Bovine mastitis is an inflammatory condition of the mammary gland of lactating bovines (cattle and buffaloes), which is one of the most significant and encountered diseases in the dairy industry. Every year dairy industries face huge economic losses due to the impact of bovine mastitis. Besides producing various physical and biochemical changes in the milk, mastitis also causes fluctuation in various blood parameters of the dairy buffaloes. The levels of total leukocyte count (TLC), and neutrophils in the blood serum of a mastitis suffering buffalo are significantly higher than a healthy buffalo. Similarly, the serum levels of various enzymes like alkaline phosphatase (ALP), aspartate aminotransferase (AST), and lactate dehydrogenase (LDH) increase significantly. The lipid peroxidation substances viz. malondialdehyde and nitric oxide have been found to fluctuate significantly while there is a significant loss in the level of macro-minerals like calcium, phosphorus, and zinc. The findings of various studies have shown the damaging effects of mastitis in the blood profile of diseased buffaloes.

**KEYWORDS**
Mastitis, buffalo, blood parameters, leukocytes, serum enzymes, lipid peroxidation

**1. Introduction**

Bovine mastitis is an inflammatory condition of the mammary gland irrespective of causes which are characterized by physical, chemical, and microbiological changes in the milk and pathological changes in the udder (Sharma et al., 2011). It can be classified into clinical mastitis (CM) and sub-clinical mastitis (SCM) based on the clinical manifestation of which the latter is the common case (Gianneechini et al., 2002). Mastitis is a costly and extremely complex disease in both clinical and sub-clinical form that results in a marked reduction in the quality and quantity of milk which occurs due to nutritional status, animal factors, and pathogenic organisms (Harmon, 1994). Sub-clinical mastitis, with the absence of apparent gross abnormalities in the milk and mammary gland but the presence of bacterial pathogens in the secretion, is 15-40 times more common than clinical mastitis and hence the most serious form of mastitis (Dhakal et al., 2010).

Direct and indirect tests can be used for early detection of sub-clinical mastitis such as the California Mastitis Test (CMT), the Mastrip Test (MST), Methylene Blue Reduction Test (MBRT), and Electrical Conductivity test (EC) (Kumari et al., 2018). Clinical mastitis, which is the most commonly diagnosed form in early lactation, also results in considerable economic losses and can be detected by visible changes in the milk and mammary gland. Clinical mastitis can be of the acute type with a sudden start and accompanied by systemic effects, sub-acute type with no symptoms, few udder disorders and some milk alterations, and chronic type with firm, thickened, and nodular udder and no milk production (Fagiolo and Lai, 2007).

The prevalence rate of mastitis in buffaloes is comparatively lower (27.36% to 45.00%) than the cows (29.34% to 78.54%) (Swami et al., 2017; Sharma, 2017). Buffaloes possess some features that would have made them prone to a greater risk of mastitis, such as more pendulous udder and long teats, however the lower prevalence of mastitis in dairy buffaloes might be accredited to their teat sphincters that are tighter than that of dairy cows (Fagiolo and Lai, 2007; Ippal et al., 1994). Dairy animals are more susceptible to clinical mastitis during the first calving and the first month of lactation when the internal keratinized teat plug dissolves away (Eberhart, 1986). Coagulase Negative Staphylococci were found to be predominant in clinical cases and Coagulase Negative Staphylococci and Coliform in subclinical cases (Dhakal, et al., 2007). Most of the farmers have poor farm hygiene and sanitation procedures that predisposes the farms to a greater risk of sub-clinical mastitis infection in dairy buffaloes (Paudyal and Sakpota, 2012). Mastitis is associated with changes in the physical, chemical, bacteriological and organoleptic properties of milk, besides causing health hazards to the public.

The involvement of polymorphonuclear (PMN) leukocytes and macrophages during the inflammatory process triggered by pathogens is pivotal against intra-mammary infections (Hussain et al., 2012). This prolific increase in the number of the PMN leukocytes and macrophages during the incidence of mastitis/ sub-clinical mastitis is attributable to the activity of various minerals, in the circulatory system, like selenium (synergistic with vitamin E), zinc, copper, etc. which have a direct role in maintaining the udder health and performance of lactating buffaloes (Cortinhas et al., 2010; O'Rourke, 2009). Apart, from the minerals, various other enzymes and their concentration in the blood (and milk as well) have been considered as diagnostic factors for clinical and sub-clinical mastitis like alkaline phosphatase (ALP), aspartate aminotransferase (AST), and lactate dehydrogenase (LDH) (Hussain et al., 2012; Qayyum et al., 2016). Similarly, the serum value level of lipid peroxidation products such as malondialdehyde and nitric oxide have been found to fluctuate with the severity of the mastitis/sub-clinical mastitis of buffaloes (Hussain et al., 2012; Qayyum et al., 2016).
2. DISCUSSION

