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Udder Health Maintenance to Augment Milk Production in Dairy Cattle: A Review

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ABSTRACT

The burning problems of udder health /subclinical mastitis (SCM) in dairy cattle is considered as a worldwide silent threat which is major reasons for low yield and poor quality milk and causes substantial economic loss. The present work was conducted at ICAR-NDRI, ERS, Kalyani (WB) through a project (2017-2020). The article's aim is to review important advances in udder health maintenance to ameliorate SCM for higher quantity and quality milk production. Many researchers worked to identify effective practices to control SCM caused by *Streptococcus agalactiae* and *Staphylococcus aureus*. Worldwide different researchers aimed to achieve better udder health and focused to detect SCM, mechanisms associated with infection, differentiating between clinical and subclinical stages, invent suitable diagnostic tests, understand exposure time, recognize specific characteristics of pathogen and establishing scientific milking procedures, *etc*. Establishment of standard operative programs, as discussed in this paper, resulted in better udder health maintenance. In changing climatic scenario and varying farm management practices globally researchers worked to redefine procedures to control SCM caused by different biotic and abiotic agents. Although, researchers achieved significant advances in SCM management, however changing herd structure and increased milk demand indicates that SCM /udder health will be one of the major issues to be dealt by scientists, entrepreneurs, dairy workers.

Key words: Dairy cow, Quality milk production, Sub-clinical mastitis, Tropics and sub-tropics, Udder health.

The udder health/subclinical mastitis in cattle is one the major reasons for low yield and poor quality milk production and ranks first among the diseases that cause substantial loss to farmers of tropics and subtropics. This silent problem causes higher economic losses in the globe. Radostits *et al.* (2000) defines mastitis as "inflammation of parenchyma of mammary glands which is characterized by physical, chemical and usually bacteriological changes in milk and pathological changes in glandular tissues". Consumer preference for better quality milk and milk products has increased due to their enhanced knowledge for health concerns of mastitic milk. They, however, do not compromise with quality standards of the milk and milk products. Researchers continued to study methods to convince dairy entrepreneurs to adapt improved practices against SCM control (Valeeva *et al.*, 2007; Singh *et al*., 2020a; Singh *et al.*, 2020b; Singh *et al*., 2020c; Singh *et al*., 2020d).

The authors of this article carried out present work in ICAR-NDRI, ERS and Kalyani (WB) during 2017 to 2020 through a project. The article's aim is to highlight the important advancements in udder health maintenance to ameliorate SCM for higher quantity and quality milk production from dairy cattle.

Impact of SCM/ udder health

Subclinical mastitis has arisen as a global threat to dairy producers as it imparts negative effects (Fig 2) on different performances of animals in almost every country of tropical and subtropical climatic conditions. Developed countries also suffer high financial losses which ultimately leads to culling, poor milk production, compromised udder health status and reduced reproductive performances of farm animals (Laxmi, 2016). Besides leading to heavy losses in milk production, the SCM animals may remain potent source of infection to other animals in the herd (Swami *et al.,* 2017; Singh *et al*., 2020e; Garai *et al*., 2021, Singh *et al*, 2021a) and causing poor udder health maintenance throughout lactation.

Causative agents responsible for SCM

Different investigations have shown that SCM cases ranged from 19 to 83% in cows (Bhakat *et al.,* 2016). Potential sources for sub-clinical mastitis in dairy animals have been presented in the Fig 1. For many years, *Streptococcus agalactiae* and *Staphylococcus aureus* were seen as the major causal micro-organisms for SCM in dairy animals. This information formed the basis for understanding mastitis in a better way. Different etiological factors associated with SCM cases in dairy cattle have been suggested (Fig 3) to

