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Effect of post-milking teat dipping on milk quality and udder health of crossbred cows

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Abstract

We aimed to determine the efficacy of different post-milking teat dips in the prevention of intramammary infection and teat condition scores in common crossbred cows (Holstein Frisian × Tharparkar) found in Indian sub-tropical conditions. Eighty healthy crossbred cows were selected and randomly divided into four groups: untreated control, 1% w/v iodine, 5% v/v lactic acid and finally essential oil mix (eucalyptus, lavender, peppermint, and tea tree oils). Samples were collected quarter-wise ($n = 308$). Sampling as well as teat scoring was done simultaneously. 1st sample was collected before starting teat dipping, followed by 15th day in milk (DIM), 45th DIM and 90th DIM, respectively. The study found that post-milking teat dipping significantly reduced the mean California mastitis test score, somatic cell count and electrical conductivity of the milk in the treatment groups compared to the control group, and also improved milk yield in the treatment groups. There were no differences between the individual treatments. The study also found a significant reduction in teat end condition and teat skin condition after 90 d of post-milking teat dipping.

Global milk demand is increasing, but achieving production targets will be challenging due to the ever-present threat of mastitis in the dairy industry. Treating and quickly diagnosing mastitis, drying off the cows, culling the affected animals and teat dipping before and after milking are just a few of the procedures involved in managing mastitis. Among these, post-milking teat dipping is arguably the most important and effective, especially as antibiotic treatment for mastitis in dairy cows may pose a public health concern (Oliver and Murinda, 2012). The probability of reducing total bacterial contamination is highest when the teat dipping employs lactic acid and iodine-based teat dips (Fitzpatrick *et al.*, 2021). At the same time, in vitro research suggests that antibacterial properties of essential oils make them effective against a variety of isolates of mastitic origin (Arbab *et al.*, 2022). Overall teat health can also be impaired by improper maintenance of milking machines leading to issues like discolouration, stiffness and ring thickening around teat ends (Hillerton *et al.*, 2002). Post-milking antiseptic treatments, including essential oils, can prevent hyperkeratosis and poor teat health by reducing roughness caused by harsh chemical components with low pH values (Ohnstad *et al.*, 2006). The purpose of this study was to evaluate the effect of an essential oil mix in relation to other recognized teat dip solutions such as iodine and lactic acid. We compared the incidence of intra-mammary infections (IMI), changes in milk composition, teat end condition and teat skin condition score between post-milking teat-dipped and non-teat-dipped animals to determine the impact of different post-milk teat dipping strategies on udder health.

Materials and methods

The study was conducted at the Livestock Research Centre of the National Dairy Research Institute, Karnal, Haryana, India. A total of 80 crossbred cows (Holstein Frisian × Tharparkar) from 2nd to 5th parity were selected and divided into four groups having 20 animals in each group. The cows were randomly assigned to GC (no teat dipping or control group), GI (1% w/v iodine-based post-milking teat dipping), GL (5% v/v lactic acid-based post-milking teat dipping) and GEO (essential oils-based post-milking teat dipping). For the latter, a 100 ml aqueous solution of essential oils was made by mixing 2–3 ml of liquid soap, 2 drops of glycerine and 0.5 ml each of eucalyptus, lavender, peppermint and tea tree oils with distilled water. Teat dipping was performed manually and sequentially teat by teat immediately after every milking, ensuring that all teats were fully immersed in the solution.

Sample collection

Using the hand milking method, milk samples were taken in the morning from each cow in the control and treatment groups on days 0, 15, 45 and 90 DIM. In total, 308 quarters were samples as some cows had fewer than four functional quarters. The first 3–4 streams of milk were discarded. Milk samples were collected in sterilized, dry plastic bottles with a volume of 50 ml.

Teat scoring

Teat end scoring as well as teat skin condition scoring was carried out using a protocol adapted from Mein *et al.* (2001) following sample collection on each sampling day. Teat end condition was scored on a 1–5 scale, corresponding to the visibility of a hyperkeratosis ring (score of 1 indicated no visible ring, 2 indicated smooth ring, 3 indicated rough ring, 4 indicated very rough ring and 5 indicated open lesion or scabs). Teat condition was scored using five parameters on 1–5 scale (score of 1 indicated smooth teat skin, 2 indicated some evidence of scaling, 3 indicated chapped teat skin, 4 indicated chapped and cracked teat skin and 5 indicated severely damaged and ulcerative teat skin with scabs or open lesions).

