Asian J. Dairy & Food Res, 35 (4) 2016 : 270-277
Print ISSN:0971-4456 / Online ISSN:0976-0563

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Somatic cell count as a monitoring system for hygienic milk production in India: A review

P.V. Jadhav*[1], S.B. Tarate[2], M. Bhuvana, D.N. Das[3] and B.R. Shome[4]

College of Veterinary and Animal Sciences,
Udgir-413 517, MAFSU, India.
Received: 07-05-2016 Accepted: 17-09-2016 DOI: 10.18805/ajdfr.v35i4.6624

ABSTRACT

The major alteration in the milk composition due to mastitis includes presence of somatic cells (neutrophills, monocytes, macrophages and mammary epithelial cells), bactericidal and bacteriostatic compounds and certain enzymes. Antibiotic residue violation and presence of foodborn pathogens with/without their toxins is another threat of immense importance. These changes in the milk account for the deterioration of the milk quality, risk of health hazards and also its acceptance in the international market. Of all these components, milk somatic cells are the single most widely used indicator of the udder health and mastitis. Somatic cell count (SCC) is used as a system for measurement of milk quality internationally. Strict legislation for monitoring the minimum SCC level is followed to ensure healthy milk in most of the developed countries. This paper introduces the concept of 'Clean White Revolution' and reviews the importance of SCC as a measure to ensure hygienic milk production in India. It also emphasizes upon a need to strengthen the existing legislations concerned.

Key words: Health hazard, Legislation, Mastitis, SCC, Standards.

INTRODUCTION

Dairy industry is of crucial importance to India. As the largest single dairy producing country, India's output continues to grow strongly in the 3-4 percent range [Ministry of Food Processing Industry (MOFPI) 2007]. India accounts for over half the total milk output of Asia. The country is not only the largest milk producer but also the world's largest consumer of dairy products, consuming almost 100% of its own milk production which is more than 13% of world's total milk production (Hemu 2010). India is thus self sufficient in its milk production to meet its domestic requirements, and generally has no requirement to import or export milk products. But still export of milk does take place. Major importers of Indian milk and dairy products are Bangladesh, China, Hong Kong, Singapore, Thailand, Malaysia, the Philippines, Japan, UAE, Oman, and other gulf countries, all located close to India.

The post economic liberalisation scenario in India has immense prospective for progress and the dairy industry especially, is gearing up to meet the export challenge. There are certain areas where a major thrust is required. Some of the major challenges related to food safety and quality in milk products export and import encompasses criteria relating to composition (butterfat, crude protein, lactose, milk solids, etc) and hygiene (total bacterial count, somatic cell count). Presence of antibiotic residue in milk is another emerging food safety threats. Of these, SCC is the most important single indicator of milk quality, reflecting the health status of the mammary gland. Majority of these problems affecting the milk quantity and quality are due to mastitis, a complex disease condition of economic importance afflicting the dairies across the world.

Somatic Cell Count (SCC)

Of all the inflammatory indicators appearing in the milk, during the course of pathogenesis of the mammary gland (Table 1), SCC is the most significant component in assessment of aspects of quality, hygiene and mastitis control. It is the most widely used single reliable indicator of udder health and is a useful predictor of intramammary infection (IMI).

Somatic cells are mainly milk-secreting epithelial cells and white blood cells. Prescott and Breed (1910) suggested use of the term 'body' cells because research at that time had suggested that the cells in milk were detached epithelial cells. By the late 1960's the term 'somatic' (meaning body) cell count became commonplace. Since cell numbers in milk are closely associated with inflammation and udder health, these somatic cell counts are accepted as the international standard measurement of milk quality [National Mastitis Council (NMC) Annual Meeting Proceedings 2001] currently.

*Corresponding author's e-mail: drprajaktavet@gmail.com
[1]College of Veterinary and Animal Sciences, Udgir, MAFSU
[2]Wochard India, Maharashtra.
[3]Genetics Dept, SRS of NDRI, Bangalore-30
[4]PD_ADMAS, Bangalore-24

Table 1: Compositional changes in the milk due to mastitis (Pyorala, S. 2003)

Factors decreased	Factors increased
Lactose	Somatic cell count
Fat	Whey proteins
Long-chained fatty acids	Bovine serum albumin
Total casein	Immunoglobulins
α_{S1} casein	κ casein
β casein	Proteose peptones
α lactalbumin	Free fatty acids
α lactoglobulin	Short-chained fatty acids
Calcium	Sodium
Magnesium	Chloride
Phosphorus	Lactate
Zinc	Enzyme activity
Potassium	Lipase
	Lysozyme
	NAGase
	β glucuronidase
	Plasmin

There are straight line relationship between milk loss and SCC (Sharma *et al*. 2011). High SCC levels in the milk cause deterioration of the milk quality. For instance, use of such milk in the production of cheese results in reduced curd firmness, decreased cheese yield, increased fat and casein loss in whey and compromised sensory quality (Ma *et al*. 2000). These effects would adversely affect the yield of milk protein concentrate (MPC), which consist of casein-type and whey proteins. Moreover, an elevated SCC score may also result in shorter (or decreased) shelf life and adverse milk flavours. Such changes in quality of milk have significant impact on export of milk and milk products and may pose heavy economic loss.

