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Lactose as an Indicator of Udder Health Status under Modern Dairy Production

Aamir Sharif
Government Poultry Farm, Bahawalpur, Livestock and Dairy Development Department, Punjab, Lahore – Pakistan; & Project Implementation Team, Punjab Economic Opportunities Program (Livestock Component), District Bahawalpur, Livestock and Dairy Development Department, Punjab, Lahore-Pakistan.
Email: aamirsharifcheema@gmail.com

Muhammad Umer
Department of Animal Reproduction,
Faculty of Veterinary Science, Lasbela University of Water, Agriculture and Marine Sciences, Uthal, Lasbela – Pakistan.

Tanveer Ahmad
Department of Clinical Medicine and Surgery, University of Agriculture, Faisalabad – Pakistan

Muhammad Qamar Bilal
Department of Livestock Management, University of Agriculture, Faisalabad – Pakistan.

Ghulam Muhammad
Department of Clinical Medicine and Surgery, University of Agriculture, Faisalabad – Pakistan.

***Abstract* – Mastitis is very important disease of dairy animals. The sub-clinical mastitis hampers milk quality and quantity. The increased somatic cell count and microbial count of milk are commonly used indicators of udder intra-mammary infections in dairy animals. Indirect indicators include California Mastitis Test, Surf Field Mastitis Test, Sodium Hydroxide Test, Catalase test etc. The modern dairy production relies on the estimation of somatic cell count, bacterial count and analysis of milk lactose to determine the quality of milk for dairy processing. Lactose (milk sugar) is reliable indicator of udder health status in modern dairy production. The developing countries are facing the challenge of sub-clinical mastitis and through early detection of mastitis based on indicators of mastitis like milk lactose can also serve the diagnosis of mastitis in dairy animals.**

***Keywords* – Mastitis, Lactose, Somatic Cell Count, Milk Production, Milk Quality.**

I. INTRODUCTION

The dairy industry of Pakistan is composed of mainly cattle and buffaloes contributing 95% of total milk production in the country (Allore, 1993). Nili-Ravi buffalo is a dynamic breed under the field conditions of Pakistan and is ranked as the best dairy breed of the world. Nili-Ravi being the finest milk breed of the world is the major ray of hope for planners, dreaming to make this country self sufficient in animal protein sources (Bilal and Ahmad, 2004). Besides poor genetic potential, poor management and nutrition, and sub-optimal health of milch animals, mastitis is among the leading factors responsible for the shortfall of milk supply in Pakistan. (Bilal *et al.*, 2004).
Mastitis is a serious disease in dairy animals causing great economic losses due to reduction in milk yield as well as lowering its nutritive value. Mastitis is the inflammation of parenchyma of mammary glands regardless of the cause and characterized by tissue changes leading to progressive damage to the secretory apparatus and resulting in loss of milk yield. Generally mastitis occurs in two forms i.e clinical or overt and sub-clinical or hidden (Radostitis *et al.,* 2000).

Sub-clinical mastitis is 15 – 40 times more prevalent than clinical mastitis and causes high economic losses in most dairy herds (Schultz *et al.*, 1978). In addition to causing colossal economic losses to farmers, the disease is important from consumers' and processors' point of view. The milk from the affected animals may harbour the organisms potentially pathogenic for humans (Barbano, 1989). Mastitis affects the milk quality in terms of decrease in protein, fat, milk sugar (lactose) contents and increase in somatic cell count. The processing of such milk results in substandard and sub-optimal output of finished fermented products like yogurt, cheese etc. The shelf life of processed milk is also reduced (Urech *et al,* 1999).

The criteria used for determining whether milk is acceptable for processing or not (for human consumption) is the level of somatic cells and lactose contents under modern dairying. Somatic or body cells in milk are of two types, namely, sloughed epithelial cells from the udder cell population and leukocytes from the blood. The epithelial cells are present in the normal milk as result of normal breakdown and repair process while leukocytes enter in milk from blood, being attracted by chemical substances released from injured mammary tissue. Most somatic cells are primary leukocytes, which include macrophages, lymphocytes and neutrophils. Studies identifying the cell types in milk have shown that epithelial cells range from 0 to 7 % of somatic cell count (SCC) but main increase in total count occurs due to the influx of neutrophils into the milk (Miller and Paape, 1985). The level of somatic cell increases with the severity of mastitis.

