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Milk electrical conductivity: An early tool to detect mastitis in buffaloes

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Abstract
Dairy sector has its dependency on udder health of lactating animals. Mastitis remains the most devastating condition related to udder health of the animal leading to huge economic loss. Mastitis occurs due to various infections. Mastitic milk has high electrical conductivity due to glandular tissue damage. The concentration of Na^+ and Cl^- ions increases while the concentration of K^+ and lactose decreases in milk. The current investigation was conducted to utilize the technique of milk electrical conductivity (EC) as a tool to detect early mastitis. Forty five milk samples were collected from the university dairy farm. The results for EC was determined as low as 3.5 mS/cm and as high as 8.05 mS/cm. The fluctuation in EC might be attributed to different concentration of electrolytes in milk. 60% milk samples showed EC values within average range and considered negative for mastitis with mean of 4.56 mS/cm, while 40% milk samples were found with high EC values than average range. The mean EC value for subclinical is 5.90 mS/cm and 6.73 mS/cm for clinical mastitis. This proposed the presence of high ionic concentration as an indication of mastitis in buffaloes. This result concludes that EC can be used as a spot on test in field conditions to detect early stage mastitis. This technique can be of immense help for farmers and dairymen to detect the stage of infection and to initiate the therapeutic protocol as early as possible which ultimately leads to resolution of infection.

Keywords: dairy, buffalo, mastitis, electrical conductivity

Introduction
In recent years, buffalo health has gained priority and research has been focused on buffalo specific health problems. Bubaline mastitis is one such ailment and it is responsible for huge economic loss in developing countries like India (Tyagi *et al.*, 2020) [15]. Mastitis has mainly two types: subclinical and clinical (Cantekin *et al.*, 2019) [3]. The problem of udder inflammation is primarily due to ill management at dairy farms. Bruising of udder tissue or teats from traumas, nursing, flies bites, or other wounds predisposes the animals to mastitis. Livestock with pendulous udder are more prone to develop udder infection compared to animals having non-pendulous udder (Sori *et al.*, 2005) [13].
Among the microbes, *Staphylococcus sp*, *Streptococcus sp.*, *Straphylococcus agalactiae*, *Escherichia coli.* and *Klebsiella sp*. are considered as common pathogens of mastitis (Tripathi *et al.*, 2018) [14]. Yeast and fungus are also frequently encountered pathogens affecting udder health. (Andrews *et al.*, 1985) [1].
Milk electrical conductivity (EC) has been in use since mid eighties to detect bovine mastitis. In this regard, several workers have used automatic sensors to detect abnormal milk (Hogeveen *et al.*, 2010) [5]. This has lead to develop keen interest in workers of modern times to use the same technique to make early detection of mastitis. (Brandt *et al.*, 2010) [2] Assessment of milk electrical conductivity using electronic detector is sufficient to give them an idea about the normal milk and abnormal milk. The specific conductance of milk reflects the concentration and activity of sodium and chloride ions. Higher values of these ions represent mastitis. This change in the concentration of sodium and chloride is detected by digital detector or EC meter.
Electrical conductivity is a measure of the resistance of milk to an electric current and conductivity is the reciprocal of the resistance. The unit of measurement for EC is millisiemens per centimeter (mS/ cm). In milk, EC is determined by the concentration of anions and cations, primarily Na+, K+, and CI-. During infections with mastitis, the milk concentration of lactose and K+ are decreased and concentrations of Na+ and CI· are increased because of increased blood capillary permeability, the loss of tight junctions and the loss of

action ion-pumping systems (Kitchen *et al.*,1980) [6]. During mastitis, changes in concentration of Na+, Cl^- and K+ in milk lead to increase in EC.

Shahid *et al*. (2011) [11] used electrical conductivity of milk to make early diagnosis of bovine mastitis. In his study, 65.2% animals were found positive for subclinical mastitis with electronic detector.

As compared to cows, the normal electrical conductivity of buffalo milk is quite lower. This is because the fat content in buffalo milk is more than cow milk. Electrical conductivity has got inverse relation with fat content (Nielen *et al*., 1992) [7].

Under the field conditions, many farmers and animal owners have no awareness of its usage. So, keeping above facts in mind, the current study was conducted to assess the milk electrical conductivity (EC) as a potential tool to detect early stage mastitis in lactating buffaloes.

Materials and Methods

Sample collection

A total of 45 fresh milk samples were collected from Instructional Dairy Farm at Nagla, Pantnagar. The samples were processed at the laboratory of Department of Veterinary Medicine for further investigation.

