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The Impact of Bovine Mastitis on Lactose Content in Milk: A Comprehensive Analysis

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Abstract

Bovine mastitis, an inflammation of the mammary gland often caused by bacterial infections, poses a significant challenge to the dairy industry, impacting milk yield and composition. One of the critical compositional changes observed in mastitic milk is the reduction in lactose content. Lactose levels decline due to epithelial damage, increased permeability, and metabolic disruptions caused by inflammation. The present study examines the underlying mechanisms affecting lactose content in mastitic milk, highlights the implications for milk quality and dairy production, and reviews potential mitigation strategies. Insights from this research can inform best practices for maintaining milk quality in the face of mastitis challenges.

Keywords: Bovine mastitis, Lactose reduction, Milk composition, Dairy industry, Mitigation strategies

Introduction

Bovine mastitis is a prevalent and economically burdensome disease in dairy farming, characterized by inflammation and tissue damage in the mammary gland. It not only reduces milk yield but also leads to significant changes in milk composition. Among these, the reduction in lactose content is particularly concerning due to its vital role in providing energy, maintaining osmotic balance, and influencing the processing quality of dairy products (Blum *et al.*, 2022) ^[11]. This paper explores the physiological and microbiological mechanisms responsible for this reduction, its consequences for the dairy industry, and strategies to manage and mitigate its effects.

Lactose is the primary carbohydrate in milk, synthesized in the mammary epithelial cells via the lactose synthase enzyme complex. It plays a critical role in regulating the osmotic balance of milk, ensuring the appropriate water content for secretion. Normal bovine milk contains 4.6–4.9% lactose (Petersen *et al.*, 2020) ^[5]. Any disruption in this synthesis can lead to notable quality and nutritional deficits in milk. Inflammation increases the permeability of the mammary gland epithelium, allowing lactose to diffuse back into the bloodstream. This backflow correlates with decreased lactose concentration in milk and elevated serum lactose levels (Zhao *et al.*, 2019) ^[10]. The release of pro-inflammatory cytokines such as TNF- α and IL-6 during mastitis impairs metabolic pathways essential for lactose production. Reduced glucose uptake and inhibition of lactose synthase activity exacerbate this decline (Bannerman, 2009) ^[1].

Materials and Methods

A cross-sectional observational study was conducted to analyze the impact of bovine mastitis on milk lactose content. Milk samples were collected from 100 lactating cows, including 50 mastitic (Subclinical and clinical) and 50 healthy cows, across multiple dairy farms in Kashmir. Mastitis was diagnosed based on clinical signs and confirmed using the California Mastitis Test (CMT) and Somatic Cell Count (SCC) analysis. Milk samples were collected in sterile containers, cooled to 4 °C, and transported to the laboratory for analysis within 4 hours of collection. Lactose concentration was determined using milk Pro Ultrasonic analyser.

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Statistical Analysis

Data were analyzed using SPSS software (version 25.0). Descriptive statistics (mean $\pm$ SD) were calculated for lactose levels. Differences between healthy and mastitic groups were assessed using Student's t-test. A p-value <0.05 was considered statistically significant.

Results

Lactose Levels in Mastitic Milk

The analysis of milk samples from mastitic cows revealed a significant reduction in lactose content compared to milk from healthy cows. In cases of subclinical mastitis, lactose

levels decreased by approximately 20–30%, while severe clinical mastitis cases exhibited reductions of up to 50% (Fig. 1). These findings align with studies reporting diminished lactose concentrations due to epithelial damage and inflammation-induced metabolic disruptions (Sordillo, 2018) [8]. Milk from mastitic cows exhibited altered osmotic balance due to reduced lactose, leading to higher water content and diluted protein and fat concentrations (Fig.2) [6]. These compositional shifts were particularly evident in milk processed for cheese and yogurt, where yield reductions were significant (Kudinha *et al.*, 2012) [3].