Statistical analysis

California mastitis scores (CMT), electrical conductivity (EC), somatic cell count (SCC), milk yield and composition of milk data were all statistically analysed using one-way ANOVA. For every parameter, the mean and standard error were determined. Duncan's multiple-range test was used to look for significant variations in the means. IBM SPSS statistics version 22 was used to calculate the Pearson correlation coefficient and to statistically examine the data.

Results and discussion

After 90 d of experimentation, the mean somatic cell count (SCC) in the control group increased to $388.1 \pm 19.1 \times 10^3$ cells/ml from $311 \pm 20.9 \times 10^3$ cells/ml at day 0. During the same period, the GI group had a drop in milk SCC from $322.1 \pm 25.6 \times 10^3$ cells/ml to $256.9 \pm 20 \times 10^3$ cells/ml. Similarly, SCC dropped from $345.2 \pm 19.7 \times 10^3$ cells/ml to $265 \pm 19.3 \times 10^3$ cells/ml in GL group. Essential oils showed comparable efficacy to both treatment groups, resulting in a significant decrease in SCC from $326.3 \pm 22.1 \times 10^3$ cells/ml at 0 d to $231.6 \pm 21.6 \times 10^3$ cells/ml after 90 d trial (Fig. 1). Lower levels of somatic cell count in the treatment groups clearly indicate that post-milking teat dipping was effective in preventing the invasion of pathogenic microorganisms into the mammary gland and thereby resulted in improving udder health. Increased SCC readings indicate udder illness, lower milk production, changes in milk composition, higher production costs and lower profit. Through the teat canal, bacteria enter the mammary gland and multiply in the milk. The mammary epithelium's ability to function is directly impacted by bacterial toxins, enzymes and cell wall components. Additionally, they promote the production of several inflammatory mediators, including neutrophils and lymphocytes, which lead to a rise in SCC and oedema from increased vascular permeability and vasodilation (Sharma *et al.*, 2011). According to our data, the antibacterial, anti-inflammatory and immunological modulatory properties of essential oils influenced the udder's defence system and improved udder health, explaining the decline in the number of SCC in the GEO group. Teat disinfectants offer a broad spectrum of efficacy and kill swiftly while leaving a persistent film on the teat skin that forms a physical and chemical barrier that provides long-term protection. When comparing the treatment group to the control group which received no teat dip (GC), the results of the current study on SCC are consistent with Kamal and Bayoumi (2015) findings, who used 0.5 percent iodine. Similar findings were also reported by Alawneh *et al.* (2020) who observed that somatic cell counts for cows administered an iodine- or lactobacillus-based solution after milking followed a similar trend.

The milk CMT scores of the groups that received post-milking teat dip based on essential oils, iodine and lactic acid did not differ statistically. However, the CMT scores of all treatment groups were significantly lower than that of the control group commencing on the 45th day of sampling (Fig. 1). The fact that the CMT response is a measure of leucocyte counts (SCC) and that SCC was significantly higher in the control group than in the treatment group, may help to explain the increased average CMT score in treatment group. Our findings are supported by those of Kamal and Bayoumi (2015), who showed that a teat-dipped group had a lower CMT score than a non-teat-dipped group. Comparable to our findings Singh *et al.* (2018) found a significant decrease in CMT by using the combination of povidone-iodine and glycerin in a ratio of 3:1.

The first two samples (0 and 15 d) exhibited no significant variation in milk electrical conductivity, whereas a significant ($P < 0.05$) difference between GC and each of GI, GL and GEO was apparent at 45 and 90 d of sampling (Fig. 1). One possible explanation for this trend in EC is that it may be the result of the control group's higher infection frequency with subsequent sampling. The active Na, Cl, and K pumping mechanisms of the mammary gland as well as tight junctions are disrupted in cows exposed to intramammary infection, causing these ions to escape into the milk leading to increased EC (Norberg *et al.*, 2004).