Lactose, the important disaccharide present in milk is formed by the mammary glands from glucose and galactose. The composition of diet or blood sugar level does not alter the lactose contents of milk. Lactose contents of milk decreases with the severity of mastitis as indicated by SCC, so an inverse relationship exists between severity of mastitis and lactose content of milk. The approximate percent estimation of milk lactose in dairy buffalo is 5.0% (Bilal and Ahmad, 2004).

The present paper reviews the significance of use of lactose as an indicator of udder health in the detection of mastitis in dairy production.

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II. Common Pathogens of Mastitis

The most common pathogens of mastitis are *S. aureus* and *Streptococcus agalactiae.* Sharif *et al.* (2007) isolated *S. aureus* (50%), *Str. agalactiae* (15%), mixed growth of *S. aureus* plus *Str. agalactiae* (15%) and coagulase negative staphylococci (CNS) (20%) from quarter milk samples of buffalo with positive score of Surf Field Mastitis Test (SFMT), whereas gram negative cocco-bacilli (10%) and mixed growth (10%) was observed in the quarter milk samples with negative score of SFMT, while 80% of quarter samples with negative score of SFMT showed no growth on microbiological examination of milk. Other etiological agents less frequently encountered include *Pseudomonads, Nocardia, Mycoplasma* and yeast (McDonald, 1979). The dairy industry is encountered with both contagious and environmental pathogens. The contagious pathogens are normally transmitted from affected to healthy buffaloes through contact. While environmental pathogens are found in the surrounding of animals on beddings, soil, feed etc and are transmitted to healthy quarters through contact with infected environment. Similarly both major and major pathogens are commonly isolated from the affected quarters of dairy animals and render the milk unfit for human consumption.

III. Prevalence of Mastitis

There is high rate of prevalence of mastitis in dairy animals. Sharif and Ahmed (2007) determined 37.75% prevalence of sub-clinical mastitis in dairy buffaloes on quarter basis and observed 51% prevalence of sub-clinical mastitis on animal basis in dairy buffaloes in and around Faisalabad (Pakistan). Bachaya *et al.* (2005) determined very high prevalence (77.98%) of sub-clinical mastitis in buffaloes based on SFMT in Attock district of Punjab (Pakistan). The high rate of mastitis in animals is due to lack of mastitis control program. The most common reasons of high rate of mastitis in dairy animals are unhygienic environment, lack of dry cow therapy, lack of pre and post milking dipping of teats, lack routine diagnosing of sub-clinical mastitis, lack of proper treatment of mastitis cases and non-culling of chronically affected animals. The incidence and prevalence of mastitis can be decreased in buffaloes through adaptation of efficient management program in developing countries (Sharif *et al.,* 2009).

IV. Diagnosis of Sub-Clinical Mastitis

The detection of mastitis is generally based upon the indicators of inflammation as a result of intra-mammary infections (IMIs). Significant changes occur in the parenchyma of udder and in the milk in response to IMI. These changes include infiltration of leukocytes (referred to as somatic cells) and increased vascular permeability. Hydrolysis of milk proteins by the hydrolytic enzymes and the oxidative substances released from phagocytes result in change in the milk composition, alteration in milk pH, ionic solutes and other milk components by phagocytes. As mastitis is frequently sub-clinical (hidden / overt) a number of tests have been developed for detecting mastitis. Most tests estimate the Somatic Cell Counts (SCC) of milk, as an indicator of inflammation of udder. A variety of tests are available to determine the presence or absence of sub-clinical mastitis based on SCC and resultant abnormalities in chemical composition of milk are usually recognized by laboratory examination. Isolation and identification of mastitis pathogens is important but necessary laboratory facilities are not available at most of the veterinary hospitals of Pakistan. So, bacteriology of milk can not be adopted as routine test to detect mastitis. Therefore, indirect test for detection of at sub-clinical mastitis are carried out in the field at farmer level. The detection of mastitis at an early sub-clinical phase can avoid the therapeutic failure in mastitis and economic losses to the dairy farmers. Reliable tests for indication of inflammation of udder are necessary to identify quarters with intra-mammary infections (IMI). Early diagnosis of sub-clinical mastitis is important because changes in the udder tissue take place much earlier than they become apparent.

