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Impact of TANUVAS Mineral Mixture Supplementation on Milk Fat and SNF Content in Milch Animals under Smallholder Farming Conditions in Krishnagiri District, Tamil Nadu

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Abstract

The livestock sector, particularly dairy farming, plays a vital role in India's rural economy, yet milk productivity and quality often remain suboptimal due to nutritional deficiencies, especially mineral imbalances. This field-level study assessed the impact of supplementation with TANUVAS mineral mixture on milk fat and solids-not-fat (SNF) content in crossbred dairy cows under smallholder farming conditions in Krishnagiri district, Tamil Nadu. Ten motivated farmers with lactating cows participated following a farmer awareness workshop on mineral nutrition. Over 30 days, cows were supplemented with 50 grams of the mineral mixture daily. Milk quality parameters—fat and SNF percentages—were monitored via cooperative society records every day. Results showed statistically significant increases in milk yield (9.66%), fat content (11.91%), and SNF content (7.08%) after supplementation. The intervention also improved farmer knowledge and willingness to adopt mineral supplementation practices. These findings highlight the critical role of balanced mineral nutrition in enhancing milk quality and productivity in unorganized smallholder dairy systems, offering a practical approach for sustainable dairy development in regions like Tamil Nadu.

Keywords: TANUVAS mineral mixture, Milk fat, SNF, Crossbred dairy cows, Krishnagiri district of Tamil Nadu

Introduction

The livestock sector plays a pivotal role in the socio-economic development of developing nations by supporting livelihoods, enhancing nutritional security, and contributing significantly to the national economy. In India, the sector is deeply integrated into the rural economy, providing employment and sustenance to nearly 70 million households involved in dairy production (FAO, 2020). According to the 20th Livestock Census, India has a total milch cow population of 74.18 million, reflecting a 9.8% increase from the previous census. With a 22.67% share in global dairy output, India has maintained its position as the world's largest milk producer for over two decades (Herrero *et al.*, 2013) ^[1].

Despite this remarkable growth in total milk output, milk productivity per animal remains low, primarily due to nutritional deficiencies and suboptimal feeding practices. In particular, the quality of milk—defined by parameters such as fat and solid-not-fat (SNF) content—remains a critical concern, especially in crossbred dairy cows, which are increasingly preferred for their higher genetic potential. However, their productive and reproductive performance is highly sensitive to imbalanced diets, particularly those deficient in essential minerals (Bhandari *et al.*, 2016) ^[2].

Minerals are indispensable for maintaining optimal physiological and metabolic functions in dairy animals. They serve as structural components of tissues, enzyme cofactors, and are crucial in immune response, reproductive function, and lactation. Inadequate intake or imbalances in macro- and micro-minerals such as calcium (Ca), phosphorus (P), zinc (Zn), copper (Cu), cobalt (Co), and selenium (Se) have been shown to compromise milk composition and overall health status.

Moreover, feed-related constraints such as poor-quality fodder, limited grazing areas, and rising feed costs exacerbate mineral deficiencies in dairy herds across India. Several studies have documented the positive impact of area-specific mineral mixture supplementation on both milk production and quality. For instance, Muwel *et al.* (2020)^[9] observed that targeted mineral supplementation improved milk fat and SNF content along with reproductive performance. Similarly, Ahmed *et al.* (2022)^[1] demonstrated that mineral mixtures enriched with trace elements such as Zn, Mn, and Cu significantly enhanced milk fat and SNF levels, thereby improving the market value of milk and economic returns to farmers.

Bhandari *et al.* (2016)^[2] emphasized the role of minerals and vitamins in rumen fermentation, metabolism, and the biosynthesis of milk components. These findings are especially relevant to crossbred dairy cows, which exhibit greater nutritional sensitivity compared to indigenous breeds. The absence of regular mineral supplementation in regions like Krishnagiri district, Tamil Nadu, where smallholder dairy farming predominates, further underscores the need for field-based studies on milk quality enhancement through balanced feeding practices.