When the group milk yields were compared, the treatment groups produced significantly higher milk than the control group (online Supplementary Table S1). The increased milk production is commonly thought to occur from eradicating infections within the mammary gland and preventing damage to the secretory cells. It is well-reported that cows with lower somatic cell counts produce more milk (Hand *et al.*, 2012). The current results are similar to those of (Rasool *et al.*, 2022), who observed a significant rise in milk output in dairy cows with subclinical mastitis following the administration of essential oils (lavender and eucalyptus oil) as a post-milking teat dip. The findings are consistent with those of Shailja and Singh (2002), who observed that animals that underwent teat dipping after milking produced a higher amount of milk overall. Similarly, Singh *et al.* (2018) showed that the post-milking teat dip significantly impacted the teat dipping group's milk production.

There were no significant changes found between control and treatment groups for milk solid not fat, protein and total solids contents as well as freezing point. However, milk fat content and lactose content were significantly lower in GC than in the treatment groups, but only at 45 and 90 DIM (online Supplementary Table S1). These findings are consistent with those of Singh *et al.* (2018) and Ali *et al.* (2022), who reported non-significant changes in milk SNF and total protein contents in treatment groups that underwent post-milking teat dipping as compared to control groups. Lactose is the major osmolar in milk and so at the point of secretion its content is relatively stable. Mastitic infection causes the mammary tight junctions to become leaky, allowing lactose to flow down its concentration gradient out of milk and into blood, which explains the drop in lactose concentration seen in milk. These same leaky tight junctions also explain the changes in potassium (decreased) and sodium (increased)

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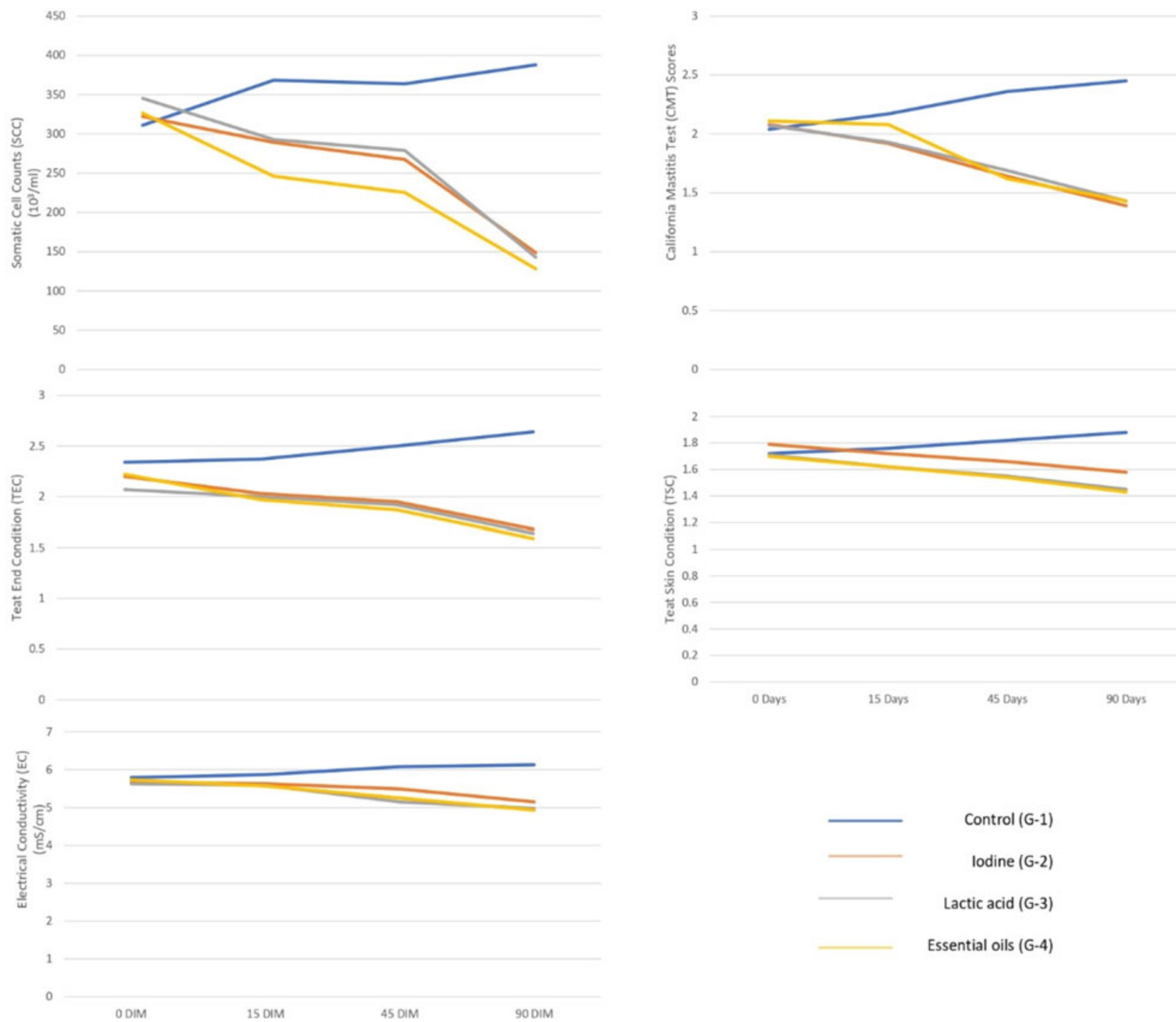

