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Trace mineral supplementation in cattle

reduces somatic cell count: Evidence from Farmer FIRST Programme

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The intervention to prevent mastitis through nutritional interventions was undertaken under the ICAR's flagship extension programme entitled Farmer FIRST Programme. It was found in earlier surveys that there was prevalence of mastitis in the adopted villages. To address this, trace mineral feeding was chosen as a strategic technological input along with advisories on ration balancing, and prevention of mastitis. The somatic cell count was chosen as an indicator of assessment, which is widely used for assessing the milk quality and diagnosing sub-clinical mastitis. Among the adopted villages in District Barnala, two villages namely Hamidi and Dhaner were selected for the intervention, from which a total of 90 cattle farms, 45 from each village with less than 10 dairy animals were selected for methodological coherence and prescriptive standards of biological research. Commercially available trace mineral supplement (comprising Zn, Cu, Mn and Fe) was distributed to the beneficiary farms and advised to feed the same to cattle at the rate of 20g/animal/day for 30 days. The data for somatic cell counts (SCC) were collected before and after the intervention from 90 farms. The results revealed drop in somatic cell count in milk from average 196.99 x 103 cells/ml of milk to 159.22 x 103 cells/ml which was found significant. However, it may be a small decrease in SCC as far as mastitis was concerned but provided evidence, which aligns with the established pattern of science, proved concerted role of trace mineral supplementation in prevention of mastitis.

Keywords: Cattle, Mastitis, Ration, Somatic cell count, Trace minerals

THE strategic position of India in livestock production has constantly been improving over time. From net importer of dairy products, the journey, which traverse over a quarter century, has positioned India at higher stakes in dairy production. As per latest BAHS (2024), India stands at zenith and owns a global share of 24% in milk production. This is because of the overarching efforts of Indian farmers and scientists backed by policy framework from the government. The technology-driven extension has been playing an unequivocal role in uplifting the socio-economic status of the farmers by guiding through better nutrition, management, healthcare, marketing, etc. All the actors in dairy production from universities to research institutions, associations to non-governmental organizations, outreach centres to line departments, both union and state ministries, etc. play a crucial role in overall development of the dairy sector in India.

Mastitis in general and subclinical mastitis (SCM) in particular, is often termed as the "invisible thief" of the dairy industry, and its economic impact on the resource-constrained Indian dairy sector is devastating. Multiple studies and meta-analyses estimate the average prevalence of SCM in India to be between 30–50% at the cow level and can be as high as 70–80% in some organized farms. Furthermore, mastitis is the most common and expensive disease of dairy animals, with SCM being 15–40 times more prevalent than clinical mastitis. The economic loss from this disease breaks the spine of dairy industry and is not from a single factor, but a combination of direct and indirect losses. The total annual economic loss due to mastitis in India is estimated to be a staggering ₹7,000 crores to over ₹11,500 crores (approx. USD 840 million to 1.4 billion). A significant portion of this around 70 percent is attributed to subclinical mastitis. Another economic factor due to

SCM is 'price penalty' which is largely implicit, due to increased Somatic Cell Count (SCC). Increase SCC leads to reduced shelf life, poor taste, and problems in processing (e.g. lower cheese yield). Losses can also be attributed to discarded milk and increased culling of the animals (NDRI 2019).

However, there is an intricate network of technologies for detection, prevention and management of mastitis. In this article, we have discussed the outcomes of trace mineral supplementation in dairy cattle for prevention of mastitis after pursuing purposive research in the adopted villages under the Farmer FIRST Programme (FFP).

Context of trace mineral supplementation

Trace minerals are critical for a robust immune system. Deficiencies in key minerals like Zinc (Zn), Copper (Cu), Cobalt (Co), Manganese (Mn), etc. directly impair the cow's ability to prevent and fight off the intramammary infections that cause mastitis. In India, where soil deficiencies are common and conventional feed often lacks adequate minerals, strategic supplementation is not just beneficial, it is essential for udder health and profitability. Mastitis is an inflammation of the udder, primarily caused by bacteria. The cow's defense system, specifically the white blood cells (leukocytes), must move from the blood into the milk to engulf and destroy these pathogens. This process is called leukocyte migration. Trace minerals are co-factors for enzymes and proteins that make this defense effective.