Public health hazards due to consumption of milk with high SCC: Direct negative effects on the safety of human due to consumption of dairy products made with milk having high SCC have not been documented. However, ingestion of large numbers of bovine neutrophils in milk may be objectionable (National Mastitis Council Report 2005). Contamination of milk by somatic cells as well as a variety of chemicals and insecticides may result in the problems like allergy, ear and tonsillar infections, bedwetting, asthma, intestinal bleeding, colic and childhood diabetes in children. In adults the problems seemed centered more around heart disease and arthritis, allergy, sinusitis, and the more serious questions of leukemia, lymphoma and cancer (http://www.afpafitness.com/articles/MILKDOC.HTM). High SCC raises the suspicion that the milk is produced under poorer standards of hygiene and from unhealthy cows. Increased SCC is also associated with reduced suitability of the raw milk for manufacturing and processing into products for human consumption (Ma *et al*. 2000).

A major concern regarding the milk with high SCC is heaved if the milk is consumed raw or when there is incomplete or faulty pasteurization (Hameed *et al*. 2006). In India approximately 65 percent of milk is consumed on farm by local milk vendors, wholesalers, retailers, and the producers themselves (Karmakar and Banerjee. 2006). This indicates that raw unpasteurized milk is consumed by a much larger segment of the population in India. Also raw milk is consumed in the form of several types of cheeses including ethnic cheeses manufactured from unpasteurized raw milk.

The other part of the story is that pasteurization may not destroy all foodborne pathogens in milk specially *Mycobacterium paratuberculosis* and *Listeria monocytogenes* (Bunning *et al*. 1988). Presence of pathogens could result in existence of bacterial toxins in milk and milk products. Collectively, milk with high SCC is a sign of the presence of foodborne pathogens in raw milk and can either directly or indirectly increases the risk of ingestion and transmission of these pathogens and their potentially harmful toxins.

Several surveys have detected foodborne pathogens in bulk tank milk (Jayarao and Henning 2001; Murinda *et al*. 2004; Van Kessel *et al*. 2004;). The major pathogens which has been identified includes.

***Staphylococcus aureus*:** It was inferred that raw milk was a potential source of enterotoxigenic *Staph. aureus* in milk and milk products (Ombui *et al*. 1992). Enterotoxigenic strains of *Staph. aureus* have been reported to cause a number of diseases or food poisoning outbreaks because of ingestion of contaminated dairy products or milk (Asao *et al*. 2003). The most recent large-scale outbreak occurred during June 2000 in Japan and it was caused by consumption of low-fat milk produced from skim milk powder contaminated with *Staph. aureus* enterotoxin A.

***Escherichia coli*:** Shiga-toxin producing *Escherichia coli* (STEC) are of immense economic and public health significance. STEC O157:H7. STEC are highly pathogenic in humans where they cause serious acute illness and long-term sequelae (Paton and Paton 1998). Manifestations of illnesses caused by STEC include non-bloody diarrhea, diarrhea-associated hemorrhagic colitis, hemolytic uremic syndrome (HUS) and thrombotic thrombocytopenic purpura. Enterohemorrhagic *E. coli* (EHEC) strains constitute a subtype of STEC serotypes that have been firmly associated with bloody diarrhea and HUS.

Streptococcus: *Str. agalactiae* is an important bovine pathogen, especially as a cause of both clinical and sub-clinical *mastitis* in dairy cows (Keefe. 1997). *Streptococcus* species produce *Streptococcus* pyrogenic toxins, they cause immunosuppression and non specific T-cell proliferation. These activities are referred to super-antigen activity.

***Salmonella* spp:** *Salmonella enteritidis* and *Salmonella baibouknown* are the common pathogenic spp which have been isolated from raw milk (Jalali *et al*. 2008). In humans, the clinical manifestation of salmonellosis exhibits enteric fever, gastroenteritis and bacteremia. Many researchers reported the presence of Salmonella spp in bulk tank milk (Murinda *et al*. 2002; Van Kessel *et al*. 2004).

Listeria monocytogenes**:** Winter *et al*. (2004) isolated *Listeria monocytogenes* from the milk of two cows and two sheep with mastitis. Clinical examination of the udder, bacteriological examinations and determination of SCC of milk samples revealed an elevated SCC (0.8 - 10.1 x 10^6 cells/ml), persistent shedding of *L. monocytogenes* and a normal appearance of milk. *Listeria monocytogenes* causes septicemia and meningitis in humans. Pregnant women are particularly susceptible since *L. monocytogenes* infection may result in spontaneous abortions or stillbirth of the fetus (Oliver *et al*. 2005). At high bacterial concentrations, *L. monocytogenes* can survive minimum HTST pasteurization. It can be an etiology of mastitis and can be shed in milk of carrier asymptomatic cows too.

