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Review article

MASTITIS, SOMATIC CELL COUNT AND MILK QUALITY: AN OVERVIEW

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SUMMARY: Mastitis is the economically most important disease in lactating cows and the prevalence under any management condition is considerably high. It causes economic losses due to reduction of both quantity and quality of milk. The groups of microorganisms causing mastitis are categorized as bacteria, fungi, mycoplasma and nocardia. Among the several cow side tests to trace intra-mammary infections (IMI) at early stage, i.e.sub-clinical mastitis (SCM), California Mastitis Test (CMT) is commonly used in which somatic cell count (SCC) is indirectly taken into account. The SCC of milk is an indicator of mammary infections because SCC positively correlates with the severity of infection. The SCC of >200,000 cells/ml is considered to be an indication of IMI. However, SCC in the milk can also vary with some other factors such as breed, age of the cow, stage of lactation, body condition score, etc. A few studies have shown that high SCC in milk affect the composition, organoleptic properties and keeping quality of raw milk and heat treated milk, yoghurts and cheese. One could argue that low SCC milk (sub-clinical mastitis) will not have a significant effect on product quality. But it should be emphasized that the natural infection occurs with various types of microorganisms that can precipitate product defects despite the low SCC. Also, attention must be paid to the bulk tank somatic cell count (BTSCC) rather than individual animal SCC. The quality of raw milk collected from different parts of the country is reported to be low with high bacteria counts mainly due to unhygienic milking and field practices. Milk quality directly influences the income of the small scale milk producers which inturn affects the sustainable dairy production. In Sri Lanka the majority of dairy farmers are small scale producers and they practice minimum milk hygiene practices compared to medium and large scale producers. Therefore, it is essential to make them aware of hygienic milking practices and implement milk quality based payments (MQBP) with added premium and penalties for the existing milk price, with the objective of encouraging clean milk production.

INTRODUCTION

Milk is a complex food with high nutritive value and milk-derived products are one of the main sources of food for the world population. Simultaneously with the continuous growth of the human population of the world, the demand for the food also rapidly increases. About 50% of the world's total milk production is consumed in the form of fresh dairy products and this share will continue to increase to 52% over the next ten years due to rising milk consumption in developing countries. Developing countries consume 68% of fresh dairy products which is expected to increase up to73% over the nextdecade (OECD/FAO, 2018). To meet the increasing demand and to gain the sustainable profit from dairy farms, continuous improvements are being carried out on average farm size and average yield of a cow (Vliegher *et al.,* 2012). However, in a global perspective, the land scarcity is a major constraint for expansion of farm size. As a result, farms tend to be deviated from conventional free range or semi-intensive management to more intensive management where farm mechanisation has also been initiated. Several studies have shown that the intensive management is more prone to diseases. Mastitis is the most economically important disease in lactating cows (Tilman *et al.,* 2002) and under any management system the prevalent rate is around 40-50% either in the form of clinical or sub clinical mastitis (SCM). Mastitis is defined as an inflammation of the mammary gland together with physical, chemical and microbiological changes, is characterised by an increase in the number of somatic cells in the milk and by pathological changes in the mammary tissue (International Dairy Federation, 1987). Mastitis has been classified in different ways and one way of classification has been done as clinical and sub-clinical, which is based on the severity of the disease (Alemu *et al.,* 2013). It has also been classified as environmental mastitis and contagious mastitis, furthermore each group has been classified as clinical, subclinical and chronic (Kudi *et al.,* 2009). Even though the clinical mastitis could be easily diagnosed by appearance of clinical signs or abnormalities in milk, the sub-clinical form needs more accurate diagnostic tools (Fragkou *et al.,* 2014). It has been reported that the sub-clinical form is more prevalent (15-40%) than clinical form in any management system (Kudi *et al.,* 2009). Identification of sub-clinical mastitis can be achieved by subjective tests, such as Californian Mastitis Test (CMT) or by the more accurate direct somatic cell count (SCC). Even though

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direct SCC gives more accurate insight into the severity of the infection, more sophisticated methods are costly while conventional methods are laborious. The SCC varies with many external and internal factors associated with the cow. Many studies have evaluated the relationship between SCC, raw milk quality and processed dairy products. Therefore, the objective of this review is to critically evaluate the studies conducted in relation to mastitis, SCC, and their relationship to milk quality and processed dairy products.