V. Udder Health and Milk Lactose

The lactose content of milk from infected glands is typically low. Mastitis results in the reduced synthetic ability of mammary gland. Decreased lactose content in milk is the indication of mastitis. Change in lactose can also reveal change in SCC of buffalo milk. Lactose, the important disaccharide present in milk is formed by the mammary glands from glucose and galactose. The composition of animal feed and diet or level of sugar in blood does not alter the lactose contents of milk. Lactose contents of milk decrease with the severity of mastitis as indicated by SCC, so an inverse relationship exists between severity of mastitis and lactose content of milk. The impaired lactose production is likely related to varied osmotic equilibrium caused by mastitis. Sodium Chloride (NaCl) enters milk from blood as a result of changed permeability and increases the osmotic pressure of milk. The osmotic pressure of milk is brought into equilibrium with blood by decreasing in the secretion of lactose. As the glandular tissue of udder is damaged due to mastitis the synthesis of lactose is decreased. Decreased concentration of lactose in cow milk results from increased permeability of tissues between milk duct of udder and blood (Schulz *et al.*, 1998). Lactose in milk can be analyzed through Colorimetric, Infrared and Gravimetric (Titration method) method.

Relationship of Milk Lactose With

A. Milk Somatic Cell Count

The lactose and somatic cell count are negatively correlated. The increasing SCC results in decrease in lactose content of milk and decrease in milk SCC results in increase in lactose content of milk. Reichmuth (1975) graphically presented that as SCC exceeded 150,000 the

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concentration of lactose decreased. Several studies have reported decrease in lactose concentration in the milk of cows presenting high SCC (Miller *et al.*, 1983; Rogers *et al.*, 1989; Auldist *et al.*, 1995). A negative correlation was observed between the percentage of lactose in milk and the severity of the disease (Miller *et al.*, 1983). According to Miller *et al.* (1983), mastitis determines a continuous reduction in lactose concentration in milk with SCC above 100,000 cells/ml. Hirpurkar *et al.* (1987) estimated lactose of milk as an aid in the diagnosis of mastitis in cows and buffaloes. Lactose levels are reduced in milk samples positive for CMT. The reduction in lactose contents in milk presenting high SCC may be due to the passage of lactose from milk into blood (Shuster *et al.*, 1991). Lactation stage and season have no significant effects on mean milk lactose content. A negative correlation exists between somatic cell count and milk lactose content in normal and mastitic milk (Chandra, 1992). According to Schukken *et al.* (1992) percentage of lactose increases significantly with decreasing bulk SCC. Canada reduced its regulatory SCC level to 500,000 in the 1980's, with decreasing bulk milk SCC, fat and lactose content increased, with little effect on protein content (Schukken *et al.*, 1992). Harmon (1994) suggested that mastitis or elevated SCC is associated with a decrease in lactose, *a*-lactalbumin, and fat in milk because of reduced synthetic activity in the mammary tissue. There is close relationship between SCC and properties of milk (Lee *et al.*, 1994). When SCC increases from 83,000 cells/ml to 870,000 cells/ml, lactose concentration reduces from 4.977% to 4.707% (Klel *et al.*, 1998). Researches also studied the possible use of milk composition profiles for the prompt diagnosis of mastitis and found that lactose content of milk significantly decreased in mastitic, as compared with normal quarters. Somatic cell count is negatively correlated with lactose (Kamal *et al.*, 1998). Sharif *et al.* (2007) found that mean milk SCC, mean LSCC (log 10 SCC) and mean milk lactose contents of unaffected / healthy quarters was 1.876×10^5 cells/mL, 5.27 and 5.04% respectively. Mean milk SCC, Mean LSCC and mean lactose contents of mastitis infected quarters was 30.94×10^5cells/mL, 6.49 and 4.24% respectively, and observed a negative correlation between SCC and milk lactose.