To the best of our knowledge, the literature related to the hematological changes in the dairy buffaloes affected with clinical and sub-clinical buffaloes in Nepal is very little. All the presented data and information have been extensively reviewed from the research and literature of other country’s authors. A significant increase (p<0.05) has been recorded in the serum level of total leucocyte count (TLC) and neutrophils, major front-line PMN cells, which was observed in between the control buffaloes and the diseased (clinical and sub-clinical mastitis) buffaloes (Basrah and Lafta, 2020). This indicates a prolific increase in the activity of leucocytes, particularly the PMN cells, during intra-mammary infections during which they infiltrate the adjacent mammary tissues and secretions as well.

<table>
<thead>
<tr>
<th>Hematological Values</th>
<th>Control Buffalo (n=10)</th>
<th>Diseased Buffalo (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLC (x 10³cells/mm³)</td>
<td>11.23±1.66</td>
<td>15.74±1.08*</td>
</tr>
<tr>
<td>Neutrophils (%)</td>
<td>47.22 ± 2.34</td>
<td>53.11±4.56*</td>
</tr>
</tbody>
</table>

Values bearing asterisk * show statistical significance (p<0.05)

Source: (Basrah, and Lafta, 2020).

Some reports have claimed to show a significant decrease in the serum level of hemoglobin in the diseased animal (Sayhood et al., 2018). They have attributed this decrease in the hemoglobin level to the release of oxidative factors due to the inflammation of lupus glands in the body that damage the plasma membrane of the RBGs and cause the breakdown of hemoglobin. However, the reports of have failed to show a significant relationship between mastitis and the hemoglobin level in the blood of the diseased dairy animal (Hussain et al., 2012; Qayyum et al., 2016). The findings of have shown an increase in the erythrocyte sedimentation rate (ESR) of diseased cows (Zannatu et al., 2015). Nevertheless, the finding is neither statistically significant nor is based on the ESR of diseased buffaloes. The report findings of have shown a significant fall in the blood serum level of macro-minerals like calcium, phosphorus, and zinc in the diseased cow, which becomes more profound with the severity of mastitis (Qayyum et al., 2016). Although, the findings of the report are limited to Cholistani cattle, and the readers will have to generalize and relate these findings to dairy buffaloes.

<table>
<thead>
<tr>
<th>Blood Serum Enzyme Level (IU/L)</th>
<th>Grade of Mastitis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Alkaline Phosphatase (ALP)</td>
<td>49.7±0.50</td>
</tr>
<tr>
<td>Aspartate Aminotransferase (ALT)</td>
<td>111.1±1.01</td>
</tr>
<tr>
<td>Lactate Dehydrogenase (LDH)</td>
<td>376.4±2.66</td>
</tr>
</tbody>
</table>

Values (Mean±SE) bearing asterisk in a row differ significantly.

Source: (Qayyum, et al., 2016).

Similarly, the report of has demonstrated the comparison of blood serum enzyme levels and lipid peroxidation substances levels with the severity of mastitis in the cholistani cattle (Qayyum et al., 2016).

<table>
<thead>
<tr>
<th>Lipid Peroxidation Substance Level</th>
<th>Grade of Mastitis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Malondialdehyde levels in blood (nmol/ml)</td>
<td>1.62±0.01</td>
</tr>
<tr>
<td>Nitric oxide levels in blood (µmol/L)</td>
<td>29.8±0.26</td>
</tr>
</tbody>
</table>

Values (Mean±SE) bearing asterisk in a row differ significantly.

Note: (Qayyum et al., 2016).

The significant increase in the lipid peroxidation substances levels in the serum might be due to the increased permeability of the microcirculatory vessels and oxidative stress due to free radical injury (Qayyum et al., 2016; Åkerstedt et al., 2011; Fagiolo and Lai, 2007).

3. CONCLUSION

Mastitis is a serious and one of the most frequently encountered diseases of the lactating cattle/buffalo with a plethora of etiological agents having a huge impact on the dairy industry and the GDP of a nation. The presented review summarizes the findings of different authors concerning the hematological changes regarding mastitis. The scope of this review is mostly limited to cholistani cattle, and therefore it has to be generalized for buffaloes, since both of them belong to the same sub-family, Bovines, with utmost physiological similarities. It has been demonstrated that the pathogenesis of mastitis is not only limited to mammary tissues and their secretion but also affects the circulatory system as well. More researches and laboratory studies on the blood profile of the buffaloes with clinical and sub-clinical mastitis is deemed necessary, such that the absolute and relative impact of the disease in the dairy industry can be assessed, particularly in Asian countries like Nepal where buffalo is a pioneer source of meat and milk products.

REFERENCES