Aetiology and pathogenesis of mastitis

According to the pathogens involved, mastitis has been categorized into four types: bacterial mastitis, mycotic/fungal/algal mastitis, mycoplasmal mastitis and Nocardial mastitis. Bacteria is the main causal pathogen among these groups and around 150 bacterial species have been isolated from infected bovine udders (Shaheen *et al.,* 2016). The bacterial pathogens have been divided into two categories based on the cellular and molecular morphology: Gram-negative species such as *Escherichia coli* and *Klebsiella pneumoniae,* and Gram-positive species such as *Streptococcus agalactiae*, *Streptococcus uberis* and *Staphylococcus aureus* (Arruda *et al.,* 2013). Further, based on the mode of transmission, mastitis can be classified as contagious and environmental mastitis (Alemu *et al.,* 2013). Contagious mastitis is caused by the spread of pathogens from infected to uninfected udder (Smith and Hogan, 2001). Environmental mastitis is caused by the contamination of teat ends from environmental pathogens present in manure, dirt, mud, pools of standing water, feed stuffs and bedding materials (Smith and Hogan, 2008). The bacterial species such as *Staphylococcus aureus*, *Streptococcus agalactiae*, *Mycoplasma bovis* and other mycoplasma species are considered to be contagious type, while *Streptococcus uberis*, *Streptococcus dysgalactiae*, *Escherichia coli* and *Klebsiella* spp are of environmental origin (Shaheen *et al.,*2016). The contagious pathogens are the main reason for SCM because they could grow on skin and the teat canal. Environmental pathogens are normally harboured for a short period of infection, with streptococci and coliforms causing 30 and 10 days of infections, respectively. Environmental pathogens mostly cause clinical mastitis and are therefore less likely than subclinical mastitis to become a herd problem (Smith and Hogan, 2008). Non-infectious mastitis can also be seen, caused by trauma or injuries to mammary gland (Smith and Hogan*,* 2001).

The udder possesses its own anatomical structures and immune mechanisms to prevent and overcome infections. The anatomical structure of teats acts as a physical barrier for invading of pathogens into the teat canal. Teat skin, teat sphincter muscle and keratin plug are included in the first line of defence (Capuco *et al.,* 1992; Lacy-Hulbert and Hillerton, 1995). Keratin layer is secreted by the cells which are lining the teat canal and this substance has a bacteriocidal effect (Lacy-Hulbert and Hillerton, 1995). However, keratin plug disappears before few days of calving and during milking the teat duct is dilated. Therefore, pathogens have a chance to enter into the teat canal and further, abrasions and cracks on teat skin facilitate the action of pathogens (Lacy-Hulbert and Hillerton, 1995). Pathogens may enter into the teat canal within one to two hours after milking when the teat canal is kept open. Bacterial fixation occurs by attaching and colonizing in new tissues (Neijenhuis *et al.,* 2001). Bacteria initially damage the tissues lining the large milk collecting ducts and cisterns and produce virulent factors, which can damage the milk secreting cells. Those damaged cells produce leukocytes attracting substances and therefore, leukocytes are recruited from blood into milk. Those leukocytes have the ability to engulf and destroy bacteria, but if bacteria are not destroyed they continue to multiply and affect entire smaller ducts and alveolar areas (Zhao and Lacasse, 2008)

Somatic cell count (SCC) in milk as an indicator of mastitis

The SCC is an important tool to predict the severity of the intra -mammary infection (IMI). Being a component of milk, SSC can be used to assess the milk quality, monitor herd health for mastitis and to decide milk quality based payment. The milk somatic cells include 75% leucocytes (i.e. neutrophils, macrophages and lymphocytes) and 25% epithelial cells and percentage of leucocytes will vary with infections in mammary tissue and various other factors (Sharma *et al*.2011). Erythrocytes can be found at concentrations ranging from 0 to 1.51×106/ml (Paape and Weinland, 1988). During the inflammatory period, somatic cells rapidly increase in number. The SCC varies depending on the presence, type and virulence factors of the pathogens (Nolan, 2017). It can also vary with other factors such as age, stage of lactation, parity, production level of the cows and environmental factors (Table 1). Cow milk SCC of >200,000 cells/ml indicates mastitis (International Dairy Federation, 1997; Hillerton, 1999). The SCC is the most common method to identify the IMI more accurately in many dairying countries.