***Mycobacterium* spp:** Karimuribo *et al*. (2005) carried out a study in which it was found that at least one member in the family was diagnosed to have tuberculosis within a period of two years before the study. Most human tuberculosis cases are due to *M. bovis* occur in young individuals and result from drinking or handling contaminated milk. As a result, cervical lymphadenopathy, intestinal lesions, chronic skin tuberculosis (*Lupus vulgaris*), and other nonpulmonary forms are particularly common (Thoen *et al*. 2006).

Normally, atypical mycobacteria are non-pathogenic in healthy individuals but become important in immunocompromised people also presence of mycobacteria in milk from traditional animals may be more important during this era of HIV-AIDS pandemicity than before (Karimuribo *et al*. 2005). Evidence has been reported that *Mycobacterium avium* subsp. *paratuberculosis*, associated with Johnes in cattle are isolated from human patients with Crohn's disease. This organism may survive some accepted milk pasteurization procedures. Although the possible association between shedding of the *Mycobacterium avium* subsp. *paratuberculosis* in milk and subsequent survival after pasteurization is compelling, the rate of shedding is low in infected cows and not related to an increase in SCC (Stabel 2005). This is however accepted with a general belief that in a tuberculis udder secondary dissemination of infection would lead to systemic distribution of infected leukocytes, concluding that high cell count milk may pose a higher risk (Hillerton and Berry 2004).

Monitoring of milk SCC

Systematic records of SCC, monthly screening tests on individual cows, and tank milk SCC provide useful management information on the clinical status of the herd and the milk quality. In some of the countries, the dairy market provides an SCC score for every pickup of milk, providing continual monitoring. A parameter based on somatic cell count that is often used is the Linear Score (LS) or the Somatic Cell Score (SCS). The LS is a base 2 logarithmic conversion of SCC. The Dairy Herd Improvement Association (DHIA) (1984) has adopted this SCC scoring system in the U.S that divides the SCC of composite milk into 10 categories from 0 to 9 known as linear scores (Table 2). The DHIA programs determine the SCC on each milking cow each month and report either the SCC or the linear score. Linear scores can thus be used to estimate production losses, but the average linear score for the lactation most accurately reflects reduced milk yield.

The National Mastitis Council has defined the SCC limits of an uninfected and/or infected mammary quarter. According to NMC guidelines (2001), the normal milk from infected/uninflamed mammary quarters will have an SCC of less than 100,000 cells/ ml. A clinically infected mammary quarters will almost always have SCC greater than 200,000 cells/ml and when quarter SCC are equal to or exceed 200,000 cells/ml and bacteria are isolated in the absence of clinical changes, then the quarter is defined as being sub-clinically infected.

International Standards

SCC is the key component of national and international regulation for milk quality. Each country has some regulatory SCC limits and regulatory tests that monitor the production and supply of quality milk.

Standards for producing milk in the U.S. are established by the National Conference of Interstate Milk Shippers (NCIMS) and approved by the Food and Drug Administration (FDA). These standards are contained in the Pasteurized Milk Ordinance (PMO). Regulatory tests are conducted for SCCs, bacterial numbers, and the presence of antibiotics and added water. The legal milk SCC limit as established by the FDA for cows is 750,000 cells/ ml, and for goats and sheep it is 1,000,000 cells/ ml. The US milk quality-monitoring program is based on routine producer sampling and testing. At least one bulk tank sample/month from each Grade A producer must be tested for somatic cell and bacteria counts. When a single BTSCC exceeds 750,000/ ml, it raises a concern. When two of the last four consecutive milk samples are above the limit, the producer is placed on

Table 2: SCC scoring system (Dairy Herd Improvement Association and Philpot, 1984)

Lactation average linear SSC score	CMT score	Somatic cell count (cells/ml)
2	Negative	50,000
3	Negative	1,00,000
4	Trace	2,00,000- 3,00,000
5	1	4,00,000- 7,00,000
6	< 2	8,00,000-12,00,000
7		16,00,000

notice and if the somatic cell concentration of 3 of the last 5 milk samples exceeds 750,000/ml, producers lose the right to sell milk for Grade A purposes and their license is suspended. To regain the license, actions must be taken to produce milk with less than 750,000 cells per ml. Once changes are made, samples are taken on an accelerated basis and tested. Enough sample results must be less than 750,000 cells/ ml in order to regain "legal" status. The US does not average several results from a particular time period; rather it uses the individual monthly cell count results.

The SCC standard of the U.S is the highest of all the major developed dairy producing countries of the world. Many of European countries, New Zealand and Australia have a legal SCC limit of 400,000/ ml. The European Union comprises fifteen member countries adhering to a common agricultural policy to manage output and provide an even spread of opportunity. Raw milk offered for sale within and into the European Union has to be produced according to the requirements of Commission Directive 89/362/EEC and to meet quality standards described in Council Directive 92/ 46/EEC. Milk buyers pay a premium of 3-5% of milk price below the premium threshold of 200,000cells/ml, a neutral price above that threshold and then introduce price reductions of 5-10% from a higher threshold, often 250 000 cells/ml, up to the regulatory level of 400,000 cells/ ml. Milk with a persistently high cell count is relatively worthless, even if some form of market can be found, penalties of 30-60% of regular price are applicable for such milk (Hillerton and Berry 2004).

