Review Article

Somatic Cell Count: An Indicator of Intramammary Infection in Dairy Animals

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Abstract

Mastitis, result of intramammary infections, exhibits serious economic problem in dairy sector due to the loss in milk yield and quality. Clinical and subclinical occurrence are common where subclinical cases are asymptomatic and need additional diagnostic tools for identification. Somatic cell counts (SCCs) in raw milk are an indicator for intramammary Intra-mammary infections (IMI) infections and thus helpful in subclinical mastitis forecasting. Somatic cells of 100,000 cells per ml are regarded as normal for uninfected milk and elevation above 200,000 cells per ml suspects IMI in cattle. The Somatic cell count (SCC) can be estimated with direct microscopic method or by flow cytometry. The major concerns of higher SCC are due to the hazardous effect on milk yield, milk quality, products processing, and pathogens that may have zoonotic importance. Good hygienic practices in shed and supplementations in rations can lower SCC and reduction of IMI. The regular monitoring of SCC is the pathway for early prediction of subclinical cases and assessing udder health management techniques for beneficent dairy business.

Keywords: Dairy, intramammary infections, mastitis, somatic cell counts

Introduction

Mastitis is an inflammatory condition of mammary tissues that have the capacity for several chemical, metabolic, and physiological changes[1] and is the outcome of interaction of factors associated with host, pathogen, and environment.[2] The pathogenic microorganisms prevalent in mastitis include different Gram-positive and Gram-negative bacteria, algae and mycoplasmas, and their varied toxins.[3] *Staphylococci* and *Streptococci* are most abundant and harmful groups of bacteria in mastitis, followed by coliform and *Corynebacterium*. The common cytological changes caused due to the micro-organisms is characterized by increase in somatic cells,[4] especially the leukocytes in the milk and pathological changes include leakage of ions; proteins, enzymes from blood and a decrease in gland's synthetic capacity so results in alteration of milk composition.[5] Being most common infectious disease of milch animals, it can cause intense economic losses to dairy industry due to reduced milk production, veterinary cost, increased labor, premature culling, discarded milk during treatment, and decreased milk quality.[6,7] On an average, 30% reduction in productivity from the affected quarters and 15% on overall production for lactation have been reported. Mastitis also decreases the shelf life and quality of dairy products.[8]

Mastitis occurs in clinical and subclinical forms in dairy animals[9] and its prevalence is significantly influenced by lactation stage, parity, breed, milk yield, body weight, anatomical abnormality of the udder, and some management aspects including nutrition.[10] Clinical mastitis is characterized by sudden onset, swollen and painful quarters, fever, dehydration, and remarkable decrease in milk yields and composition alterations. Flakes and blood in milk can be seen in severe cases. While subclinical mastitis (SCM) is asymptomatic inflammation of mammary tissue, it is 15–40 times more common than clinical form of mastitis whereby the milk and udder appear normal but eventually

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lead to clinical mastitis with high rate of new infections.[11] The invisible nature of subclinical cases thus is more harmful and needs some additional diagnostic tool for identification. Frequently used tools to determine SCM are somatic cell count (SCC) and bacteriological culture.[12] Somatic cells indicate the resistance or the susceptibility of cows to mastitis so that their levels can be used for prediction of intramammary infections. Lower SCC means better animal health.[13] Practically, an elevation of SCC or leukocytes in raw milk is considered abnormal due to higher correlation between SCC and bacteriological status. Thus, SCC levels are considered as reflector of milk quality.[14] According to International Dairy Federation, the recommendations to diagnose and control mastitis are based on SCC.[15]

Economic Burden of Mastitis

Mastitis is among the most costly disease as it consumes more time for treatment and always comes with other associated losses as decreased yield, culling of infected ones, and compromised milk quality.[16] The economic impact of clinical mastitis in buffaloes in Nepal was estimated to be 63 USD/buffalo/lactation with an additional cost of 30 USD for treatments, veterinary services, and extra labor.[17] Similarly, study in Turkey had shown the annual loss due to higher SCC to be 217.8 USD per milking cow. In India, annual loss in dairy sector due to mastitis was reported to be of Rs. 60.53 billion out of which subclinical cases contribute 72% of total loss.[18] Another study had illustrated the total loss of 526 million dollars in India and 2 billion dollars in the USA annually due to mastitis.[19] In the whole, worldwide annual loss due to mastitis was recorded nearly of 35 billion USD.