Sharma *et al.*(2011) and Bharti *et al.* (2017) reported that there was a positive correlation between SCC and parity, which is attributed to epithelial damage and prevailing pathogen with repeated infections. Also, Sharma *et al.*(2011) and Chegini *et al.*(2016) reported that SCC is high in the late lactation than the early lactation which has been explained as being due to the dilation of the teat canal. A seasonal variation in SCC has been observed, being higher in cows calved in summer than that of winter (Bharti *et al.,* 2017, and Baul *et al.,* 2011).

The diagnosis of mastitis varies from conventional physical examination to application of modern nano technology based techniques. A comprehensive review on diagnosis of mastitis from laboratory to farm has been published by Ashraf and Imran (2018). Figure 1 illustrates an overview of mastitis diagnostic tests applied in the laboratory and the field.

Table 1: Variation of Somatic Cell Counts (SCC) with different animal factors in Jersey cows.

Animal factors	**SCC /ml of milk**
Overall	238,231
Parity	
1st	82,035
2nd	287,739
3rd	313.328
4th and above	939,723
Stage of Lactation	
Early	90,364
Mid	124,738
Late	731,113
Production Level	
Low	653,130
Medium	65,917
High	306,902
Season of Calving	
Summer	502,342
Rainy	156,314
Winter	141,905

Source: Bharti *et al.* (2017)

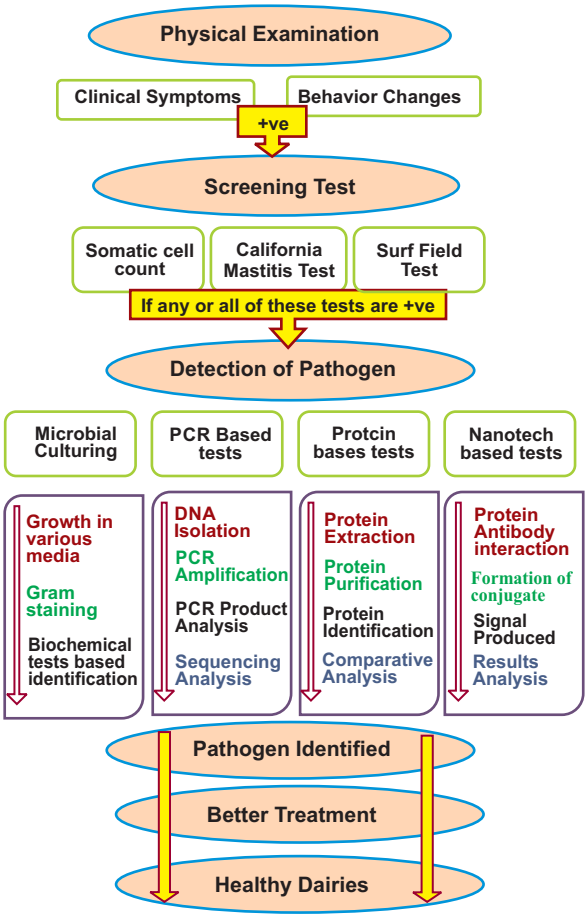

Figure 1: Mastitis diagnostic tests applied in the laboratory and the field.