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be important in case of SCM (Sharma and Maiti, 2012). Though numerous bacteria are identified as causative agents for IMI. SCM cases are reported to be more predominant by 15-20 times than clinical mastitis cases in tropics and subtropics. The streptococci were identified as most prevalent bacteria, staphylococci (most likely *Staph. aureus*) were responsible for more than one-fifth of such cases. The occurrence of large numbers of bacteria in milk was an obvious public health issue. In a report of a researcher (Varshney and Naresh, 2004), *Streptococcus dysgalactiae* was major organism observed from SCM cases in cows followed by *Staphylococcus aureus* and others. Scientist (Kumar *et al.,* 2009) remarked that while more than twenty types of infections can lead to mastitis; at least 99% are of *Str. agalactiae* origin and others include streptococci, staphylococci and bacillary mastitis (including coliform, pseudomonas *etc*). The majority of cases were caused by only a few common bacterial pathogens, including different species of *Staphylococcus*, *Streptococcus*, Coliforms and *Actinomyces pyogenes* (Makovec and Ruegg, 2003). During year 1994 to 2001, *Strep. agalactiae* and *Staph. aureus* isolated from different samples of milk given to Wisconsin Veterinary Diagnostic Laboratory showed a dramatic decline (Makovec and Ruegg, 2003) and gram-negative pathogens were observed in overall results of milk samples from cows showing clinical symptoms (Oliveira *et al.,* 2013).

Diagnosis of SCM

Potential battery tests for diagnosis of SCM and management strategies for its melioration is presented in Fig 4. As per the recommendations of International Dairy Federation (IDF), microbiological status of separate udder quarters and somatic cell counts were found as common and reliable tests to detect alterations in milk constituents as a result of an inflammatory process (Sudhan and Sharma, 2010). Researchers (Kumari *et al.,* 2018) executed different tests for diagnosis of SCM in tropical Indian conditions *viz*. modified California mastitis test (MCMT), modified white side test (MWST), surf field mastitis test (SFMT), electrical conductivity (EC), pH test and laboratory test for milk quality *viz*. methylene blue reduction test (MBRT). Although thresholds used for defining mastitis were highly variable (reaching 3,000,000 cells/ml), an early comparative study noted that most of milk samples from apparently healthy udder contained <100,000 cells/ml and identified approximately 200,000 to 250,000 cells/ml as a reasonable threshold for discriminating healthy and abnormal milk samples. For many years, the threshold of 500,000 cells/ml combined with isolation of >200 CFU/ml of pathogenic bacteria was commonly used to define subclinical mastitis (Kuipers *et al.,* 2016). The development of faster and more automated methods to somatic cells count (SCC) in milk was an area of intense research. With progress in methods for measuring SCC, different regulatory authorities started setting threshold limits for bulk tank SCC. The recent era of managing udder health using monthly SCC testing of individual cows was initiated and SCC values came into routine use as a mastitis management tool (Reneau, 1986).

Dry cow SCM /udder health

Scientists (Bhakat *et al.,* 2019) stated that IMI in dry cow causing SCM is one of the major constraints for dairy operations at tropical regions. Researchers (Neave *et al.,* 2017) suggested for after dry period disinfection of teats prior to milking, wiping with separate towels, use of sanitized milking gloves and teat cups. They advocated use of antibiotic therapy at dry cow to further reduce infections. Scientists (Bhakat *et al.,* 2016) reported that significantly ($P<0.01$) higher SCC in IMI cows than in non-IMI Jersey crossbred dry cows. National Mastitis Council (NMC) recommended "5-Point Plan" for mastitis (subclinical and clinical) control program (Fig 5) which should be started from dry cow itself. Dairy cattle may be susceptible to IMI during dry period. Management of dry cow therapy (DCT) has been proposed as an effective way to control mastitis. However, usage of antibiotics for dry cows has been reported to cause adverse effects on both human and animal health.

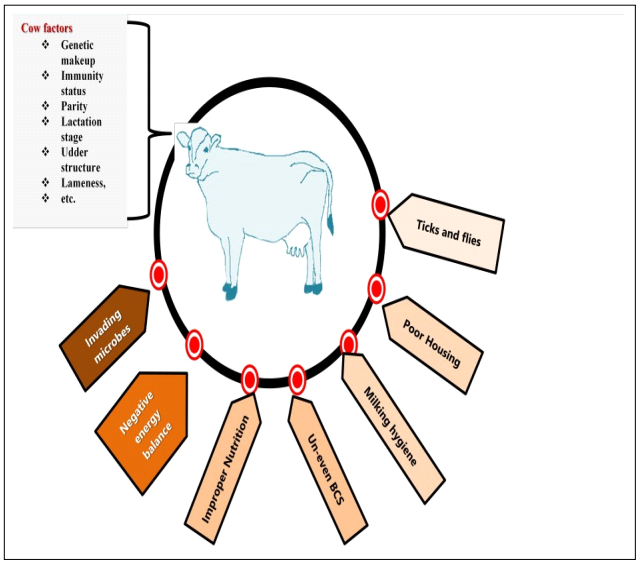

Fig 1: Potential sources for sub-clinical mastitis in dairy animals.