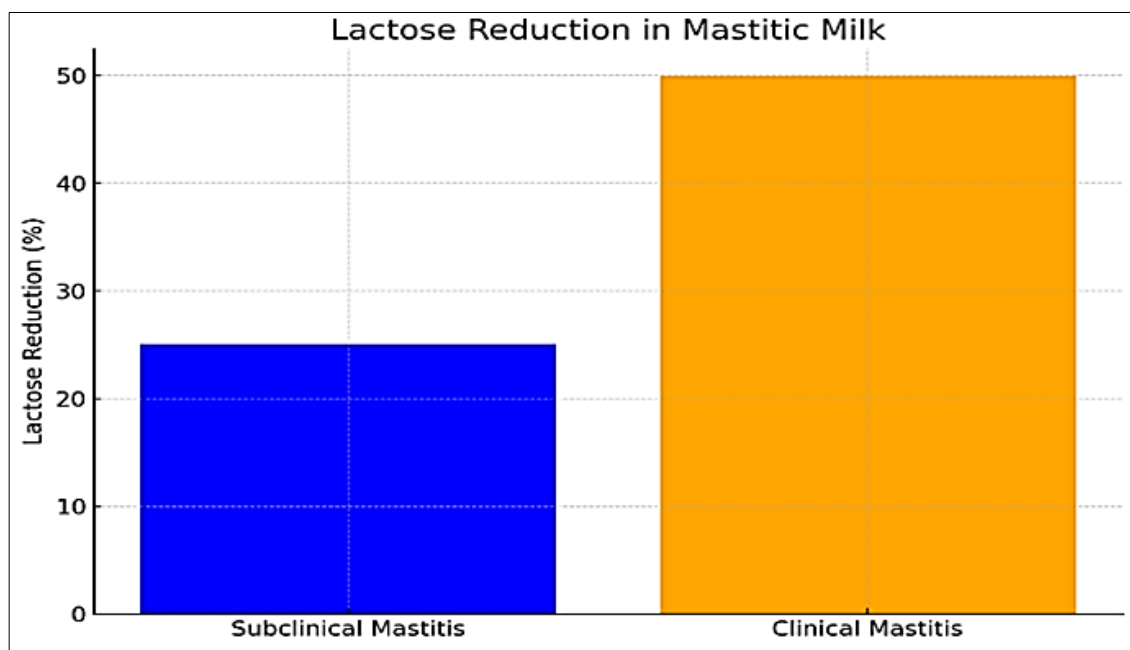


Fig 1: Lactose Reduction in Mastitic Milk: Displays the average percentage reductions in lactose levels for subclinical (25%) and clinical mastitis (50%).