In Canada, the legal SCC limit which was 500,000/ ml has been changed to 400,000 recently. The policy change came into effect at the beginning of August 2012 (http://www.ontariocanada.com/registry/view.do?postingId=8062&language=en). This is the latest milk quality commitment Dairy Farmers of Canada have made after implementing the Canadian Quality Milk program (CQM). On par with the other countries, penalties are imposed on Canadian dairy farmers enrolled in Dairy Herd Improvement programs under the Ontario Milk Act if the milk does not meet the regulatory standards. To determine if a SCC penalty is applicable monthly weighted average (MWA) SCC of three previous months are taken into consideration. SCC penalties increase with each successive violation in any rolling 12-month period, with a shut-off from the milk market being applied for incurring four SCC penalties in any rolling 12-month period. Penalty rates are $3, $4 and $5/L for the first, second, third and subsequent penalties in a rolling 12-month period (http://www.milk.org/ Corporate/PDF/ RawMilkQuality-LetterApr24_2012.pdf).

Indian scenario

In India however, there are no such legal regulatory SCC standards for milk production (though they exist for milk export). Neither the Legislation nor the patrons are concerned about the high SCC levels in milk which reflects the poor farm hygiene, antibiotics residues, and presence of pathogenic organisms and toxins in milk. A through perusal of literature showed varied SCC limits being used to define the health status of the cow in India. Dang and Singh (2006) imply that milk from healthy mammary gland has about 100,000 somatic cells/ml and values higher than this indicates secretary disturbances. The SCC variation in different breeds indicates a subordinate SCC level in the Indigenous breeds compared to the high producing exotic or crossbred animals (Table 3).

Jha *et al*. (1993) in their attempt to catalog SSC as an indication of mastitis, suggested that the cell count more than 5 lakh cells/ml to be considered as the positive indication of mastitis. Recently Sharma *et al*. (2010) have defined that the animals are said to be suffering from subclinical mastitis when no gross abnormalities are present in milk or udder but growth of bacteria on culture media are seen and the SCC ≥ 2 lakh cells/ml of milk. Surprisingly Das *et al*. 2008 in a research to detect latent and sub clinical mastitis in cows and buffalo from different organized herds in Kolkata revealed that a SCC value of 7 lakh cells/ml of milk would be the cut off value for detection of subclinical mastitis. Thus, attempts to define the SCC limits by various researchers in India so far has resulted in a mixed type of outcome and have been summarized in Table 3. The values in table 3 shows a wide variation ranging from 1.22 lakh cells/ml to 15.51 lakh cells/ml of the milk however the major observations revolve around 2 lakh ≥ to 4 lakh cells/ml.

Table 3: Reported values of SCC in milk of animals suffering from Subclinical Mastitis

Species	Breed/Species	SCC	(lakh cells/ml) Reference
Buffalo	Murrha	7.2 ± 0.3	Ghosh *et al.* (2004)
Indigenous Cattle	Sahiwal	6.8 ± 0.2	Ghosh *et al.* (2004)
	Kankrej	2.42	Tarate *et al.* (2012)
	Gir	2.22	Tarate *et al.* (2012)
Cross breed Cattle	Karan Freies	8.3 ± 0.69	Samantal *et al.* (2006)
	Karan Swiss	7.2 ± 0.711.28 ± 0.92	Samantal *et al.* (2006)De and Mukherjee (2009)
	HF x Brown Swiss x Hariyana	10.54 ± 0.7	De and Mukherjee (2009)
	HF x Hariyana	15.51 ± 0.94	De and Mukherjee (2009)
	Crossbreed	3.58 – 4.04	Singh and Garg (2012)
	Crossbreed	2.34 ± 0.44	Gera and Guha (2012)

Legislative policy in India

Recent statistics shows that India's milk and milk products output (milk equivalent) growth is set to outpace the growth in the global market. India will account for nearly half the 226 million ton total milk output of Asia (MOFPI, 2007). This demonstrates that establishment of a SCC standard is of utmost importance and has to be addressed immediately in order to compete in the international dairy markets.

On the contrary, there are various food legislations and enforcement procedures that have been implemented in India. The Food Safety and Standards Authority of India (FSSAI) Expert Group on Milk and Milk Products under NDDB have formulated legislations including Milk and Milk Products Order (MMPO) in the country that are intended to regulate safety and quality of food. But it only includes provisions like rules for production, hygienic conditions, packing, labelling, marketing, penalty etc. According to MMPO, any dairy or premises, handling more than 10,000 litres of milk per day has to obtain the registration from appropriate registering authority. Such dairy units will be subject to inspection to ascertain the hygiene and food safety conditions. Although such regulatory bodies have been established, there are still large lacunae in the functionality of these bodies. As a result, many of such registered dairy units have not come into existence and many others have different installed capacities than the registered ones. Therefore, the actual installed capacity is not known.