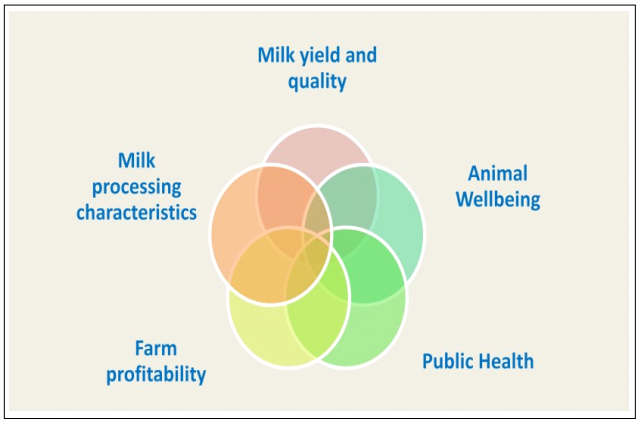

Fig 2: Concerning effects of SCM.

Nevertheless, researchers (Kumari *et al.,* 2019a) reported that intra-mammary therapy of dry cow with suitable herbal preparations along with internal and external teat sealant may be another management practice to prevent post-calving mastitis cases. In addition to it, they remarked that herbal measures for fly control was effective ($p<0.01$) for lower SCM cases. Maintenance of proper body condition score (BCS) from drying off to lactation period, through proper energy provision in the diet by changing concentrate amount has been reported to control SCM cases (Singh *et al.,* 2020d; Singh *et al*., 2020g). Such farmer friendly management strategies can be considered as an alternative and novel approach for controlling mastitis and maintenance of udder health in dairy cows. Research finding on fly control measures in hot humid tropical region and dry period duration were effectively arrest the transmission of pathogens causing SCM and maintaining good udder health throughout lactation (Bhakat *et al.,* 2020a and 2021).

Lactating cow SCM / udder health

The first emphasis was on treatment of IMI caused by *Strep. agalactiae* and *Staph. aureus*. Though the use of antibiotics to treat mastitis was common, the limitations of therapy were well known. Researchers (Trinidad *et al.,* 1990) reviewed for different factors that contribute to therapeutic success of, cow, pathogen and treatment of animals infected with *Staph. aureus* again emphasized that only specific animals responds to therapy utilising antibiotics. As coliform caused mastitis was identified as an emerging problem, researchers began to evaluate unique challenges in treating these infections. Though it was identified that many cases were not severe, defining effective treatment of per-acute and acute cases was a high priority and almost no controlled studies were available to guide treatment decisions. Until 1990s, few trials were performed to validate recommendations for the treatment of coliform mastitis but initial experiments indicated that antimicrobial

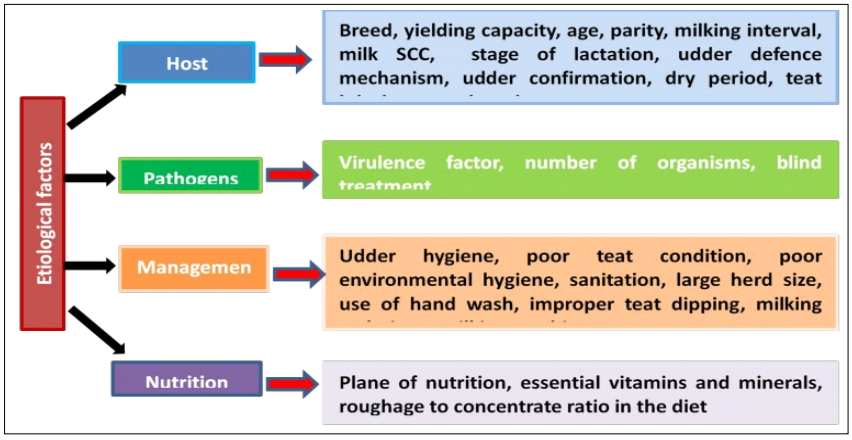

Fig 3: Different etiological factors associated with SCM cases in dairy animals.