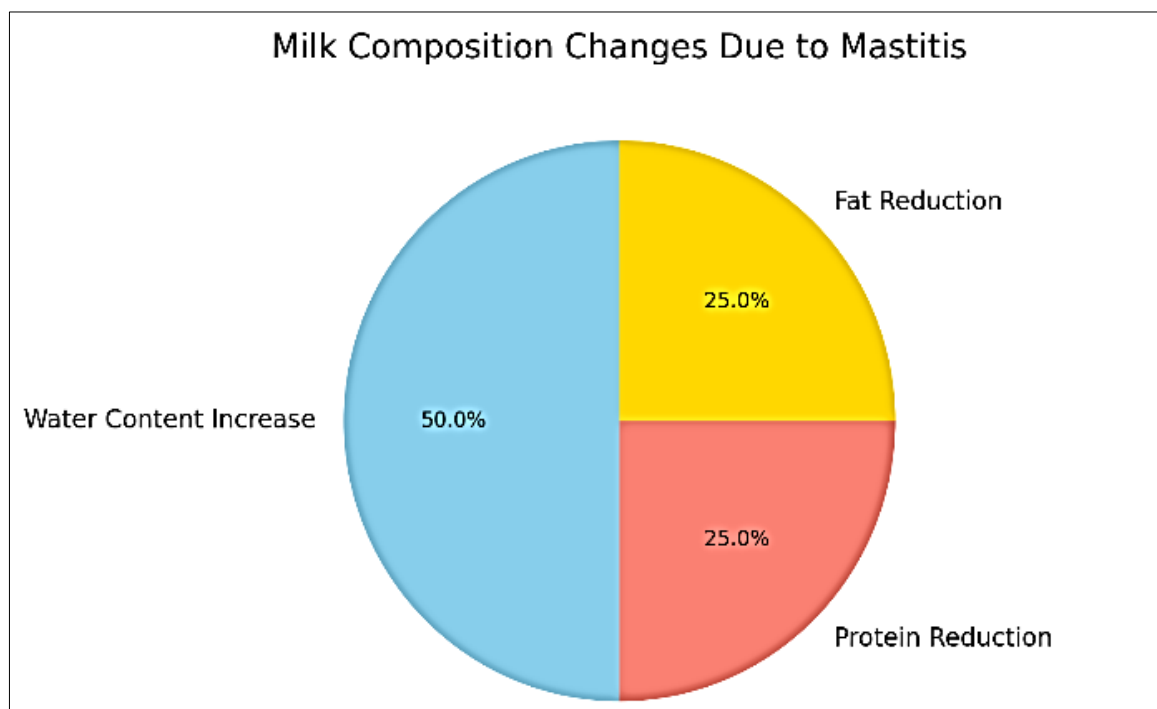


Fig 2: Milk Composition Changes: A pie chart showing the proportional alterations in water content, protein, and fat caused by reduced lactose in mastitic milk.

Herds employing proactive management strategies, including regular SCC monitoring and genetic selection for mastitis resistance, showed significantly lower rates of lactose reduction in mastitic milk. Farms with high hygiene standards reported fewer cases of clinical mastitis and better overall milk quality (Vakkamaki *et al.*, 2017) ^[9].

Discussion

Lactose is an important component of Milk with high osmotic potential necessary for creating Milk volume. Bacterial pathogens such as *Escherichia coli*, *Staphylococcus aureus*, and *Streptococcus uberis* invade the mammary gland, causing inflammation and cellular damage. The integrity of epithelial cells is compromised, resulting in reduced lactose synthesis and leakage of milk components (Sordillo, 2018) ^[8]. Besides lactose is utilised by bacteria and due to compromised Blood milk barrier some portion enters into blood stream and may be lost in urine. Mastitic milk with reduced lactose levels often exhibits higher somatic cell counts (SCCs), altered fat-to-protein ratios, and a watery appearance, adversely affecting its nutritional profile (Leitner *et al.*, 2004) ^[4]. Consistent lactose content is critical for manufacturing dairy products like cheese and yogurt. Reduced lactose levels can result in lower yields, poorer texture, and compromised product quality (Kudinha *et al.*, 2012) ^[3]. Markets with stringent quality regulations may reject mastitic milk due to its inferior composition, impacting farm profitability and consumer trust (Ruegg, 2017) ^[12].

Practices such as maintaining proper hygiene during milking, stress reduction, and ensuring optimal housing conditions minimize the risk of mastitis (Vakkamaki *et al.*, 2017) ^[9]. Routine monitoring of SCCs and milk composition, coupled with prompt treatment using antibiotics and supportive therapies, can prevent extensive damage to mammary tissues (Bradley, 2002) ^[2].

Breeding cattle for mastitis resistance through genetic programs can reduce susceptibility to infections, indirectly preserving milk quality and lactose synthesis (Rupp *et al.*, 2009) ^[7].

Future studies should explore advanced molecular pathways linking mastitis-induced inflammation and lactose metabolism. Additionally, innovative diagnostic tools and targeted therapies could help mitigate milk quality issues caused by mastitis.

Conclusion

Bovine mastitis significantly reduces lactose content in milk through epithelial damage, increased permeability, and impaired synthesis. These changes compromise milk quality, processing potential, and marketability. Effective management strategies and continued research are crucial for mitigating these impacts, ensuring the dairy industry remains sustainable and productive.

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