Source: Ashraf and Imran (2018)

Among the direct and indirect techniques that are available for diagnosis of mastitis, indirect methods such as the California Mastitis Test (CMT), Sodium Lauryl Sulphate Test (SLST), Surf Field Mastitis Test (SFMT) and White Side Test (WST) can be used as cow side tests under field conditions (Sharma *et al.,* 2011). The CMT is extensively applied all over the world despite the fact that it is very subjective. In CMT, a reagent containing mainly a detergent is used to coagulate the DNA present in the somatic cell nuclei. On the visual appearance of the gel formation, a CMT score is given and SCC can be indirectly assumed through the given score (Whyte *et al.,* 2005). Table 2 shows the association of CMT score, SCC, and the somatic cell score (SCS).

Accuracy of SCC with mastitis causing pathogens and the threshold level of SCC for mastitis detection is very important since there can be false positive identifications. Pamela and Reniemnn (2002) reported that the sensitivity to detect mastitis at SCC 200,000 cells/ml is varied between 73-89% and when threshold value is increased to 250,000 cells/ml, positive prediction value for subclinical mastitis is also increased. Based on the mastitis causing pathogens, the SCC varies, and contagious pathogens such as *Streptococcus agalactiae* and *Staphylococcus aureus* generally cause greater SCC elevation than environmental pathogens (Bharti *et al.,* 2017). Table 3 shows the SCC in milk for different isolated pathogens.

Table 2: Association of Somatic Cell Count (SCC), California Mastitis Test (CMT) score and Somatic Cell Scores (SCS)

SCC Range (cells per mL)	Approximate SCC midpoint (cells per mL)	SCS	CMT Score	Visible Reaction
0 – 200,000	12,500 25,000 50,000 100,000 200,000	0 1 2 3 4	Negative	Mixture remains liquid, no evidence of precipitate
150,000 – 500,000	400,000	5	Trace	Slight precipitate, best seen by tipping, disappears with continued movement
400,000 -1,500,000	800,000	6	1	Distinct precipitate but no tendency toward gelformation
800,000 – 5,000,000	1,600,000 3,200,000	7 8	2	Mixture thickens immediately, moves toward centre
>5,000,000	6,400,000	9	3	Gel forms and surface becomes convex

Source: Pamela and Reniemnn (2002)

Quality of milk in Sri Lanka

In Sri Lanka, the quality of milk is far below the standards of most dairying countries. According to Silva *et al.* (2016) around 20% of milk collected to milk collecting centres has to be discarded. Several studies that have been carried out in different locations of the country showed exceptionally higher total bacterial counts both in raw milk and also in some processed milk (Deshapriya *et al.,* 2007, Abeygunawardena *et al.,*2017, Sanotharan and Deshapriya, 2018). Abeygunawardena *et al.* (2017) reported that the poor microbial quality of raw milk in studied areas of Kurunegala District was attributed to the inefficient cleaning and disinfection of udder and utensils coupled with poor concern and negligence of farmers towards appropriate hygienic practices. A higher total viable count and Coliform count have been recorded even in bulk containers (Ranasinghe *et al.,* 2017). Vairamuthu *et al.* (2010) stated that milk quality of Jaffna district has been drastically affected by the following practices during milking; washing the udder and hands with only water without a detergent, wiping the udder after washing only using hand, and the milking of infected and healthy cows at the same time. They have also found that the total aerobic bacteria and coliform counts were 22 x 10^5 and 47 x 10^3 CFU, respectively and these values are higher than the acceptable levels. Sanotharan and Deshapriya (2018) reported that the unhygienic milking practices, usage of plastic utensils in milking and time duration between milking to chilling affect the keeping quality of the milk in Ampara District. According to Rahularaj *et al.* (2019) most of the medium and small scale dairy farmers in Sri Lanka practice machine milking with improper cleaning procedure, which increases the prevalence of the subclinical mastitis and directly affects the milk quality. The high prevalence of sub-clinical mastitis is a major contributor for poor milk quality (Rahularaj *et al.,* 2019, Gunawardena *et al.,* 2014). The milk collection system is a strong contributor to poor milk quality in Sri Lanka. The number of bacteria remaining in raw milk reaching the processing factory from the small-hold farmers showed a positive trend with the milk holding time in transportation (Weerasinghe *et al.,* 2017). Field practices such as mixing of milk from different chilling centres and long period of storage were identified as major contributing factors for microbial load and acidity level in milk collected in different areas of the country. Weerasinghe *et al.* (2017) also concluded that