In the current intervention, a commercially available high-potency trace mineral supplement was used which per kg contained zinc (96 g), copper (20 g), cobalt (2500 mg), manganese (20 g), chromium (2000 mg), iodine (6000 mg) and iron (40 g). Zinc strengthens the keratin plug in the teat canal, the first physical barrier against bacteria. It also forms the part of the enzyme Superoxide Dismutase (SOD), which neutralizes free radicals produced during inflammation. Copper has antioxidant and anti-inflammatory properties whereby it acts as cofactor for Cu-Zn SOD. It helps control the inflammatory response in the udder. It is essential for "respiratory burst," the process neutrophils use to kill engulfed bacteria. Cobalt is used by rumen microbes to synthesize Vitamin B12, which is crucial for energy metabolism and immune cell function. A deficiency can lead to a sluggish immune response. Manganese along with being cofactor for SOD, is essential for glycosyltransferases, the enzymes important for cellular integrity and function. Particularly during transition period and heat stress, chromium can improve insulin sensitivity and potentially reduce the immunosuppressive effects of cortisol. A less stressed cow has a more competent immune system. High levels of iodine in teat dips are directly bactericidal. Dietary iodine helps maintain healthy, pliable teat skin, which is more resistant to chapping and bacterial entry.

Interventions under FFP

A quasi-experimental, pre-post intervention study was designed to evaluate the efficacy of a strategic technological package in improving udder health in dairy cattle. The intervention was premised on the critical role of trace minerals in immune function and the high prevalence of subclinical mastitis in the region, which incurs significant economic losses. Somatic Cell Count (SCC) was selected as the primary outcome measure due to its well-established correlation with intramammary infection and its status as a key international indicator of raw milk quality. The study was conducted in District Barnala, Punjab. The intervention was carried out over a defined period, with pre-intervention data collection followed by a 30-day intervention phase and subsequent post-intervention data collection. From the adopted villages under Farmer FIRST Project in District Barnala, two villages namely Hamidi and Dhaner were purposively selected for the intervention based on high incidences of mastitis and sub-clinical mastitis.

Within each selected village, a total of 90 cattle farms were selected, with 45 farms from each village (N=90). The farms having less than 10 dairy animals were selected and large farms were excluded to ensure methodological coherence and adhered to prescriptive standards for biological research. The core intervention was a commercially available trace mineral supplement (Teamin®), which was distributed to all 90 beneficiary farms. Farmers were instructed to feed the supplement at a standardized dosage of 20 g/animal/day. Alongside the supplement, farmers were provided with advisories on ration balancing and mastitis prevention through online and offline media. The intervention period was 30 days for each farm to ensure uniformity in assessing the short-term impact.

Data for the primary outcome variable, i.e. Somatic Cell Count (SCC), were collected twice for each farm. Milk samples were collected from all 90 farms (45 from Hamidi and 45 from Dhaner) immediately prior to the commencement of trace mineral feeding. This established the pre-interventional baseline SCC level. Following the 30-day intervention period, milk samples were collected again from the same 90 farms using identical sampling protocols, which constituted post-interventional SCC level. The composite milk samples (as per the defined protocol) were collected aseptically, preserved appropriately, and analyzed using a standardized method for SCC, using calibrated portable somatic cell counter at the Department of Veterinary Medicine, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, to ensure accuracy and reliability. The collected data was analyzed to determine the intervention's effect. The pre- and post-intervention SCC data was compared using a paired

t-test to ascertain if the observed reduction in SCC was statistically significant. The unit of analysis was the farm-level average SCC.

Impact

The effect of the trace mineral supplementation protocol for 30 days on udder health was assessed by comparing the average Somatic Cell Count (SCC) before and after the intervention. The results demonstrated a statistically significant reduction in SCC following the supplementation period. The mean SCC across all 90 farms decreased from 196.99 × 10^3 cells/mL pre-intervention to 159.22 × 10^3 cells/mL post-intervention. This represents an absolute reduction of 37.77 × 10^3 cells/mL, equivalent to a 19.2% decrease from the baseline level. Statistical analysis confirmed that this reduction was significant at $p< 0.05$, indicating that the observed effect is unlikely to be due to random chance.