As per the MMPO, the registered units should be inspected at least once in a year for complying with the requirements. The MMPO authorities have entrusted the task of inspection to the Export Inspection Council of India (EICI) and the National Productivity Council (NPC) – each registered unit to be inspected by them alternately. However, the annual inspections of the registered units are highly irregular and inadequate (FSSAI, 2009). Ultimately even though such legislations exist in our country, there is a need for effective implementation of the rules and to strengthen the monitoring system.

Alternatively, the Bureau of Indian Standards (BIS) has also formulated and revised standards and guidelines for various dairy products and processes. Emphasis is also laid on hygienic requirements in food processing establishments. Also, the Export (Quality Control and Inspection) Act (1963) provides rules for Good Hygienic Practices and Good Manufacturing practices to be implemented by the dairy businesses intending to export their products (FSSAI, 2009). According to EICI (2008), the cow milk SCC should not be more than 400,000 cells/ ml and SPC (at 30°C) should not be more than 100,000 cfu/ ml for exportation. No such SCC standards however have been formulated for the regular 'milk production-supply-system' within the country.

Recommendations

'Clean White Revolution': After '*White Revolution*'; a '*Clean White Revolution*' needs to be implemented at the grass root level in India as a tribute to the generosity of Dr. Verghese Kurien, "*Father of the White Revolution*". For initiation, some cow side preliminary diagnostic techniques such as California Mastitis test, testing the electrical conductivity of milk can be introduced to farmer's door step through which the milk quality will be monitored at the small holdings. In the international market SCC is used as an index to measure the quality of milk and its suitability for human consumption (Pandey *et al*. 2005). In such stipulations, Indian milk does not counterpart the international standards. Hence, a rigid system to define the milk quality needs to be established and the existing legislations need to be strengthened to attain hygienic milk production. In conclusion, better farm hygiene, training of farmers for early detection of mastitis and introduction of fat+SNF+SCC system for milk acceptance can be implemented to execute a "Clean White Revolution" in India.

Selection of quality Germplasm and breeding of mastitis resistant animals: SCC is widely used for indirect selection of mastitis resistant animal. There exists a reasonably high genetic correlation between SCC and clinical mastitis. Currently Denmark, Sweden and Finland use SCC as an additional source of information in a multi-trait model to increase the accuracy of breeding value estimation for mastitis resistance (Heringstad *et al*. 2000). With the advent of molecular technology, markers and numerous functional candidate genes have been found to be involved in this complex mechanism. This has added to the efficacy of selection of the breeding germplasm.

Initially the research was focused on two genes encoding proteins, *lactoferrin* and *lysozyme* (Seyfert *et al*. 1996). Many researchers however gradually reported the involvement of genes like *Toll Like Receptors* (*TLR)-2, TLR-4* and *TLR-6* (Mariotti *et al*. 2009), *Caspase Recruitment Domain 15* (*CARD-15*) (Pant *et al*. 2007), *β-defensin* (Petzl *et al*. 2007), cytokines like *Interleukins (IL)-6, Granulocyte macrophage-colony stimulating factor* (*GM-CSF*) and *Tumour necrosis factor* (*TNF*)-*α*(Gramsci 2007), *Interleukin 1β (*IL1β), *IL8, chemokine (C-C motif) ligand 5 (CCL5), Complement factor 3 (C3)* (Griesbeck-Zilch *et al*. 2009) and *Chemokine receptors; CXCR2* (Porozynski 2008).

Most extensively studied genes were those encoding the bovine *major histocompatibility complex* (*MHC or BoLA*) molecules, because of their essential role in the induction and regulation of acquired immune response (Rothschild, *et al*. 2000). Aarestrup *et al*. (1995) reported a consistent association of *MHC* alleles *A11* and *A12* (A30) with decreased SCC, whereas alleles *A21* and *A26* were associated to increased cell counts. Also found unfavorable relationships between *A26* and cell counts and between

Table 4: QTLs for mastitis resistance traits

Trait	Chromosome region	Reference
SCS	1, 3, 7, 8, 18, 21 and 23	Schulman *et al.* (2002); Schrooten *et al.* (2000)
Clinical Mastitis	14	Schulman *et al.* (2002)
SCC and Clinical Mastitis	4, 11, 18 and 27	Klungland *et al.* (2001); Schulman *et al.* (2002)

A7(w50) and clinical mastitis, respectively. Mallard *et al.* (1995) also reported that alleles *A7(w50)*, and *A26* were associated with significantly lower antibody response to *S. aureus.*

Some genes that do not directly play a major role in immunity were also reported to show significant association with SCC. Some of them include *S-adenosylhomocysteine hydrolase coding gene* (*AHCY*), *DNA-dependent protein kinase* (*PRKDC*), *Heterogeneous Nuclear Ribonucleoprotein-U* (*HNRPU*), *Osteoclast stimulating factor I* (*OSTF1*) (Schwerin *et al*. 2003), *Butyrophilin* (*BTN1A1*), *the bovine breast cancer 1, early onset gene* (BRCA1) (Yuan *et al*. 2012).