B. Milk Quality and Quantity

There is little variation in lactose concentration of milk within lactation and from one lactation to the next lactation, which is a benefit for lactose as a parameter for detection of mastitis (Kitchen, 1981). Mastitis, the primary cause of increased SCC, causes injury to milk secretory cells in the mammary gland which interferes with the synthesis of lactose, fat and protein (Schallibaum, 2001). It also affects milk yield. There are changes in the permeability of membranes which leads to increased leakage of blood components into the udder and changes in milk composition. Mastitis causes decrease in milk production and decrease in lactose yield causing losses to buffalo milk producers (Ceron-munoz *et al.*, 2002). The lactose level in mastitic milk is significantly reduced in case of mastitis. Generally, the quantity and quality of milk are greatly affected by the degree of udder inflammation, which in turn affect the processing properties of milk and its nutritive value (Rawdat and Omaima, 2000). Mastitic milk has low percentage of lactose and after treatment of mastitis with tri-sodium citrate, milk lactose restores to normal composition (Singh *et al.*, 1997). The composition of milk is markedly influenced by the health status of the udder. The occurrence of inflammatory process or mastitis generally leads to an increase in somatic cell count (SCC) in milk, which has been associated with changes in milk composition and properties. These changes may occur both in the main constituents of fluid milk, such as lactose, proteins and fat and in minor components such as minerals and enzymes (Auldist and Hubble, 1998).

C. Intra-mammary Infections (IMI)

Lactose content of milk from infected quarters is significantly decreased in inverse proportion to the number of leukocytes in mastitic buffaloes (Qureshi and Ahmad, 1980). One of the most promising parameters for monitoring sublcinical mastitis is lactose (Pyorala, 2003). It was observed that the lactose concentration of the infected glands of goat udder is significantly reduced than uninfected / healthy udder (Leitner *et al.,* 2004). Intra-mammary infections result in tissue damage and the decreased synthetic ability of the enzyme systems of the secretory cells, and the biosynthesis of lactose is also decreased (Kitchen, 1981). The lactose determination in milk can help in diagnosing the sub-clinical mastitis at an early stage when abnormalities start just at a cellular level (Ahmad *et al.*, 1988). Pyorala (2003) reviewed that the most promising parameters for monitoring sublcinical mastitis are milk N-acetyl-β-D-Glucosaminidase activity, lactose and electrical conductivity along with some other indicators such as optical and milk flow measurements. In one study mean lactose contents were correlated along with scores of Surf Field Mastitis Test. The mean lactose contents found in control cases i.e. SFMT N (Negative) were 5.10, mean lactose content for T (Traces) were 4.81, mean lactose contents for cases in first degree mastitis with respect to severity (P-1) were 4.66, mean lactose contents for P2 were 3.92 and mean lactose contents found for P3 cases were 2.66 which was an index of third degree mastitis. Analysis of variance of mean milk lactose contents for SFMT showed that there was significant decrease in lactose content with the severity of mastitis (Sharif *et al.*, 2007).

D. Major and minor pathogens of mastitis

The composition of milk of mastitic cow has a highly significant decrease in lactose. The types of bacteria isolated from mastitis cases has significant effect on lactose and acidity of milk (Mohammad *et al.*, 1998). Singh *et al.* (1998) compared biochemical composition of milk samples of healthy and mastitic cows and found decreased lactose content in mastitic cows. Singh *et al.* (2000) determined the efficacy of different tests for the detection of sub-clinical mastitis in cows and found that the percentages of agreement of lactose was 71.47%. In one study the major milk pathogens associated with clinical signs of mastitis were accompanied by higher

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SCC, lower lactose concentration and higher protein concentration. Changes were more marked when *Escherichia coli* was present. *Corynebacterium bovis* did not alter milk chemical composition whereas coagulase negative Staphylococci (CNS) slightly reduced lactose concentration and increased SCC (Coulon *et al.*, 2002). Hamann (2002) proposed that lactose was one of the most useful markers of mastitis. Subclinical mastitis significantly decreased milk quality in terms of decreased lactose (Majewski and Tietze, 2002). Sharif *et al.* (2007) also found that mean milk lactose was more decreased in quarter samples infected with major pathogens than quarter infected with minor pathogens of dairy buffaloes.

Lactose is a reliable indicator of mastitis under modern dairy production. Apart from diagnosis of sub-clinical mastitis in modern dairy production, lactose is also the indicator of milk quality. Further improvements are suggested in dairy production sector in terms of designing a diagnostic kit for rapid analysis of quantity of lactose in milk for quick detection of mastitis in advanced dairy herds and under modern dairy production.

REFERENCES

[1] Ahmad J., I. Hussain, N. Mahmood and R. Munir, 1988. Lactose determination as an aid to sub-clinical mastitis diagnosis. Pak. Vet. J. 8: 25-28.

[2] Allore, H.G. 1993. A review of the incidence of the mastitis in buffaloes and cows. Pak. Vet. J. 13: 1-7.