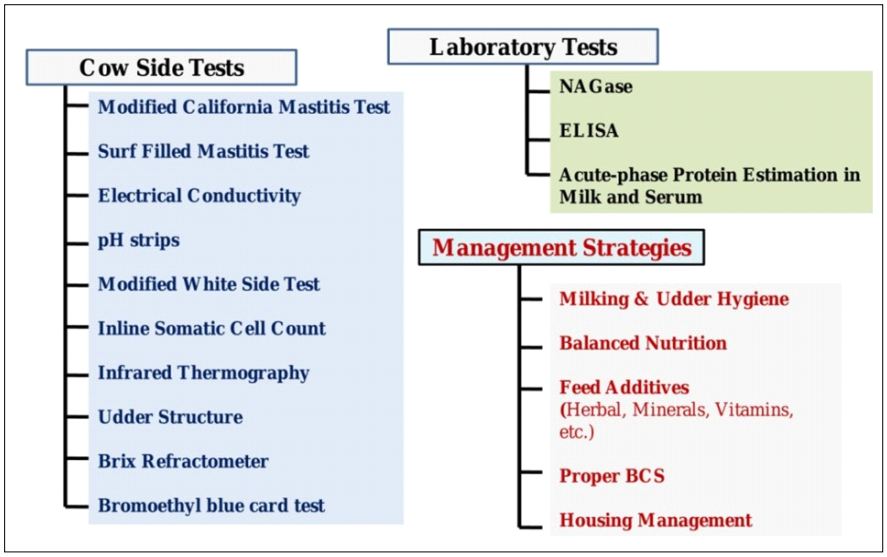

Fig 4: Potential battery tests for diagnosis of SCM and management strategies for its amelioration.

therapy did not improve outcomes of mastitis caused by *Escherichia coli* (Barkema *et al.,* 2006) and challenged prevailing concepts of how mastitis should be treated. The important role of host immune response in clearance of coliform infections (rather than antibiotic therapy) has been highlighted by researchers (Burvenich *et al.,* 2007). Furthermore, scientist (Ruegg, 2017) indicated that with the increasing pressure to reduce antibiotic usage on dairy farms, additional research is needed to develop evidence-based line of alternate treatment with herbal applications which limit the use of antibiotics for maintaining good udder health throughout lactation of dry cow.

Control of SCM for better udder health maintenance

SCM control and udder health maintenance in both manual and automatic milking settings remain a questionable task. Role of competent attendant in managing udder health remains necessary today as it was in earlier decades (Hovinen and Pyorala, 2011).

Scientific management practices of milking operation to curb SCM cases

Researchers (Bharti *et al.,* 2017) observed more SCM cases in hind quarter than fore quarter of udder parts and remarked from their study that udder structure and it's type may significantly ($p<0.01$) cause IMI development and SCM in crossbred cows. A management strategy which reduces bacterial load over teat ends may be one of the measure for SCM control and maintaining good udder health. Pre-milking sanitation is always recommended by washing udders and teats with water or disinfectants, but studies conducted by researchers (Galton, 1988) indicated that pre-milking teat sanitizations dramatically lowered IMI cases by *Streptococcus uberis*. Researchers (Bhakat *et al.,* 2015) recommended adoption of hygienic milking procedures at each milking. Milk processors prefer the milk with low bacterial contamination, sediments, or residues which in turn is seen to encourage the adoption of pre milking teat preparations.

Automatic milking procedure to control SCM

Researchers (Bharti *et al.,* 2015a; Bharti *et al*., 2015b) suggested that suitable machine milking may alter IMI and SCM cases along with considerable changes in milk constituents. Researchers found that working of different parts of milking machines should be uniformed to lower the chances of new IMI (Baxter *et al.,* 1992). Researches lead down the roadmaps to understand the concept of milking machines which influences the physiology and milk let down along with the occurrence phenomenon of sub clinical mastitis cases. Scientists (Bhakat *et al.,* 2017a) reported that IMI in dairy animals can be significantly controlled by machine milking as compared to that in the case of hand milking when proper hygiene measures adopted. Researchers (Thompson, 1981) suggested for judicious follow ups of data generated through various sensors over milking machines. With the progression of time, use of automatic milking systems increased in many regions however, data so obtained from these machines need to be utilized in justified and effective ways (Jacobs and Siegford, 2012). While, researchers (Spencer, 1998) found that machine milking may lead to new IMI cases by becoming contagious media for other herd mates and also, it may lead to unwanted changes in teat morphology. However, very promising ill effects of machines for milking were not reported (Paul and Bhakat, 2018) this might be due to proper hygienic methods followed during complete milking operations. Scientists (Bhakat and Dutta, 2014; Mandal *et al.,* 2021; Singh, 2021; Singh *et al*., 2020i) reported that defective floor type of dairy cow shed with automatic milking provision can also affect udder health adversely in tropical climate and ridge ventilation can help to increase milk production with better udder health at lower Gangetic tropical climate.