Distinct studies on Quantitative trait loci (*QTL*) have resulted into reporting of *QTLs* on almost all chromosomes, and several were confirmed by at least two independent studies. Such "confirmed" QTL exist on chromosome 1, 3, 7, 8, 18, 21 and 23 for SCC, and on chromosome 14 for clinical mastitis. Few chromosomes (*BTA* 3, 4, 11, 18 and 27) exhibit QTL for both SCC and clinical mastitis (Table 4). Marker data along with the combination of the phenotypic data thus can be used for efficient selection of the bulls and the mothers of the bulls, adding to increased chances of selection of disease free animals and ultimately hygienic milk.

CONCLUSION

With the current system of dairy management structure there resides a constant risk of supply of milk with higher SCC, antibiotic residues, bacterial toxins and inflammatory enzymes. This will directly affect the safety, acceptability and suitability of Indian milk in international market. National Dairy Plan- Phase I (NDP-I) have been implemented in April 2012 with the major emphasis to provide high quality, disease- free semen. An important clause to select the bulls of the dams with lower SCC needs to be incorporated in this plan to initialize a 'Clean White Revolution' in India.

REFERENCES

Aarestrup, F.M., Jensen, N.E. and Ostergard, H. (1995). Analysis of associations between major histocompatibility complex (BoLA) class I haplotypes and subclinical mastitis of dairy cows. *J. Dairy Sci*., **8:** 1684–1692.

Asao, T., Kumeda, Y., Kawai, T., Shibata, T., Oda, H., Haruki, K., Nakazawa, H. and Kozaki, S. (2003). An extensive outbreak of staphylococcal food poisoning due to low-fat milk in Japan: estimation of enterotoxin A in the incriminated milk and powdered skim milk. *Epidemiol. Infect*. **130:**33.

Bunning, V.K., Donnelly, C.W., Peeler, J.T., Briggs, E.H., Bradshaw, J.G. R.G. Crawford, C.M. Beliveau and Tierney, J.T. (1988). Thermal inactivation of Listeria monocytogenes within bovine milk phagocytes. *Appl. Environ. Microbiol*., **54:** 364.

Dang, A.K. and Singh, M. (2006). Udder the most important asset of Dairy industry, its care and management. *Indian Dairyman*, **58:** 57-63.

Das, S.C., Guin, S., Ghosh, A.K., Mitra, J., Das, D.K., Mitra, K. and Das, S.K. (2008). Evaluation of total bacterial count (TBC) and Somatic cell count (SCC) for detection of latent and subclinical mastitis in cow and buffalo. *Indian J. Animal Sci*., **78:** 827-829.

De, U.K. and Mukherjee, R. (2009). Prevalence of mastitis in crossbred cows. *Indian Vet. J*., **86:**858-859.

Directive 92/46ECC Council. (1992). Diario Official de las Comunidades Europeas. European Council, Brussels, Belgium. **268:** 1–34.

Export Inspection Council of India (EICI) **-** Executive instructions on Approval and monitoring of Processing establishments for export of Milk products. Document No. EIC/Milk –Ex. Instructions./ February 2008 / Issue 5.

Food Safety and Standards Authority of India (FSSAI)- Expert Group on Milk and Milk Products under National Dairy Development Board (NDDB). 2009. Base working paper on strategy and action plan for ensuring safety of Milk and Milk Products.

Gera, S. and Guha, A. (2012). Effect of subclinical mastitis on milk biochemical constituents in crossbred cows. *Indian Vet. J.*, **89:** 33-34.

Ghosh, C.P., Nagpaul, P.K. and Shiv Prasad. (2004). Subclinical mastitis in cattle and buffalo and it's impact on somatic cell count and milk composition. *Indian Journal of Dairy Science*, **57:** 329-333.

Gramsci, B. (2007). Cytokine Expression in Milk Somatic Cells during Mastitis in cattle and buffaloes. Anand, Gujarat: Anand Agricultural University. M.V.Sc Thesis

Griesbeck-Zilch, B., Osman, M., Schwerin, C., Bruckmaier, R.H., Meyer, H.H. and Wellnitz, O. (2009). Analysis of key molecules of the innate immune system in mammary epithelial cells isolated from marker- assisted and conventionally selected cattle. *J. Dairy Sci*., **92:** 4621-4633.

Hameed, K.G.A, Sender, G. and Korwin-Kossakowska, A. (2006). Public health hazard due to mastitis in dairy cows. *Animal Science Papers and Reports*, **25:** 73-85.

Heringstad, B., Klemetsdal, G. and Ruane, J. (2000). Selection for mastitis resistance in dairy cattle: a review with focus on the situation in the Nordic countries. *Livestock Production Science*, **64:** 95–106.

Hillerton, J.E. and Berry, E.A. (2004) . Quality of the milk supply: European Regulations Versus Practice, Proceeding of NMC Annual Meeting, pp 39.

Internet: Hemu. (2010). Opportunities And Challenges in The Indian Dairy Industry. Agropedia. http://agropedia.iitk.ac.in/content/opportunities-and-challenges-indian-dairy-industry

Internet: Ministry of Food Processing Industry (MOFPI). (2007). Downloaded from: http://mofpi.nic.in/ContentPage.aspx.CategoryId=142.