[3] Auldist, M.J., S. Coats, G.L. Rogers and G.H. McDowell, 1995. Changes in the compositional of milk from normal and mastitic dairy cows during lactational cylcle. Aust. J. Exp. Agric. 35: 427-436.

[4] Auldist, M.J. and I.B. Hubble, 1998. Effects of mastitis on raw milk and dairy products. Aust. J. Dairy Technol. 35: 28-36.

[5] Bachaya, H.A., Z. Iqbal, G. Muhammad, A. Yousaf and H.M. Ali, 2005. Subclinical mastitis in buffaloes in Attock district of Punjab (Pakistan). Pak. Vet. J. 25: 134-136.

[6] Barbano, D.M., 1989. Impact of mastitis on dairy product quality and yield: Research update. 28th Annual Meeting, National Mastitis Council, Inc. Tampa, Florida, USA.

[7] Bilal, M.Q. and A. Ahmad, 2004. Dairy Hygiene and Disease Prevention. Usman and Bilal Printing Linkers, Faisalabad, Pakistan.

[8] Bilal, M.Q., M.U. Iqbal, G. Muhammad, M. Avais and M. Sajid 2004. Factors affecting the prevalence of clinical mastitis in buffaloes around Faisalabad district (Pakistan). Int. J. Agri. Biol. 6: 185-187.

[9] Ceron-munoz, M., H. Tonhati, J. Durate, J. Oliveira, M.M. Berrocal and H. Jurado-Gamez, 2002. Factors affecting somatic cell counts and their relations with milk and milk constituents yield in buffaloes. J. Dairy Sci. 85: 2885–9

[10] Chandra, A., 1992. Detection of mastitis in dairy herds by milk lactose analysis. Ind. J. Vet. Med. 12: 72-73.

[11] Coulon, J.B., P. Gasqui, J. Barnoun, A. Ollier, P. Pardel and P. Dominique, 2002. Effect of mastitis and related germ yield and composition during naturally occurring udder infections in dairy cows. Anim. Res. 51: 383-393.

[12] Hamann, J. and V. Kromker, 1997. Potential of specific milk composition variables for cow health management. Livest. Prod. Sci. 48: 201-208.

[13] Harmon, R.J., 1994. Symposium: Mastitis and genetic evaluation for somatic cell count-Physiology of mastitis and factors affecting somatic cell counts. J. Dairy Sci. 77: 2103-2112.

[14] Hirpurkar, M., S.K. Tanwani, M.N. Moghe and R.C. Dhir, 1987. Lactose estimation of milk as an aid in the diagnosis of mastitis in cows and buffaloes. Haryana Veterinarian. 26: 56-58.

[15] Kamal, A., V.S. Rajora, S.P. Pachauri, G.C. Gupta and A. Kamal, 1998. Milk profiles in clinical mastitis. Ind. J. Anim. Sci. 68: 467-468.

[16] Kitchen, B.J., 1981. Review of the progress of dairy science: Bovine Mastitis: Milk compositional changes and related diagnostic tests. J. Dairy Sci. 48: 167-188.

[17] Klel, L., J. Yun, A. Sapru, J. Lynch, D. Barbano, P. Sears and D. Galton, 1998. Effects of milk somatic cell count on Cottage cheese yield and quality. J. Dairy Sci. 81: 1205-1213.

[18] Lee, S.J., C.W. Lin and M.C. Chen, 1994. Relationship between somatic cell count and attributes of raw goat's milk. J. Chin. Society Anim. Sci. 23: 278-294.

[19] Leitner, G., U. Merin and N. Silanikove, 2004. Changes in milk composition as affected by subclinical mastitis in goats. J. Dairy Sci. 87: 1719-1726.

[20] Majewski, T and M. Tietze, 2002. Influence of subclinical mastitis on hygienic quality of milk. Biuletyn Informacyjny Instytut Zootechniki. 40:181-186.

[21] McDonald, J.S., 1979. Bovine mastitis: Introductory remarks. J. Dairy Sci. 62: 117-118.

[22] Miller, R.H. and M.J. Pappe, 1985. Relationship between milk somatic cell count and milk yield. Proc. 24th Ann. Meeting Natl. Mastitis Council. Inc., Arlington, VA, USA. pp: 60-72.

[23] Miller, R.H., U. Emanulesson, E. Person, L. Brolund, J. Philipsson and H. Funke, 1983. Relationships of milk somatic cell count to daily milk yield and composition. Acta Agric. Scand. 33: 209-223.