Table 3: Somatic Cell Count (SCC) in milk for different isolated pathogens

Isolated Pathogen	SCC (cells/ml)	Reference
Staphylococcus aureus	871,000	Souza *et al.,* 2016
	20,000,000	Sharma *et al.,* 2011
	1,990,000	Bortolami *et al.,* 2015
	173,820	Condas *et al.,* 2017
Streptococcus agalactiae	1,943,125	Souza *et al.,* 2016
	13,600,000	Sharma *et al.,* 2011
	4,660,000	Bortolami *et al.,* 2015
	183,450	Condas *et al.,* 2017
Streptococcus uberis	803,500	Souza *et al.,* 2016
	4,240,000	Bortolami *et al.,* 2015
	161,570	Condas *et al.,* 2017
Coagulase-negative staphylococci	482,000	Souza *et al.,* 2016
	13,600,000	Sharma *et al.,* 2011
	1,970,000	Bortolami *et al.*, 2015
Klebsiella spp.	132,850	Condas *et al.,* 2017
Staphylococcus chromogenes	67,860	Condas *et al.,* 2017
	7,800,000	Sharma *et al.,* 2011

quality of milk is better in the Central Province where the ambient temperature is comparatively low. A dairy value chain study carried out in the Uva Province of Sri Lanka clearly showed that the milk quality directly influences the income of the small scale milk producers, which inturn affects the sustainable dairy production at small scale level. Therefore, the study emphasized the need of milk quality improvement (Wijethilka *et al.,* 2017; Wijethilaka, 2018).

SCC and milk quality

The lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy cows, contains not less than 8.25% of milk solid-non-fat (SNF) and not less than 3.25% milk fat. It is also affected by many animal related and environmental factors (Nobrega and Langoni, 2011). Typical bovine milk contains 87% water and 13% solid as shown in Table 4.

Table 4: The composition of typical cow milk.

Cow milk Composition	Percentage
Water	87.5
Total Solids	12.7
Fat	4.5
Protein	2.9
Lactose	4.1
Ash (minerals)	0.8

Source: Fox (2003).

Mastitis causes reduction in quantity and quality of milk. Some components in milk such as fat, lactose and protein are decreased while somatic cells, whey protein, free fatty acid and enzymes are increased due to the inflammation (Pyorala, 2003). Table 5 shows the changes in milk components and milk volume due to mastitis. Sharma *et al.* (2011) reported that the reduction of milk components during mastitis is caused by the reduction of synthesis due to the cellular damages and elevation of some components due to leakage from blood as a result of pathological changes in the underlying tissues. The extent of changes in milk composition is specific for the mastitis causing pathogen. The elevation of free fatty acid level, proteolytic and lipolytic enzymes, and sodium and chloride ions, can cause drastic changes in keeping quality of milk.

Table 6 shows the relationships between different SCC ranges and the changes in milk constituents. Coulona *et al.* (2002) stated that some mastitis causing pathogens alter only specific components of milk and some other pathogens do not alter the milk components. As an example *Corynebacterium bovis* does not alter the milk composition. *Streptococcus dysgalactiae* and *E. coli* significantly increase the protease enzymes (peptone and plasmin) in milk but do not affect fat and protein content.

Ma *et al.* (2000) reported that protein and fat percentages are higher in mastitis milk than in normal milk. High SCC (849,000 cells/ml) in milk mainly affects the flavour of the milk. During the milk storage and processing, somatic cells release proteases and lipases that react with proteins and fat leading to bitterness and rancidity in milk (Irma *et al.,* 2013). Also the lipases act on the fat globule membrane thereby exposing the milk triglycerides to further degradation by milk lipoprotein lipase. Increased lipolysis leads to increased free fatty acid (FFA) in the milk. Therefore, high FFA in milk leads to the development of rancidity and off flavour during storage (Santos *et al.,* 2003b; Irma *et al.,* 2013). Further, during storage of infected fresh milk in cold condition, casein/true protein ratio is reduced due to the activity of a plasmin enzyme which causes lysis of the major protein, casein.