Jalali, M., Abedi, D., Pourbakhsh, S.A. and Ghoukasin, K. (2008). Prevalence of Salmonella spp. in raw and cooked foods in Isfahan-Iran. *Journal of Food Safety*, **28:** 442-452.

Jayarao, B.M. and Henning, D.R. (2001). Prevalence of foodborne pathogens in bulk tank milk. *J. Dairy Sci*., **84:** 2157.

Jha, V.C., Thakur, R.P., Yadav, J.N. and Rai, L.B. (1993). Epidemiological investigation of subclinical bovine mastitis in the eastern hills of Nepal. *Vet. Res. Kathmandu*, **8:** 35-39.

Karimuribo, E.D., Lughano, J.K., Robinson, H.M., Kapaga, A.M., Sindato, C. and Kambarage, D.M. (2005). Studies on mastitis, milk quality and health risks associated with consumption of milk from pastoral herds in Dodoma and Morogoro regions, Tanzania. *J. Vet. Sci*., **6:** 213–221.

Karmakar, K.G. and Banerjee, G.D. (2006). Opportunities and challenges in the Indian dairy industry. Technical Digest. **9:** 24-27. Retrieved 17 June 2011, from http://www.nabard.org/fileupload/DataBank/TechnicalDigest/ContentEnglish/issue9td-6.pdf

Keefe G.P. (1997). Streptococcus agalactiae mastitis: a review. *Canadian Veterinary Journal*, **38:** 429-437.

Klungland, H., Sabry, A., Heringstad, B., Olsen, H.G., Gomez-Raya, L., Vage, D.I., Olsaker, I., Odegard, J., Klemetsdal, G., Schulman, N. and Lien, S. (2001). Quantitative trait loci affecting clinical mastitis and somatic cell count in dairy cattle. *Mamm. Genome*, **12:** 837–842.

Ma, Y., Ryan, C., Barabano, D.M., Galton, D.M., Rudan, M.A. and Boor, K.J. (2000). Effects of somatic cell count on quality and shelf-life of pasteurized fluid milk. *J. Dairy Sci*., **83:** 264-274.

Mallard, B.A., Leslie, K.E., Dekkers, J.C.M., Hedge, R., Bauman, M. and Stear, M.J. (1995). Differences in bovine lymphocyte antigen associations between immune responsiveness and risk of disease following intramammary infection with Staphylococcus aureus, *J. Dairy Sci*., **78:** 1937–1944.

Mariotti, M., Williams, J., Dunner, S., Valentini, A. and Pariset, L. (2009). Polymorphisms within the Toll-Like Receptor (TLR)-2, -4, and -6 Genes in Cattle. *Diversity,* **1:** 7-18

Murinda, S.E., Nguyen, L.T., Ivey, S.J., Gillespie, B.E., Almeida, R.A., Draughon, F.A. and Oliver, S.P. (2002). Molecular characterization of Salmonella spp. isolated from bulk tank milk and cull dairy cow fecal samples. *J. Food Prot*., **65:**1100.

Murinda, S.E., Nguyen, L.T., Nam, H.M., Almeida, R.A., Headrick, S.J. and Oliver, S.P. (2004). Detection of sorbitol-negative and sorbitol-positive Shiga toxin-producing Escherichiamcoli, Listeria monocytogenes, Campylobacter jejuni and Salmonella spp. in dairy environmental samples. *Foodborne Pathogens and Disease*, **1:** 97.

National mastitis council (NMC) Board of director's report. (2005). Human health risks associated with high somatic cell count milk. Symposium summary of 44th Annual Meeting in Orlando. p. 1-3. Florida.

National mastitis council. (2001). Normal and Abnormal Raw Milk Based on SCC and Signs of Clinical Mastitis. NMC Guidelines.

Oliver, S.P., Jayarao, B.M. and Almeida, R.A. (2005). Foodborne pathogens, Mastitis, Milk quality, and Dairy Food Safety. NMC Annual Meeting Proceedings 2005. pp 3-27.

Ombui, J.N., Arimi, S.M. and Kayihura, M. (1992). Raw milk as a source of enterotoxigenic Staphylococcus aureus and enterotoxins in consumer milk. *East Afr. Med. J*., **69:**123.

Pandey, P., Pandey, V. and Singh, J. (2005). Somatic cell count in relation to milk production, milk composition and subclinical mastitis: a review. *International Journal of Cow Science*, **1:** 27-32.

Pant, S.D., Schenkel, F.S., Leyva-Baca, I., Sharma, B.S. and Karrow, N.A. (2007). Identification of single nucleotide polymorphism in bovine CARD 15 and their association with health and production traits in Canadian Holsteins. *BCM Genomics,* **8:** 421 (DOI- 10.1186/1471-2164-8-421).

Pasteurized Milk Ordinance (PMO). (1995). Grade "A" Pasteurized Milk Ordinance. U.S. Dept. of Health and Human Services, Washington, DC.