[24] Mohammed, I.E., O.A.O. Elowni and G.E. Mohamed, 1998. Factors affecting composition of mastitic milk of Friesian cattle in Sudan. Ind. J. Anim. Sci. 68: 379-381.

[25] Pyorala, S., 2003. Indicators of inflammation in the diagnosis of mastitis. Vet. Res. 34: 565-578.

[26] Qureshi, M.A and I. Ahmad, 1980. Significance of milk lactose and leukocyte count in the diagnosis of mastitis. Pak. J. Sci. Res. 32: 263-269.

[27] Radostitis, O.M., C.C. Gay, D.C. Blood, and K.W. Hichiff, 2000. Veterinary Medicine. 9th Ed., W.B. Saunders Company, London, UK.

[28] Rawdat, A.M and M.M. Omaima, 2000. Some biochemical changes in serum and milk of mastitic buffaloes. Egypt. J. Agric. Res. 78: 1737-1747.

[29] Reichmuth, J. 1975. Somatic cell counting - Interpretation of results. Page 93 in Proc. IDF Seminar on Mastitis Control, Intl. Dairy Fed., Brussels.

[30] Rogers, S.A., S.L. Slattery, G.E. Mitchell, P.A. Hirst and P.A. Grieve, 1989. The relationship between somatic cell count, composition and manufacturing properties of bulk milk 3. Individual properties. Aust. J. Dairy Technol. 44: 49-52.

[31] Schultz, L.H., R.W. Broom, D.E. Jasper, R.W.M. Berger, R.P. Natwke, W.N. Philpot, J.W. Smith and P.D. Thompson, 1978. Current Concepts of Bovine Mastits, 2nd Ed. National Mastitis Council, Inc., Washington, D. C., USA. pp.6-9.

[32] Schulz, J., T. Hanisch, S. Dunke, S. Springer and K. Beek, 1998. Decreasing concentration of lactose in cow milk resulting from increased permeability of tissues between milk ducts of udder and blood. Panktische Tierarzt. 19: 657-665.

[33] Sharif, A., T. Ahmad, M.Q. Bilal, A. Yousaf, G. Muhammad, S.U. Rehman and F.M. Pansota. 2007. Estimation of milk lactose and somatic cells for the diagnosis of sub-clinical mastitis in dairy buffaloes. Int. J. Agri. Boil. 9: 267-270.

[34] Sharif, A. and T. Ahmad. 2007. Prevalence of severity of mastitis in buffaloes in district Faisalabad (Pakistan). J. Agri. Soc. Sci., 3: 34-36.

[35] Sharif, A. and G. Muhammad and M.A. Sharif. 2009. Mastitis in Buffaloes. Pak. J. Zool. Suppl. Ser. 9: 479-490.

[36] Schallibaum, M. 2001. Impact of SCC on the quality of fluid milk and cheese. p. 38-46 in Proc. 40th Annual meeting, National Mastitis Council, Madison, WI.

[37] Singh, T.J, Varindra, S. Singh, K.S Dhillon and S. Singh, 1997. Effect of trisodium citrate mastitis treatment on some milk constituents in cows. Ind. J. Anim. Sci. 67: 1055-1056.

[38] Singh, R., K.B. Singh, S.S. Khera, S.S. Sudhan and R. Singh, 1998. Effect of subclinical and clinical mastitis on milk composition in cross-bred dairy cows. Ind. Vet. J. 75: 462-465.

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[39] Singh, R., B.K. Bansal, S.K. Uppal., D.S. Malik and R. Singh, 2000. Diagnosis of subclinical mastitis: a comparative study of different tests. Ind. J. Anim. Res. 34: 120-123.

[40] Schukken, Y.H., K.E. Lesile, A.J. Weersink and S.W. Martin, 1992. Ontario bulk milk somatic cell count reduction program. 1. Impact on somatic cell counts and milk quality. J. Dairy Sci. 75: 3352-3358.

[41] Shuster, D.E., R.J. Harmon, J.A. Jackson and R.W. Hemken, 1991. Suppression of milk production during endo-toxin induced mastitis. J. Dairy Sci. 74: 3763-3774.

[42] Urech, E., Z. Puhan and M. Schallibaum, 1999. Changes in milk protein fraction as affected by subclinical mastitis. J. Dairy Sci. 82: 2402-2411.

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