In the present study, measurement of electrical conductivity was done by passing AC voltage through the milk with conductivity cell. Electrical conductivity varies with the presence of dissolved solids in the solution. This was determined by using Pen type Portable E-1 TDS and EC meter.

Procedure

Firstly, the electrode protective cap was removed before use. The "ON/OFF" button was pressed and the meter was dipped into the milk sample. After sometimes, when the reading become constant, the "HOLD" button was pressed and took out from the sample. The electrode was wiped clean after every use and the meter was switched off and the protective cap was replaced. The results were expressed in mS/cm.

Results and Discussion

The results for the analyzed 45 raw milk samples of lactating buffaloes were shown in Table 1 with ranges of milk EC values. According to these results, the milk samples were classified as healthy, subclinical mastitic and clinical mastitic milk.

On the basis of analyzed results, 60% milk samples (30 in number) had EC values less than 5.5 mS/cm and considered as healthy whereas, 40% milk samples (15 in number) had EC values greater than 5.5 mS/cm and considered as mastitic. The minimum value of EC for healthy milk was 3.5 mS/cm and maximum value was 5.2 mS/cm with mean value of 4.56 mS/cm. The mastitic milk had minimum EC value of 5.9 mS/cm and maximum of 8.05 mS/cm.

Table 1: Electrical Conductivity Values (range) for Healthy, Subclinical, and Clinical Mastitis

No. of Samples	Percentage of Samples	EC (mS/cm)	Milk Status
30	60	3.00-5.500	Healthy
13	26	5.5-6.50	Sub clinical Mastitis
2	4	6.50-8.50	Clinical Mastitis

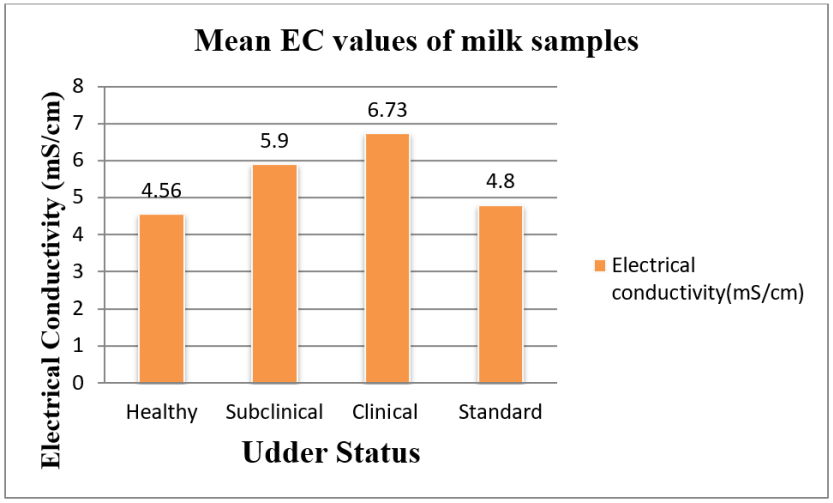

Fig 1: Comparison between mean EC values of Milk Samples

The standard range for EC of normal milk is between 4.0-5.5mS/cm as suggested by Spakauskas *et al*. (2006) [12]. The mean values of EC for healthy, subclinical and clinical mastitic milk were 4.87mS/cm, 5.37mS/cm and 6.44 mS/cm respectively as suggested by Norberg *et al*. (2004) [9]. Fahmid *et al*. (2016) [4] collected 50 milk samples and the result for EC was determined as low as 3.00 mS/cm and as high as 8.5 mS/cm. 40% milk samples showed EC values within average range and considered negative for mastitis with mean of 4.87 mS/cm, while 60% of milk samples were found with high EC values than average range. The mean EC value for subclinical mastitis is 5.97mS/cm and 6.7mS/cm for clinical mastitis. Saber *et al*. (2017) [10] showed that EC ranges of 2.2-3.95 mS/cm had high sensitivity with a negative predictive value which means that samples laid within this range will be negative for subclinical mastitis.

Conclusion

In conclusion, timely assessment of milk electrical conductivity can play an important role to detect mastitis at an

early stage. The analyzed results clearly discriminated the healthy, subclinical and clinical mastitic milk status. The EC value for healthy, subclinical and clinical mastitic milk was 4.56 mS/cm, 5.9 mS/cm and 6.73 mS/cm respectively. By using electronic detectors, farmers can easily screen out their animals for mastitis making them able to locate the abnormal quarter. This technique can be used as spot on test in field conditions to rule out the stage of infection. All these traits has made the electrical conductivity a potential tool for early mastitis detection in buffaloes so that necessary therapy should be initiated as early as possible.

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