Somatic Cell Counts

Somatic cells are the defense cells released against intramammary infections and have the capacity to repair the tissue damage. SCCs are hence taken as the indicator of raw milk quality and used in monitoring the udder hygiene in dairy farms.[20] During intramammary inflammation, SCC gets elevated and the elevation is due to increased leukocytes that include macrophages, lymphocytes, and neutrophils. SCC thus is the cells of immune response and the part of the natural defense mechanism that helps to distinguish the infection. The gold standard to evaluate IMI is somatic cells count, a cytological examination and other methods are compared with SCC.[21] When mammary cells get infected, resident somatic cells influence the leukocytes in bloodstream and then massive influx of polymorphonuclear cells in milk occurs which increases the cell count in milk.[22]

Higher SCC is taken as an interpretation of IMI but some researchers have shown controversial opinion on selecting dairy animals with lower SCC as these cells contribute to defense mechanism and low numbers may increase susceptibility of mastitis.[23]

Somatic cell values

Many researches have shown different levels of somatic cell values at quarter, cow or bulk tank for uninfected milk in many countries. Sharif & Muhammad (2008) had stated the limit of SCC for healthy quarter to be 100,000 cells/ml and that for composite milk also should not exceed 100,000 cells/ml. Decreased milk production and increased infection rate will alter the bulk tank somatic cells increment. An elevation above 200,000 cells/ml is considered abnormal and the normal level ranges between 1-2 lakhs per ml in well managed farms.[24,25] The legal limits of SCC in milk in countries differ as per their standards such as 300,000 cells/ml in China and EU, 400,000 cells/ml in Australia, Newzealand and Canada, 500,000 cells/ml in Brazil and 750,000 cells/ml in USA.[26] The significance of ranges of somatic cell count values to identify the status of mastitis as compared to other test is presented in Table 1.

Somatic cell count in buffaloes

Lower SCC had been reported in buffaloes than that of cattle under similar housing practices. The total SCC in normal buffalo milk varied from 50,000 to 375,000 cells/ml with lots of variations than that of cattle. The lowering of SCC in buffaloes may be due to higher capacious udder with less stress in udder than in cattle and the thinner streak canals with perfect sphincter closure mechanism. However, Dhakal (2006) had illustrated the prevalence of sub-clinical cases when the SCC raised above 200,000 per ml. Buffalo milk SCC significantly rises by day 21 of involution and first week pre-partum. The chances of IMI in dry period is low but after calving, teat sphincter loosens and continuous synthesis and removal of milk may have positive relation to increasing SCC. The SCC in clinical and sub-clinical mastitis is significantly higher than the normal milk with their values ranging 6,806,000 cells/ml; 958,000 cells/ml and 176,000 cells/ml respectively in an average.[27]

Somatic cell count in small ruminants

Applying cattle milk SCC for regulating goat milk is discriminatory and threatening to goat dairy industry. Hence, preparation of separate standards is needed.[28] Goat and sheep milk possess relatively higher SCC than bovine that is about 100,000 cells/ml in milk. The nature of secretion in goat is apocrine type rather than merocrine as in cattle due to which higher SCC is prevalent. In other studies, milk of sheep and goat reveal lower SCC than cattle as they produces lesser milk and lower chances of IMI. The legal milk SCC for goat and sheep in US is 1,000,000 and 750,000 cells/ml, respectively, but there exists no any legal limits in EU.[29] Higher SCC in goat milk has not shown any significant difference in pH and in fat, protein, and total solid contents.[30] Hussein *et al*. (2020) considered SCC >10^6 cells/ml as indicator for SCM and revealed 52.56% prevalence in dairy goats in Egypt.[31]

Somatic cell count measuring methods

The inexpensive method to measure the somatic cells is direct microscopic method using Newman-Lampert staining technique whereas other automated devices for rapid determination of SCC through flow cytometry are also

Table 1: Significance of somatic cell counts of milk over a range of counts

SCC/ml	Significance
0-250,000	No pathogenic bacteria present
	No mastitis
	Negative reactions by MWT and CMT
	WMT readings of 5 or less
	Less than 20% oxygen for Catalase test
250,000-500,000	Considered normal milk (no pathogenic bacteria)
	May show trace (1) reaction by CMT (A precipitate begins to form, thickening into a gel as concentration of cells increases)
	Catalase → <20% oxygen
	MWT → Trace reaction
	WMT → 5-13 mm
500,000-1,000,000	Some mastitis or other abnormality is present.
	CMT - weak positive (1) i.e, a distinct precipitate forms but no gel and may be reversible, disappearing upon continued movement of the paddle).
	Catalase Test → 20-30 %oxygen
	MWT →trace reaction; about 400/0 of the tests may still show negative.
	WMT →11-19 mm
1.0-1.5 million	Milk is abnormal, either from mastitis or for
	other reasons.
	CMT → weak positive (1)
	Catalase Test→ 30-400/0 oxygen for counts to 2 million
	MWT → 83 0/0of tests show 1+ reaction
	WMT→l7-22mm
1.5-2.0 million and higher	Milk is abnormal
	CMT → positive (l to 2). Mixture thickens immediately, with some suggestion of gel formation. Upon swirling, mixture tends to move toward the center, leaving bottom of outer cup edge exposed.
	Catalase Test → (40% and over) over 2 million_
	MWT → (1 + to 2 +)
	WMT → 20-25 mm