While the post-intervention SCC of 159.22 × 10^3 cells/mL still lies above the ideal threshold for uninfected quarters (<100 × 10^3 cells/mL), the statistically significant ($p<0.05$) reduction is biologically and economically meaningful. This decline indicated a substantial decrease in the inflammation level within the mammary gland. The initial SCC of 196.99 × 10^3 cells/mL is indicative of a significant subclinical mastitis burden in the study population, a common challenge in Indian dairy herds as reported by Sharma *et al.* (2020). The observed 19.2% reduction aligns with the established role of trace minerals in immune potentiation. Minerals like zinc, selenium, and copper are co-factors for critical enzymes in the antioxidant defense system (e.g. Glutathione Peroxidase, Superoxide Dismutase), which protects leukocytes from oxidative damage during phagocytosis, thereby enhancing their ability to eliminate pathogens.

The magnitude of the SCC drop observed in this study is consistent with findings from other controlled trials. A meta-analysis by Salman *et al.* (2023) on the role of micronutrients in bovine mastitis concluded that supplementation with organic trace minerals, particularly Zinc and Selenium, consistently led to SCC reductions ranging from 15–30% percent. Furthermore, a specific study by Kumar *et al.* (2018) on crossbred cows in India found that a 60-day supplementation of a balanced trace mineral mixture resulted in a significant SCC decrease from 218 × 10^3 cells/mL to 178 × 10^3 cells/mL, a pattern strikingly similar to our findings. This consistency across studies reinforces the reliability of the present results.

It is crucial to interpret this "small decrease" in the context of mastitis dynamics. Subclinical mastitis is a chronic condition, and reversing established intramammary infections is challenging. The primary role of trace minerals is 'prophylactic rather than therapeutic'; they strengthen innate immunity to prevent new infections and help the immune system better control existing ones. The significant reduction achieved here suggests the intervention successfully enhanced the cows' immune resilience. As Weiss (2005) noted, correcting a trace mineral deficiency to manifest as an improved SCC can take 60–90 days due to the time required for immune cell turnover. The significant improvement seen in just 30 days in this trial is therefore highly promising, and a longer supplementation period would likely yield further gains.

From an economic perspective, even a modest reduction in SCC has substantial implications. A decrease in SCC is directly correlated with increased milk yield and improved milk quality (higher fat and protein content). Research by Hagnestam-Nielsen *et al.* (2009) demonstrated that for every 100,000 cells/mL reduction in SCC, milk yield can increase by up to 0.5 kg/day in the subsequent lactation. Therefore, the observed reduction of ~38,000 cells/mL in this study translates to tangible, albeit modest, production gains. When scaled across a herd and over time, this leads to significant economic benefits for smallholder farmers by reducing hidden losses, which are the hallmark of subclinical mastitis. The findings of this study provide compelling evidence that targeted trace mineral supplementation, integrated with management advisories, is an effective strategy for improving udder health and controlling subclinical mastitis in smallholder dairy systems.

Limitations and future directions

A limitation of this study is the relatively short 30-day intervention period. Future research should investigate the long-term effects of supplementation over an entire lactation, monitoring not only SCC but also the incidence of new clinical mastitis cases. Additionally, correlating the SCC data with specific bacteriological findings would provide a more granular understanding of the intervention's impact on different mastitis-causing pathogens.

SUMMARY

In conclusion, the strategic feeding of a trace mineral supplement at 20 g/animal/day for 30 days resulted in a statistically significant and biologically relevant reduction in somatic cell count. This finding provides robust, evidence-based validation for integrating targeted micronutrient supplementation into standard dairy management practices in India. By scientifically bolstering the innate immunity of dairy cattle, this approach offers a sustainable and proactive strategy to combat the pervasive economic losses inflicted by subclinical mastitis, thereby strengthening the resilience and profitability of the smallholder dairy sector.

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