Paton, J.C. and Paton, A.W. (1998). Pathogenesis and diagnosis of Shiga toxin-producing Escherichia coli infections. *Clin. Microbiol. Rev*., **11:** 450.

Petzl, W., Holm Zerbe, Gunther, J., Yang, W., Nurnberg, G. and Schuberth, H.J. (2007). Escherichia coli, but not Staphylococcus aureus triggers an early increased expression of factors contributing to the innate immune defense in the udder of the cow. *Vet. Res*., **39:**18.

Porozynski, R. (2008). Detection of genetic polymorphism associated with mastitis. Netherland: University of Waginin. Thesis.

Prescott, S.C. and Breed, R.S. (1910). The determination of the number of body cells in milk by a direct method. *J. Infect. Dis*., **7:** 632.

Pyorala, S. (2003). Indicators of inflammation in the diagnosis of mastitis. *Vet. Res*., **34:** 565–578.

Rothschild M.F., Skow, L. and Lamont, S.J. (2000). The major Histocompatibility Complex and it's role in disease resistance and immune responsiveness. Axford R.F.E., Bishop S.C., Nicholas F.W., Owen J.B (Eds.), Breeding for disease resistance in farm animals. CAB International, pp. 73–105.

Samanta, A., Prasad, S. and Ghosh, C.P. (2006). Incidence of subclinical mastitis in Karan Swiss and Karan Fries crossbred cows. *Indian J Dairy Sci*., **57:** 329-333.

Schrooten, C., Bovenhuis, H., Coppieters, W. and van J.A.M. Arendonk. (2000). Whole genome scan to detect quantitative trait loci for conformation and functional traits in dairy cattle. *J. Dairy Sci*., **83:** 795–806.

Schulman, N.F., Moisio, S.M., Koning de, D.J., Elo, K., Maki-Tanila, A. and Vilkki, J. (2002). QTL for health traits in Finnish Ayrshire cattle. Proc. 7th World Congr. Genet. Appl. Livest. Prod. p. 09-19. Montpellier, France.

Schwerina, M., Czernek-Schäfera, D., Goldammera, T., Katab, S.R., Womackb, J.E., Pareekc, R., Pareekc, C., Walawskic, K. and Brunner, R.M. (2003). Application of disease-associated differentially expressed genes – Mining for functional candidate genes for mastitis resistance in cattle. *Genet. Sel. Evol*. **35:** S19–S34.

Seyfert, H.M., Henke, M., Interthal, H., Klussmann, U., Koczan, D., Natour, S., Pusch, B., Senft, B., Steinhoff, U.M., Tuckoricz, A. and Hobon, G. (1996). Defining candidate genes for mastitis resistance in cattle: the role of lactoferrin and lysozyme, *J. Anim. Breed. Genet*. **113:** 269–276.

Sharma, N., Pandey, V. and Sudhan, N.A. (2010). Comparison of some indirect screening tests for detection of subclinical mastitis in dairy cows. *Bulg. J. Vet. Med.*, **13:** 98.

Sharma, N., Singh, N.K. and Bhadwal, M.S. (2011). Relationship of somatic cell count and mastitis: An overview. *Asian-Aus. J. Anim. Sci*., **24:** 429-438.

Singh, M. and Garg, A. (2012). Milk compositional changes in subclinical and clinical mastitic milk of cross bred cows. *Indian Veterinary Journal*, **89:** 66-68.

Stabel, J.R. (2005). Paratuberculosis and Crohn's disease. Proc. 44th NMC Annual Meeting. Orlando, FL. pp 36-40.

Tarate, S.B., Jadhav, P.V., Ghadhigaonkar, D.D., Khade, P., Bhatt, V., Khan, A., Joshi, C.G. and Rank, D.N. (2012). Evaluation of breed- dependent variation in microbial load during scbclinical mastitis in cattle using Real Time PCR. *Indian J Dairy Sci*. **65:** 60-65.

Thoen, C., LoBue, P., DeKantor, I. (2006). The importance of Mycobacterium bovis as a zoonosis. *Vet. Microbiol*., **112:** 339-345.

Van Kessel, J.A., Karns, J.S., Gorski, L., McCluskey, B.J. and Perdue, M.L. (2004). Prevalence of Salmonellae, Listeria monocytogenes and fecal coliforms in bulk tank milk on US dairies. *J. Dairy Sci*., **87:** 2822.

Winter, P., Schilcher, F., Bago, Z., Schoder, D., Egerbacher, M., Baumgartner, W. and Wagner, M. (2004). Clinical and histopathological aspects of naturally occurring mastitis caused by Listeria monocytogenes in cattle and ewes. *J. Vet. Med. B*., **51:** 176.

Yuan, Z., Chu, G., Dan, Y., Li, J., Zhang, L., Gao, X., Gao, H., Li, J., Xu, S. and Liu, Z. (2012). BRCA1: a new candidate gene for bovine mastitis and its association analysis between single nucleotide polymorphisms and milk somatic cell score. *Mol Biol Rep*., **39:** 6625-31.