Key: 1. MWT: Modified Whiteside Test. 2. WMT: Wisconsin Mastitis Test, 3. CMT: California Mastitis Test. 4. Catalase Test, Adapted From: Gordon *et al.* (1980)[37]

available that allows counting and identifying SC types in lesser time.[32] Electronic cell counters use very sensitive fluorescent dye like Sofia Green to dying the milk cells and then pipetted on measuring chambers of disposable chip. The machine then analyzes the loaded chip and result is displayed in the form of counts, graphs, and images. Furthermore, differential SCC representing the polymorphonuclear neutrophils and lymphocytes proportions in milk has been come up as an additional indicators for IMI.[33]

Impact of Increased Somatic Cell Count in Milk

Milk productivity

Increase in SCC indicates the subclinical mastitis which leads unseen decreasing yield in milk of about 12% where an increment of 100,000 cells/ml will lead to reduce the yield by 900 kg per lactation. Hence, productivity loss is an important loss in dairy farm. Decrease in milk yield and rising cells counts is visible at least about 1 week before diagnosing clinical mastitis. Higher-yielding cows are in continuous stress of milk production and get prone to disease leading to higher SCC.

Milk composition and quality

Mammary parenchyma changes are common in IMI which lead to alteration of membrane permeability, blood flow to udder, and changes in filtering capacity due to which compositional changes in milk is inevitable. Decrease in shelf life, low fat and casein content, and increased bacterial counts are associated with higher SCC. This increment is caused by an increase in blood mammary barrier that result infiltration of more ions, proteins, and inflammatory cells. In some cases, despite the rise in fat, protein, and total solid contents are seen, the overall quality gets depleted which may be due to decreased milk yield during elevated SCC.

On products

Qualitative and quantitative changes in milk will surely reduce the yield and quality of milk products. The higher SCC milk bears greater rancidity, bitter taste, and unpleasant aroma between 14 and 21 days of storage due to the continued breakdown of fat and proteins. A decline in value of SCC from 290,000 to 200,000 cell/ml increased the yield of cheese by 4.5%. The shelf life and quality of the cheese, cream, butter, and milk powder gets deteriorated with higher SCC.[13] The deterioration is associated with the increase in moisture and alkaline pH of milk and does not support starter organisms for fermentable products formation.[10] Even the fermentation procedures in yogurt formation may stop in case of higher SCC.[34]

On public health

Residue of antibiotics that are used to lower SCC by the reduction of food poisoning and zoonotic pathogens present in IMI such as *Staphylococcus sp., Escherichia coli, Campylobacter jejuni, Salmonell sp., Clostridium sp., Yersinia enterocolitica, Streptococci sp., etc.*, have hazardous effect in human health. The greatest risk to human health relies if unpasteurized or improperly pasteurized milk is consumed and any pathogens of IMI may affect.[35]

On fertility

Reproductive efficiency is directly related with the udder health condition. Siatka *et al*. (2019) had well illustrated that the higher SCC negatively influences the conception rate and calving interval in dairy cows.

Use/Interpretation of Somatic Cell Count

Single SCC record is inconclusive but very valuable component to monitor the udder health status in herd. Repeating the SCC results on fortnightly or monthly basis can give actual fluctuations on the prevalence of infections. SCC ranges can provide early prediction of mastitis and can act accordingly. Isolation of somatic cells in milk can open new avenues for treating mastitis and milk productivity of cow in the near future. Pathway toward production cost reduction in dairy farms, udder health management is one milestone that needs to be covered and is possible by regular SCC monitoring.[14] Risk assessment in the udder health programs implementation is essential to achieve the hygienic goals and to prevent new intramammary cases. Somatic cells need to be accounted regularly.

Reduction and Management of High Somatic Cell Count

Dry cow management to prevent the bacterial invasion and damage of parenchymatous tissues is must to keep SCC in normal level. Supplementations with vitamins and minerals help in enhancing the immune systems of animals. Along with the good hygienic practices in the farm, some other techniques are described by recent study for reducing SCC such as using vaccines against mastitis pathogens, administering melatonin, utilizing omics for quality milk yield and antioxidant supplementation in production cycle. Some of the additives used in ration to lower SCC are MgO and β-carotene that functions for prevention of adverse fermentation process in intestine and reduce fecal counts of E. coli, a potential environmental pathogen for IMI.[36] Post milking teat dipping to reduce new IMI and intra-mammary antibiotics administration at drying off had also played significant role in reducing SCC level in milk.[37] Cefquinome in lactating dairy cows was found effective to reduce and eliminate SCM.[38] A study in Nepal concluded training package to the farmers on control of mastitis was beneficial and need to be scaled up across small holder farmers.[39]

Conclusion

An economically important disease, mastitis, in dairy animals can be identified with the estimation of SCC in milk, and by considering the factors associated with increasing SCC, the mammary health targets can be set and attained. Different factors such as stress, milking systems, milking frequency, parity, stages of lactation, and shed management practices are significantly associated with SCC in milk. The loss in dairy sector can be prevented with the forecasting of upcoming intramammary infections by monitoring SCC in milk. The common techniques to lower SCC in dairy herds are good hygienic practices in farm, teat-dipping, dry cow therapy, and adequate feeding to cover negative energy balance during lactation.

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Conflicts of interest

There are no conflicts of interest.

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