in the dairy industry in India, with an estimated total loss of INR 6,053.21 crore. The majority of this loss is due to subclinical mastitis, which accounts for around 70 to 80% of all cases and causes an economic loss of INR 4,365.32 crore. Crossbred cows were found to be particularly susceptible to subclinical mastitis, with an average annual loss of INR 592.87 per lactation and INR 700.18 due to decreased milk production. The annual losses in the dairy industry due to mastitis were estimated to be around INR 2.37 thousand crore, with subclinical mastitis accounting for approximately 70% of the losses. Therefore, there is a need for better preventive measures to reduce the impact of mastitis on the dairy industry in India [7].

Several Diagnostic Methods are Utilized for Detecting Subclinical Mastitis (SCM)

As per the guidelines from the International Dairy Federation (IDF), the microbiological status of the quarter and the somatic cell count (SCC) stand out as primary tests for detecting alterations in milk due to inflammatory processes. Over the years, numerous tests have emerged for subclinical mastitis (SCM) diagnosis. Langer, *et al*. outlined both direct and indirect tests capable of SCM detection. Indirect tests, valuable for gauging milk quality, include cow-side tests such as Modified California Mastitis Test (MCMT), Modified White Side Test (MWST), Surf Field Mastitis Test (SFMT), and screening tests like Electrical Conductivity (EC) and pH tests. Laboratory tests, notably Methylene Blue Reduction Test (MBRT), also contribute to SCM identification [8].

Inflammation in the mammary gland correlates directly with an increase in SCC in milk. Consequently, SCC is recognized as a significant marker for SCM and serves as a direct diagnostic test. Various studies have assessed SCM prevalence based on diverse tests [9].

Current Treatment

Resistant Pathogens

A major obstacle in the effective treatment of mastitis is the growing resistance of pathogens to commonly used antibiotics, resulting in the need for more expensive antibiotic alternatives. There Is an increased risk of selecting for resistant isolates because of over-use and misuse of antibiotics. In addition, antibiotic residues present in milk and dairy products can contribute to the resistance of pathogens, as they may remain potent at sub-therapeutic concentrations, allowing the selection of resistant strains. Even though the use of antibiotic therapy can significantly reduce the duration and severity of mastitis, the risk of selecting antibiotic-resistant strains needs to be carefully considered [10].

Culture and Sensitivity Tests

By performing appropriate culture and sensitivity tests, the most effective antibiotic can be selected based on the isolated pathogens. This can reduce the risk of selecting for resistant isolates, while ensuring that the selected antibiotic is effective in treating the infection. In addition, the results of these tests can provide useful information on the prevalence of antibiotic resistance in the dairy herd, which can guide improved antibiotic use practices [11].

Alternative Treatment Options

There are alternative treatment options that can be used in conjunction with antibiotics or as stand-alone treatments to reduce the risk of selecting for antibiotic-resistant isolates. These include non-antibiotic treatments like alternative options for treating mastitis include non-antibiotic treatments such as anti-inflammatory, pain relief, and anti-pyretic drugs, which could be effective in reducing the clinical signs of disease. Nutritional interventions include optimizing the nutritional management of dairy cows has been shown to improve immune function, reduce the incidence of mastitis, and improve the response to antibiotic treatment. Immunocompromised therapies like the use of immunocompromised therapies like immunostimulants, which are non-antibiotic treatments that work by activating the cow's immune system, has been successful in reducing the incidence of mastitis [6].

Treating Mastitis in Lactating Cows

Different treatment methods for mastitis in lactating cows. The most commonly used method is the use of antibiotic-containing paste injected into the mammary gland via intra-mammary route. This treatment is usually performed every one or two milking for up to 3 days. Alternative methods include the use of herbals and homoeopathic approaches. There are mixed opinions on the use of antibiotics to treat mastitis [12].

One argument against the use of intra-mammary preparations is that a larger amount of the product is needed compared to the intramuscular route, which could lead to systemic dispersal. However, research has shown that approximately 97% of intramammary product stays in the udder, compared to only 3% for the intramuscular route [13].

More research is needed to develop effective antimicrobial products and improve detection systems to predict mastitis and treat it before it becomes clinical. Early treatment is key to successful recovery, and farmers tend to use more than the recommended amount of treatment.