Lactose concentration is low in infected milk which is a result of the secretary cell damage. Mastitis pathogens severely affect the tight junctions of the secretary cells therefore, low secretion of lactose and changes in osmotic pressure cause low level of water transfer for milk synthesis, which causes low yield in infected cows (Nobrega and Langoni, 2011; Bruckmaier *et al.,* 2004). Ogola *et al.* (2007) stated that there can be changes in minerals in milk due to mastitis, sodium and chlorine concentrations are increased in infected milk because of the leakage from ruptured mammary cells but calcium concentration is at low level because calcium is incorporated with casein micelles and decreases in casein reduce the calcium concentration. However, changes in major constituents are more prominent and it can vary in a pathogen specific manner as summarised in Table 7.

Table 5: Changes of major compositional parameters of bovine milk due to mastitis

Constituent	Normal Milk	Mastitis Milk
Fat%	3.45	3.2
Free fatty acids (ADV) %	0.8	3.92
Triglyceride fatty acids		
C4 – C12 mg/g fat	126.4	144.2
C16 – C18 mg/g fat	708.4	641.5
Phospholipids mg/g fat	7.0	14.3
Carotenes mg/g fat	6.3 -7.5	16.6 - 74.4
Total Protein%	3.61	3.56
Total casein mg/ml	27.9	22.5
Total whey protein mg/ml	8.7	19.8
Bovine serum albumin mg/ml	0.1 – 0.2	21.5
Total immunoglobulin mg/ml	0.9	18.3
Proteose – peptone mg/ml	1.82	9.24
Lactose%	4.5 - 5.3	3.3 - 4.9
Somatic cells x10^3/ml	20 - 1000	100 - 5000

Source: Kitchen (1981)

Table 6: The changes in milk constituents with different ranges of Somatic Cell Counts (SCC)

Milk components	SCC (x 10^3cells/ml)			
	<100	<250	500-1000	>1000
Decrease (in g/100 ml)				
Lactose	4.90	4.74	4.60	4.21
Casein	2.81	2.79	2.65	2.25
Fat	3.74	3.69	3.51	3.13
Increase (in g/100 ml)	0.81	0.82	1.10	1.31
Whey proteins (Total)	0.02	0.15	0.23	0.35
Serum albumins	0.12	0.14	0.26	0.51
Immunoglobulin	0.091	0.096	0.121	0.147
Chloride	0.057	0.062	0.091	0.105
Sodium	0.173	0.180	0.135	0.157
Potassium	6.6	6.6	6.8	6.9
pH				

Source: Schallibaum *et al.* (2001)

Table 7: The changes in major milk constituents with different mastitis causing pathogens

Mastitis Pathogens	Fat %	Protein %	Lactose %	Reference
Staph. aureus	- 0.082	- 0.044	- 0.041	Reis *et al.,* 2013
Coagulase negative	- 0.175	- 0.033	- 0.023	
staphylococci	-0.24	-1.7	- 67.4	Bezman *et al.,* 2015
Streptococcus spp.	- 0.232	- 0.031	- 0.062	Reis *et al.,* 2013
	-7.2	+3.67	-16.3	Bezman *et al.,* 2015
Corynebacterium spp.	-0.138	+ 0.052	-0.082	Reis *et al.,* 2013
E. coli	-3.6	+ 0.56	-47.37	Bezman *et al.,* 2015

SCC and Dairy Products

The quality of milk products mainly depends on the composition and quality of the raw milk. High SCC will influence the dairy product quality by affecting keeping quality, flavour, and the structure of the product (Ogola *et al.,* 2007; Ma *et al.,* 2000). The impact of SCC on dairy products, including pasteurized or Ultra High Temperature (UHT) milk, yoghurt and cheese are presented in the following paragraphs.