Given these perspectives, improving milk quality rather than merely increasing quantity has become a key priority for sustainable dairy development in India. Despite India's overall success in milk production, disparities in milk quality persist due to localized nutritional gaps and lack of awareness among farmers. The present study was undertaken with the following specific objectives:

- To promote awareness among dairy farmers regarding the importance of micronutrient supplementation in achieving optimal milk composition and animal health.
- To assess the effect of TANUVAS mineral mixture supplementation on the milk fat and SNF content of crossbred dairy cows reared under field conditions in Krishnagiri district, Tamil Nadu.

Materials and Methods

The present study was conducted in an adopted village located in Krishnagiri district of Tamil Nadu, a region characterized by mixed cropping and integrated livestock farming systems. The objective was to assess the effect of TANUVAS mineral mixture supplementation on milk quality, specifically fat and SNF content, under field-level, unorganized farming conditions—representative of the majority of smallholder dairy systems in India.

Selection of Farmers and Animals

A farmer awareness workshop was organized in the adopted village, with active participation from over 50 dairy farmers. The program emphasized the importance of mineral nutrition in improving livestock productivity and milk quality. From among the participants, 10 interested smallholder farmers—each owning at least five lactating dairy cows—were selected for inclusion in the study. The selection was made randomly among those who expressed interest, with the aim of representing typical unorganized farm conditions. Unlike structured experiments conducted on organized farms with standardized conditions (e.g., same breed, lactation stage, feeding, and management), this study aimed to evaluate mineral mixture supplementation under natural, heterogeneous conditions. This approach reflects the real-life variability encountered in rural dairy systems,

thereby providing more practical and applicable insights for smallholder farmers.

Supplementation Protocol

The cows were supplemented with TANUVAS Mineral Mixture, a standardized formulation developed by the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) for application across all agro-climatic zones of Tamil Nadu. The composition includes major minerals such as Calcium (23%), Phosphorus (12%), and Magnesium (6.5%), which are crucial for bone development, milk synthesis, and metabolic function. In addition, it contains trace minerals in carefully balanced proportions to support physiological and reproductive health: Iron (0.5%), Iodine (0.026%), Copper (0.077%), Manganese (0.12%), Cobalt (0.012%), Zinc (0.38%), Sulphur (0.5%), Fluorine (0.07%), and Selenium (0.3 ppm). This balanced mineral profile is intended to improve overall animal health, enhance immune function, and potentially contribute to better milk production. Farmers were advised to administer 50 grams per cow per day, divided into two equal doses (morning and evening), mixed with drinking water. The supplementation was continued daily for a period of 30 days.

Milk Data Collection

Milk samples were not collected directly by the investigators. Instead, milk quality parameters—specifically fat percentage and SNF—were obtained from the local milk cooperative society records, where each participating farmer regularly supplies milk. These societies use standardized and calibrated equipment to assess milk quality. Milk data for fat and SNF content were recorded every day (Days 1 - 30) throughout the supplementation period. This schedule enabled continuous monitoring of trends over time and facilitated the identification of any changes attributable to the mineral supplementation.

Statistical Analysis

Data analysis was performed using SPSS software. To evaluate the cumulative effect of mineral mixture supplementation, a paired t-test was employed. Specifically, the average fat and SNF content from the first three days (Days 0, 1, and 3) were compared with the average values from the last three days (Days 28, 29, and 30). To effectively communicate the impact of the intervention in a farmer-friendly manner, the percentage increase in milk quality parameters was also calculated using the following formula:

$$\text{Percentage Increase} = \left(\frac{\text{Experiment Ending period} - \text{Experiment Starting period}}{\text{Experiment Starting period}} \right) \times 100$$

A significance level of $p < 0.05$ was considered statistically significant for all comparisons.

Results and Discussion

Impact of Awareness Workshop on Mineral Mixture Utilization

A mineral mixture awareness workshop was conducted in the adopted village in Krishnagiri district as a preparatory step before field-level mineral supplementation. Over 50 dairy farmers actively participated in the workshop, which included interactive lectures, audiovisual sessions, and distribution of educational pamphlets in the local language. The content focused on the importance of balanced mineral

nutrition, benefits of TANUVAS mineral mixture, and practical methods of supplementation in an unorganised farm setting.