BCS, genetic selection and animal behaviour to control SCM

Researchers (Paul *et al.,* 2019) reported that elevated levels SCC in milk of jersey crossbred cows having under or over BCS. Scientists (Paul *et al.,* 2020) utilized BCS technique though USG (ultra-sonography) for crossbred cows and suggested that consideration of BCS at calving can be recommended as a reliable criterion for selecting cows as a higher milk producing animal having improved udder health. Researchers (Shook and Schutz, 1994) remarked that genetic susceptibilities towards SCM may cause IMI in different animals belonging to same families. Selections for mastitis resistance properties in animals gradually progressed in US farms (Vukasinovic *et al.,* 2017). Scientists (Bharti and Bhakat, 2019) investigated that increasing post milking standing period more than 35 minutes through management interventions such as allocation of freshly chopped fodders just after milking may reduce SCM cases and maintain good udder health throughout lactation.

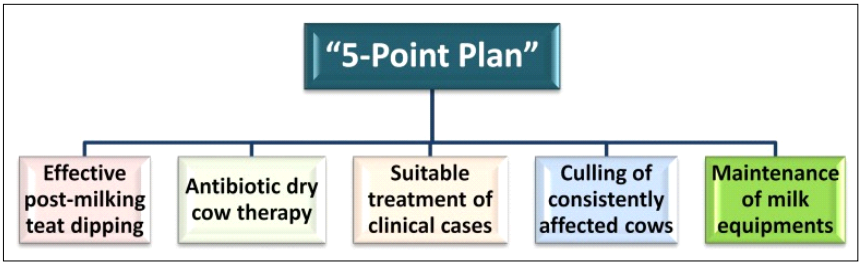

Fig 5: The "5-Point Plan" recommendations of NMC for mastitis control program.

Hygiene and nutritional strategies to control SCM

Researchers (Paul *et al.,* 2018; Langer *et al.,* 2014 and Bhakat *et al.,* 2017b) remarked that higher SCC was very critical as higher SCC in milk disrupts mammary epithelial and reduces milk quality ultimately leading to poor returns. Scientists (Garai *et al.,* 2017) found that small scale dairy farmers with 2-3 animals had higher SCM cases due to poor hygiene in tropical villages of West Bengal and in these villages most of the small category farmers maintained 1-3 dairy cows. Researchers (Smith *et al.,* 1985) suggested that high density concentrate based feeding may also lead to SCM cases but associations of nutrition were not observed until scholars (Weiss *et al.,* 1990) investigated in their study that Vit E and Selenium deficiency in dairy animals were the cause and prolongation for clinical mastitis. Scientists (Kumari *et al.,* 2019b) investigated that oral supplementation of sodium tri citrate may reduce SCM in hot humid regions. Studies conducted by different researchers revealed the importance of such vital nutrient in the working of neutrophils in dairy animals (Hogan *et al.,* 1993; Singh *et al.,* 2020f). Researchers (Wathore and Bhakat, 2016; Singh and Bhakat 2019; Singh *et al*., 2020h) observed that dietary supplementation of Vitamin E to cow may potentially reduce SCM in tropical climate and helps for maintaining better udder health status during lactation period.

CONCLUSION

As farm sizes grew and management intensified, researchers identified emergence of opportunistic pathogens that often led to sub-clinical mastitis/poor udder health status. Recent advances in milking management and milking machines have resulted in wide adoption of scientific functioning of milking systems and standardized milking procedures. Limitations of antimicrobial drugs have been identified but use of antibiotics to treat cows affected with some microbes remains an important issue for SCM control. The globalization has a great impact on milk quality standards. The ability to participate in global dairy trade is increasingly dependent on production of milk that meets the best quality standards which are defined by milk processors rather than government regulators. To ensure sustainability of dairy farming, necessary infrastructures, policies and trainings should be provided to dairy entrepreneur for controlling SCM to obtain better udder health for overall milk production augmentation in dairy cattle.

Conflict of interest

All authors declare that they have no conflict of interest.

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