High SCC and heat treated milk quality

Fresh milk is subjected to various levels of heat treatment with the objectives of eliminating milk borne pathogens and extending keeping quality. However, depending on the temperature applied and holding time the effect of heat treatment on milk is varied. Most of the novel heat treatment methods such as pasteurization, UHT treatment and sterilization can be applied to fresh milk to eliminate viable microorganisms, but still the activity of heat stable enzymes remains. The presence of exogenous enzymes is high when there is high SCC in milk. Ma *et al.* (2000) have observed a higher Acid Degree Value (ADV), an indication of high lipolysis activity and casein hydrolysis leading to reduction in CN/TP ratio in pasteurised (74C°/34S) milk with high SCC (849,000 cells/ml, 2.5% fat) during storage at 5°C for 21 days. Also they have detected poor organoleptic attributes such as bitterness and rancidity that consisted with proteolysis and lipolysis in high SCC milk. Santos et al. (2003a) have also detected reduction in casein percentage in total protein (CN/TP) during the storage time and this reduction is higher in high SCC (376,000 cells/ml) than low SCC (26,000 cells/ml) pasteurized milk stored at 6°C.

Three main parameters such as bacteria in milk, proteolysis and lipolysis are responsible for the off flavour development and reduced shelf life (Santos *et al.,* 2003b; Ma *et al.,* 2000). In pasteurized unpreserved milk, psychotropic bacterial count (PBC) was increased $>10^3$cfu/ml at 5°C storage on 22 days for high SCC (1,113,000 cells/ml) but PBC was increased $>10^3$cfu/ml at 5°C storage on 26 days for low SCC (26,000 cells/ml) (Santos *et al.,*2003a). Plasmin is a proteolytic enzyme which hydrolyses β-casein and α-casein and when this enzyme is elevated in milk even after SCC has decreased, its activity remains (Leitner *et al.,* 2006; Bugaud *et al.,* 2001; Santos *et al.,* 2003a). Plasmin and plasminogen are heat resistant and there fore, the activity is not affected by the High Temperature Short Time (HTST) pasteurized treatment and by UHT treatment. Therefore, during storage of pasteurized and UHT milk, plasmin is still in active form leading to further proteolysis (Newstead *et al.,* 2006; Prado *et al.,* 2006). Alichanidis *et al.* (1986) found that inactivation of plasmin was higher in lower temperature (85˚C or below) than the higher temperature (130 or 143˚C) heat treatment and they suggested the reasonas being that in lower temperature, enzyme protein is gradually unfolded and becomes partially denatured. Thereafter, it will be hydrolysed by remaining enzymes in active form, but in high temperature, enzymes quickly unfold to inactive form and thereafter at normal temperature those inactive enzymes gradually refold to active form. Therefore, even though milk is subjected to high temperature heat treatment, enzymes remain active throughout the storage period.

Effect of high SCC on Yoghurt

Yoghurt is a fermented product which includes well known set, blended, and strained yoghurts. A limited number of research show that high SCC had little impact on the properties of the unstrained yoghurt. When yoghurt is produced from high SCC milk, there are no changes in pH, titratable acidity, fat and protein during 30 days of storage at 5°C. Yoghurt produced from milk with low SCC (400,000 cells/ml) could be stored at 5°C for 30 days without any organoleptic changes, but consistency of yoghurt prepared using milk with high SCC (>400,000 cells/ml) was affected on day 20 and the taste was decreased after day 30 (Oliveira *et al.,* 2002).

Fernandes *et al.* (2007) reported that the viscosity and free fatty acids (FFA) in the stirred yoghurt prepared from high SCC (1,943,000 cells/ml) milk was higher than the low SCC (147,000 cell/ml) yoghurt during storage on days 10, 20 and 30. The viscosity, proteolysis and lipolysis were increased and pH was decreased in cold stored yoghurt which was made from milk of SCC 398,000 cells/ml than from milk of 95,000 cells/ml. High FFA level was found in yoghurt made from above 1,150,000 cells/ml (Hachana and Paape, 2012). When yoghurt is produced with high SCC milk (400,000 cells/ml) the yoghurt culture activity is reduced by 35%. But if the milk has been boiled for 2 min or heated at 90°C for 20 min somatic cells will be completely inactivated. However, if the cell count is above 400,000 cells/ml the growth of the yoghurt culture organisms will be inhibited even though the heat treatments are given (Tamime and Robinson, 2004).