Pre-Workshop Awareness Level

Before the workshop, a preliminary interaction with the farmers revealed that:

- Only 20–30% of the farmers had ever heard of mineral mixtures.
- Among those, very few had ever used mineral supplements regularly.
- There was a general perception that balanced concentrate feed was sufficient, and the role of minerals in improving fat, SNF, reproduction, and animal health was not clearly understood.
- Some farmers had misconceptions, such as fearing mineral mixtures might cause heat stress or indigestion.

Workshop Outcomes

Post-workshop feedback and interactions indicated a significant improvement in knowledge and willingness to adopt mineral supplementation:

- Over 85% of the participants acknowledged understanding the concept of trace mineral requirements.
- Progressive farmers shared success stories, motivating peer farmers to take up supplementation practices.
- Videos showcasing before-after improvements in milk quality and animal fertility played a key role in breaking myths.
- Pamphlets were distributed covering details of dosage, method of administration, benefits, and scientific evidence from earlier studies.
- A majority of participants expressed enthusiasm to test the intervention in their own herds.
- From this pool, 10 interested and motivated farmers—each owning at least five lactating cows—were selected for the actual supplementation study.

Discussion

These observations are consistent with earlier reports emphasizing the role of educational interventions in livestock health and nutrition adoption. According to Pouchepparadjou *et al.* (2024) ^[10], farmer-centric training programmes significantly increase the uptake of nutritional

technologies, especially when combined with local demonstrations and extension materials. The translational approach—from lab to land—gained traction only when farmers could relate outcomes to their own practice.

Thus, the workshop laid the foundation for effective implementation of the field study, ensuring that farmers not only received the supplements but also understood the science and economics behind it. It helped bridge the gap between organized research findings and unorganized farming realities, which is especially vital in states like Tamil Nadu, where integrated smallholder farming systems dominate the dairy landscape.

Impact of Mineral Mixture on Milk Quality

Minerals are essential nutrients that play pivotal roles in maintaining animal health, enhancing metabolic efficiency, and improving both the yield and composition of milk. Deficiencies in macro- and micro-minerals can impair enzymatic activities, hormone regulation, rumen microbial efficiency, and epithelial integrity—ultimately limiting milk productivity and quality (Bhandari *et al.*, 2016) ^[2].

Combined Interpretation of Farmer-wise Performance

Across all ten farmers, a consistent trend of improvement was observed in milk yield, fat percentage, and SNF percentage following 30 days of TANUVAS mineral mixture supplementation. The average increase in total daily milk yield ranged from 0.90 L to 1.20 L per animal, with fat percentage rising by approximately 0.50 to 0.60%, and SNF increasing by about 0.50%. These enhancements were evident in both low- and high-yielding animals, demonstrating the universal applicability of mineral supplementation across varying productivity levels.

Animals starting with relatively lower baseline yields (e.g., 7.03–9.99 L/day) showed marked improvements, suggesting that mineral deficiencies might have been limiting their potential. The improved fat and SNF levels indicate enhanced metabolic function, possibly due to better ruminal fermentation, epithelial health, and nutrient absorption facilitated by trace elements such as calcium, phosphorus, zinc, cobalt, selenium, and magnesium. These elements are known to influence enzymatic pathways, hormone regulation, and microbial synthesis essential for milk component production (Ahmed *et al.* 2022) ^[1].