Treating Mastitis in Non-Lactating Cows

Dry cow therapy is the use of antibiotics to prevent mastitis infections in cows during their resting or non-lactating period (6-10 weeks before calving). It has been shown to be effective in reducing the rate of mastitis infections by 67-82%, and is considered a cost-effective intervention. The efficacy of DCT in controlling mastitis infections has been re-examined and shown to be significant for certain pathogens such as *S. Uberis* and coliforms, making it an important intervention for mastitis prevention [14].

Why to Use Medicinal Plants as an Alternative Treatment?

Medicinal plants, steeped in a rich historical legacy, emerge as a formidable natural resource, offering a compelling alternative in therapeutic interventions. Beyond their conventional roles, these plants harbour potent antibacterial agents, representing a wellspring for novel antibiotics. Furthermore, they exhibit versatility by serving as efflux pump inhibitors, targeting bacterial virulence, or synergistically complementing existing drugs. Their integral role in ethno-veterinary medicine, particularly in the treatment of ailments like bovine mastitis, underscores their significance [15].

Various reports support the use of medicinal plants in the treatment of SCM. An herbal formulation containing *Eucalyptus globulus*, *Glycyrrhiza glabra*, *Curcuma longa*, *Cedrus deodara*, and *Paedaria foetida* improved the immunity and exhibited antibacterial property in various breeds of cows like Kankrej and Gir cow [16]. *Brassica oleracea* showed a promising results against infectious bovine mastitis by interfering in the mechanisms of action of genes such as MTOR and TP53 [17]. *Prosopis juliflora* alkaloids improves the immunity against SCM via down regulating various cytokines like IL-1, IL-6, IL-8 and IFN-γ. *P. juliflora* alkaloids also showed the antibacterial action against pathogens responsible for SCM [18]. Various essential oils are also exhibiting an antibacterial action against pathogens responsible for SCM. Essential oils from *Mentha pulegium*, *Nepeta cataria, Melissa officinalis* showed strong antibacterial activity against *S. aureus* and *E. coli* bacteria in disc diffusion assay [19]. *Piper betle* extract solution used as teat dipping solution inhibits and eliminates bio-film in bovine mastitis against *Staphylococci* bacteria [20].

Various phytochemicals like Quercetin and Curcumin modulates the cellular and molecular function of the neutrophils in *Staphylococcus agalactiae* SCM [21]. Gallic acid, a principle phenolic compound present in many fruits exhibited immunomodulatory action milk phagocytes in bovine mastitis caused by *S. aureus* [22]. Chlorogenic acid, an another phenolic compound, can be used as a substitute in

multidrug resistant *E. coli* induced mastitis [23].

This comprehensive review seeks to illuminate the diverse array of medicinal plants employed in the treatment of bovine mastitis. Beyond a mere cataloguing of plant species, the article delves into detailed antimicrobial studies, unravelling the efficacy of these botanical interventions [24].

In contemplating the logic behind tapping into this natural product resource, the review emphasizes the dual facets of tradition and innovation. The enduring wisdom embedded in ethno-veterinary practices finds resonance in the modern context, offering a holistic and sustainable approach to address the complexities of bovine mastitis. As we navigate the intricate landscape of antibacterial solutions, the insights gleaned from this review underscore the potential of medicinal plants not only as therapeutic agents but as integral components in shaping the future of veterinary medicine [25,26].

Conclusion

Bovine mastitis is a complex and costly disease that affects the dairy industry worldwide. It can be caused by different types of bacteria, some of which are resistant to antibiotics and pose a serious threat to animal and human health. Therefore, there is a need for alternative and sustainable solutions to prevent and treat mastitis infections, and one of them is the use of medicinal plants. This paper reviewed the potential of various phytochemicals derived from medicinal plants to inhibit the growth and biofilm formation of mastitis-causing bacteria, as well as to modulate the immune response and reduce inflammation in the udder. The paper also discussed the challenges and opportunities of using medicinal plants as a complementary or alternative therapy for bovine mastitis, such as the availability, safety, efficacy, and standardization of plant extracts and products. Further research is needed to validate the in vitro and in vivo results of phytotherapy for mastitis, and to explore the optimal combinations, dosages, and delivery methods of plant-based remedies. The use of medicinal plants could offer a promising and eco-friendly approach to enhance the health and welfare of dairy cows, and to improve the quality and safety of milk products.

Conflicts of Interest

Authors declare no conflict of interest.

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