Mastitis on Cheese quality

When high SCC milk is used to produce cheese, low cheese yield, inefficiency in yield, improper texture and poor overall organoleptic properties can be seen (Talukder and Ahmed, 2017). High SCC promotes the retention of more moisture in cheese and depending on the type of cheese off-flavour development can be seen (Bobbo *et al.,* 2017). Further, lipolysis and proteolysis can be seen in most types of cheese leading to reduced curd firmness, loss of fat and protein in whey (Talukder and Ahmed, 2017) and influence the rennet coagulation resulting low yield of poor quality cheese (Pirisi *et al.,* 1996).

Similarly, Mazal *et al.* (2007) have produced Prato cheese from high SCC milk (>600,000 cells/ml) and low SCC milk (<200 cells/ml) and they detected significantly higher total protein and non-protein nitrogen, lower true protein and casein concentrations, and higher proteolysis during ripening, resulting in higher whey protein concentration.

Klei *et al.* (1998) reported that cottage cheese made from high SCC milk (872×10^3cell/ml) had higher proteolytic activity resulting in loss of more protein in whey and wash water, higher moisture content in the curd, lower lactose content and lower yield, when compared to cheese made from low SCC (83×10^3cell/ml) milk from same Holstein cows whose teats were inoculated experimentally with 1000 cfu of *Strep. agalactiae.*

Conclusion

The severity of mastitis, intensity of udder damage and effect on milk quality depend on many animal related and environmental factors. In terms of minimising the losses, dry cow management, early detection of sub-clinically infected animals, and application of hygienic milking practices are of utmost importance. Early diagnosis of sub-clinical mastitis can minimize the economic losses due to cost of treatment, milk volume loss, premature culling and milk rejection due to poor hygienic quality parameters at milk reception. Most importantly, indiscriminate use of antibiotics in lactating cows as dry and lactating cow therapies can be minimized if the occurrence of new mastitis cases and spread of existing cases are controlled. Thus, many dairying countries are deviating from more intensive management to semi-intensive/free grazing systems with an aim of improved animal welfare, with genetic improvement for disease resistance, climate smart dairy farming, nature loving dairy farming, use of herbal drugs, etc. Although there are various tests available at laboratory level and as cow side tests the cost per cow is a major concern. SCC is one of the most important and reliable indicators of IMI that can be used to detect SCM, but it is expensive and cumbersome than more conventional way of counting. Therefore, more reliable and cost effective methods must be developed at an affordable cost for small scale farmers. When mammary tissue is damaged from infections, milk fat, lactose and casein concentrations are decreased but total protein concentration is elevated. Milk from infected udder contains an elevated microbial population, somatic cells, and higher concentration of exogenous enzymes. They exert a synergistic deleterious effect on both raw milk and processed dairy products. However, there are only a limited number of studies that have been carried out to show the effect of SCC on processed dairy products. In many studies, experimental inoculation of lactating udder with a specific pathogen showed very high SCC milk and when this milk was used to produce pasteurised milk, yoghurt or cheese those products have shown extremely deleterious effects. Therefore, it could be argued that low SCC milk (sub-clinical mastitis) will not have a significant effect on product quality. But it should be emphasized that the natural infection occurs with various types of microorganisms that can precipitate product defects despite the low SCC. Attention must be paid to the bulk tank somatic cell count (BTSCC) rather than individual animal SCC. In Sri Lanka the majority of dairy farmers are small scale producers and they use minimum milk hygiene practices compared to medium and large scale producers. Therefore, it is essential to make them aware of hygienic milking practices and implement milk quality based payments (MQBP) with added premium and penalties for the existing milk price with the objective to encourage clean milk production. Moreover, there must be institutional emphasis towards research and development, and to disseminate knowledge on dairy science and technology, if Sri Lanka is to be self-sufficient in milk and to have a sustainable dairy production.

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