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Impact of mastitis pathogens on blood antioxidant enzymes in transition dairy cows

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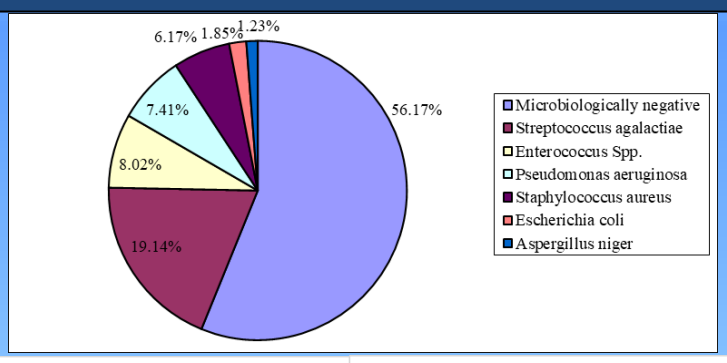
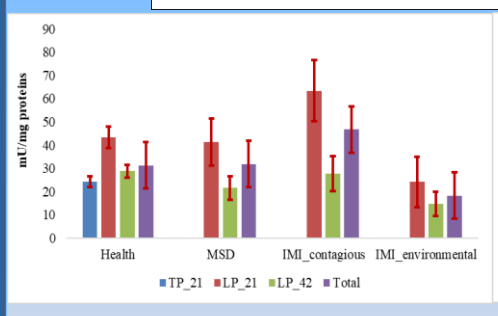
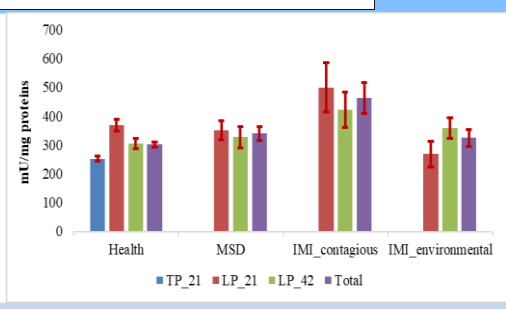
Introduction

Oxidative stress in animal systems is a phenomenon that results from an imbalance between reactive oxygen species (ROS) production and the capacity of antioxidant defences. This imbalance can damage cellular proteins, lipids, and nucleic acids, thereby contributing to various physiological and pathological conditions in animals. When ROS levels exceed the buffering capacity of endogenous antioxidants, oxidative damage occurs, which can disrupt normal cellular function and lead to disease states. Dairy cows in the peripartum period exhibit significantly increased oxidative stress levels due to metabolic disturbances, which predispose them to intramammary infections (IMI) and mastitis. The most significant connection between oxidative stress and mastitis lies in the inflammatory response. The primary objective of this study was to establish a connection between mastitis pathogens and oxidative stress through the activity of superoxide dismutase (SOD) and glutathione peroxidase (GPX) in blood samples collected from dairy cows during the transition period from late gestation to early lactation.

Results







Fixed variable	df	SOD[a]	GPX[b]
Model[a,b]	4	88.001***	365.692***
Mastitis pathogen	4	88.001***	365.692***
Error	629		
Total	633		

[a]R^2 = 0.355; [b]R^2 = 0.697

Mastitis pathogens were isolated from 43.83% of udder quarters with persistent milk secretion disorder (MSD), and the dominantly isolated microorganisms were grouped as contagious: Streptococcus agalactiae (19.14%) and Staphylococcus aureus (6.17%) or environmental: Enterococcus spp. (8.02%), Pseudomonas aeruginosa (7.41%), Escherichia coli (1.85%) and Aspergillus niger (1.23%).

Contagious mastitis pathogens have increased the average activity of SOD in blood, especially in LP_21. Environmental mastitis pathogens did not increase SOD activity in blood compared to mastitis-free cows and those with MSD; instead, SOD activity was reduced.

The average GPX activity was higher in the blood of cows with IMI caused by contagious mastitis pathogens. The charts indicate that SOD and GPX activity in blood increases when IMI is caused by major mastitis pathogens.

The results indicated that the presence of mastitis pathogens in the milk during the period of early lactation has a statistically significant influence ($p<0.001$) on the SOD and GPX activity in the blood serum of transition dairy cows.

Discussion

Given that IMIs typically trigger an influx of leukocytes and other macrophages into milk, an elevated SCC has been extensively used as an indicator of mastitis. While higher CMT scores generally indicate increased SCC levels, the accuracy of CMT or SCC in reflecting pathogen-specific IMIs remains uncertain (Dingwell et al., 2003). The concordance between CMT results and bacteriological findings ranges from 70 to 86%, varying with the causative agent (Sanford et al., 2006).

The escalated activity of SOD and GPX observed in the period after parturition was probably a consequence of the increased synthesis of ROS triggered by the immune response to mastitis pathogens. Previously published paper indicates that the transition period in dairy cows has a statistically significant influence ($p<0.001$) on SOD and GPX activity in blood serum (Nakov et al., 2023). This imbalance in antioxidant enzyme activity increases the risk of oxidative stress during this critical period.

When mastitis afflicts a dairy cow, whether clinical or subclinical, the immune system responds to the invading pathogens (usually bacteria) by releasing various inflammatory molecules and immune cells. Moreover, inflammation and oxidative stress appear to mutually influence each other in the context of mastitis, ultimately fostering a vicious cycle where inflammation leads to increased oxidative stress, which in turn further intensifies inflammation (Turk, 2017). This immune response generates ROS as a part of the body's defence mechanism to eradicate pathogens.

Different pathogens may elicit varying responses in terms of oxidative stress and antioxidative enzyme activity (Erisir et al., 2006; Kleczkowski et al., 2008). To counterbalance the potentially harmful effects of ROS, cows have antioxidative defence mechanisms in place. Antioxidative enzymes SOD, GPX and CAT help neutralize ROS and maintain a balanced oxidative state within the body. These enzymes play a crucial role in protecting cells and tissues from oxidative damage. Because SOD activity increases the production of hydrogenated peroxide by dismutation of superoxide, protection against ROS would be achieved only with the increased GPX activity and hydrogenated peroxide reduction (Maurya et al., 2014). The increased activity of antioxidant enzymes in dairy cows that have mastitis in the period of early lactation may indicate that oxidative stress is exacerbated. Elevated somatic cell counts (SCC), which are indicative of mastitis, have also been correlated with increased oxidative stress markers, emphasizing the detrimental effects that oxidative stress has on udder health (She et al., 2023).

Conclusions

In dairy cattle, oxidative stress is a critical factor during transition periods like parturition and lactation. During these phases, metabolic demands intensify, leading to altered redox status; consequently, imbalances between oxidant and antioxidant systems can predispose animals to metabolic and infectious diseases. The relationship between oxidative stress, anti-oxidative enzymes, and mastitis in dairy cows underscores the importance of managing oxidative levels to prevent mastitis. Nutritional interventions and management practices that bolster antioxidant defences may be an essential strategy to mitigate oxidative damage and improve udder health, dairy production and animal welfare.

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