Figure 1. Average values (±SE) of somatic cell counts (SCC), California mastitis test (CMT) scores and electrical conductivity (EC) in control and treated animals.

concentrations in milk, which in turn account for the altered EC value (Alhussien and Dang, 2018). Our results somewhat coincide with those of Shailja and Singh (2002), who found a minor increase in the percentage of milk fat and lactose in the treatment group compared to the control group, although bnin their case the difference was not statistically significant. Comparing the essential oil-based group to the conventional iodine and lactic acid-based post-milking teat dipping solution, the results were equivalent and exhibited no significant differences in any of the above-mentioned parameters.

Teat condition score is a valuable tool for monitoring teat health. It helps identify issues with milking machine settings, assess teat dip concentration and better awareness of the cow's environment, all at little cost. TEC and TSC values did not differ significantly between groups at 0 and 15 DIM (ie, including after 15 d of post-milking teat dipping). However, after 45 and 90 d, both TEC and TSC values were significantly higher in GC compared to the treatment groups (Fig. 1). Skin conditioners such as essential oils are added to teat dips to prevent water loss and protect the skin from chemicals. However, this emollient action keeps teats wet, but it may be detrimental in cold winter conditions. To prevent this, teats should be blotted dry before being let out in chilly environments. Corresponding results were reported by Morrill *et al.* (2019), where the 1% iodine-based postmilking teat dip had a better teat end score than the control group.

Mastitis infections are primarily caused by bacteria entering the mammary gland through the teat canal. The teat-end protects the mammary gland, making it the first line of defence against IMI. The extent of bacterial contamination and penetration into the teat canal may be influenced by the kind and extent of teat tissue injury. We examined the relationship between teat-end TEC and TSC values and found a significant although not especially high correlation ($r = 0.413$). Additionally, there was a correlation ($P < 0.01$) between SCC and teat end condition ($r = 0.374$), but not between teat skin condition and SCC ($r = -0.023$). We did observe that mastitis was more prevalent in teat-ends with significant wear down, which were raw and ulcerated, affecting the TEC scores. However, whilst we found a significant correlation between TEC and clinical mastitis ($r = 0.447$, $P < 0.01$), the same was not true for TSC ($r = 0.014$). The link between a range of degrees of teat-end hyperkeratosis and the rate of udder infection is less clear. The level of teat-end thickness was higher in the clinical mastitis quarter than in the healthy quarter. When the cow's teat ends are abnormal, the probability of new mastitis infection

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increases considerably. This highlights the importance of healthy teat-end in commercial set-up. It is very helpful to evaluate teat-end callosity which may help in identifying and resolving issues and problems related to milking management. The key characteristics of normal teat ends are smooth and soft, while abnormal ends are chapped, cracked, red or have open lesions.

In conclusion, a post-milking essential oil based teat dip is equally effective as established iodine and lactic acid products in management strategies to reduce new intramammary infection rate in dairy cows. All three post-milking teat dipping solutions can be considered effective and safe, as the product was not irritating to the teat and did not negatively affect teat condition when compared to the control group.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022029924000591.

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