Table 1: Comparison of milk yield (L), SNF (%), and fat (%) between start (Day 1–3) and end (Day 28–30) of the experiment among 10 farmers (Mean ± SE)

Experiment start (First 3 Days – Day 1, 2 & 3)									
Farmer	Morning			Evening			Total		
	Milk	SNF	Fat	Milk	SNF	Fat	Milk	SNF	Fat
Farmer 1	6.14±0.10	8.24±0.05	4.57±0.07	3.85±0.08	8.19±0.06	5.29±0.06	9.99±0.18	8.22±0.06	4.93±0.07
Farmer 2	4.34±0.18	8.10±0.08	4.08±0.06	3.19±0.16	8.15±0.08	4.51±0.05	7.53±0.32	8.12±0.08	4.30±0.06
Farmer 3	4.58±0.29	8.21±0.06	4.84±0.06	2.45±0.06	8.49±0.06	5.27±0.07	7.03±0.34	8.35±0.06	5.06±0.06
Farmer 4	12.10±0.05	7.91±0.05	3.47±0.06	8.67±0.17	7.67±0.07	4.39±0.06	20.77±0.64	7.79±0.06	3.93±0.06
Farmer 5	5.53±0.29	7.73±0.06	3.75±0.06	3.42±0.29	7.24±0.04	5.91±0.06	8.95±0.56	7.49±0.05	4.83±0.06
Farmer 6	5.67±0.17	7.56±0.06	4.89±0.06	1.81±0.10	7.35±0.04	5.89±0.06	7.48±0.13	7.45±0.05	5.39±0.06
Farmer 7	7.63±0.03	6.53±0.06	3.60±0.06	5.43±0.28	7.90±0.03	4.65±0.08	13.07±0.32	7.22±0.04	4.13±0.07
Farmer 8	9.75±0.90	8.30±0.05	4.11±0.05	8.37±0.32	8.09±0.06	5.75±0.08	18.12±1.16	8.20±0.06	4.93±0.07
Farmer 9	15.56±0.39	7.18±0.06	3.95±0.04	10.77±0.12	7.90±0.06	5.47±0.07	26.33±0.51	7.54±0.06	4.71±0.05
Farmer 10	14.12±0.49	7.59±0.06	3.70±0.06	10.78±0.61	7.37±0.07	5.11±0.05	24.90±1.00	7.48±0.07	4.40±0.06
Experiment End (Last 3 Days – Day 28, 29 & 30)									
Farmer	Morning			Evening			Total		
	Milk	SNF	Fat	Milk	SNF	Fat	Milk	SNF	Fat

Farmer 1	6.74±0.14	8.84±0.09	5.17±0.12	4.35±0.13	8.69±0.11	5.79±0.11	11.09±0.27	8.77±0.10	5.48±0.11
Farmer 2	4.94±0.20	8.70±0.13	4.68±0.11	3.69±0.21	8.65±0.13	5.01±0.09	8.63±0.39	8.67±0.13	4.85±0.10
Farmer 3	5.18±0.30	8.81±0.10	5.44±0.10	2.95±0.10	8.99±0.11	5.77±0.11	8.13±0.38	8.90±0.10	5.61±0.11
Farmer 4	12.70±0.55	8.51±0.10	4.07±0.10	9.17±0.21	8.17±0.12	4.89±0.11	21.87±0.75	8.34±0.11	4.48±0.10
Farmer 5	6.13±0.32	8.33±0.10	4.35±0.10	3.92±0.34	7.74±0.08	6.41±0.10	10.05±0.64	8.04±0.09	5.38±0.10
Farmer 6	6.27±0.18	8.16±0.10	5.49±0.10	2.31±0.15	7.85±0.08	6.39±0.11	8.58±0.23	8.00±0.09	5.94±0.11
Farmer 7	8.23±0.09	7.13±0.10	4.20±0.10	5.93±0.33	8.40±0.05	5.15±0.12	14.17±0.42	7.77±0.08	4.68±0.11
Farmer 8	10.35±0.92	8.90±0.10	4.71±0.09	8.87±0.37	8.59±0.11	6.25±0.12	19.22±1.21	8.75±0.10	5.48±0.11
Farmer 9	16.16±0.43	7.78±0.10	4.55±0.07	11.27±0.17	8.40±0.10	5.97±0.11	27.43±0.59	8.09±0.10	5.26±0.09
Farmer 10	14.72±0.55	8.19±0.10	4.30±0.10	11.28±0.66	7.87±0.12	5.61±0.10	26.00±1.12	8.03±0.11	4.95±0.10

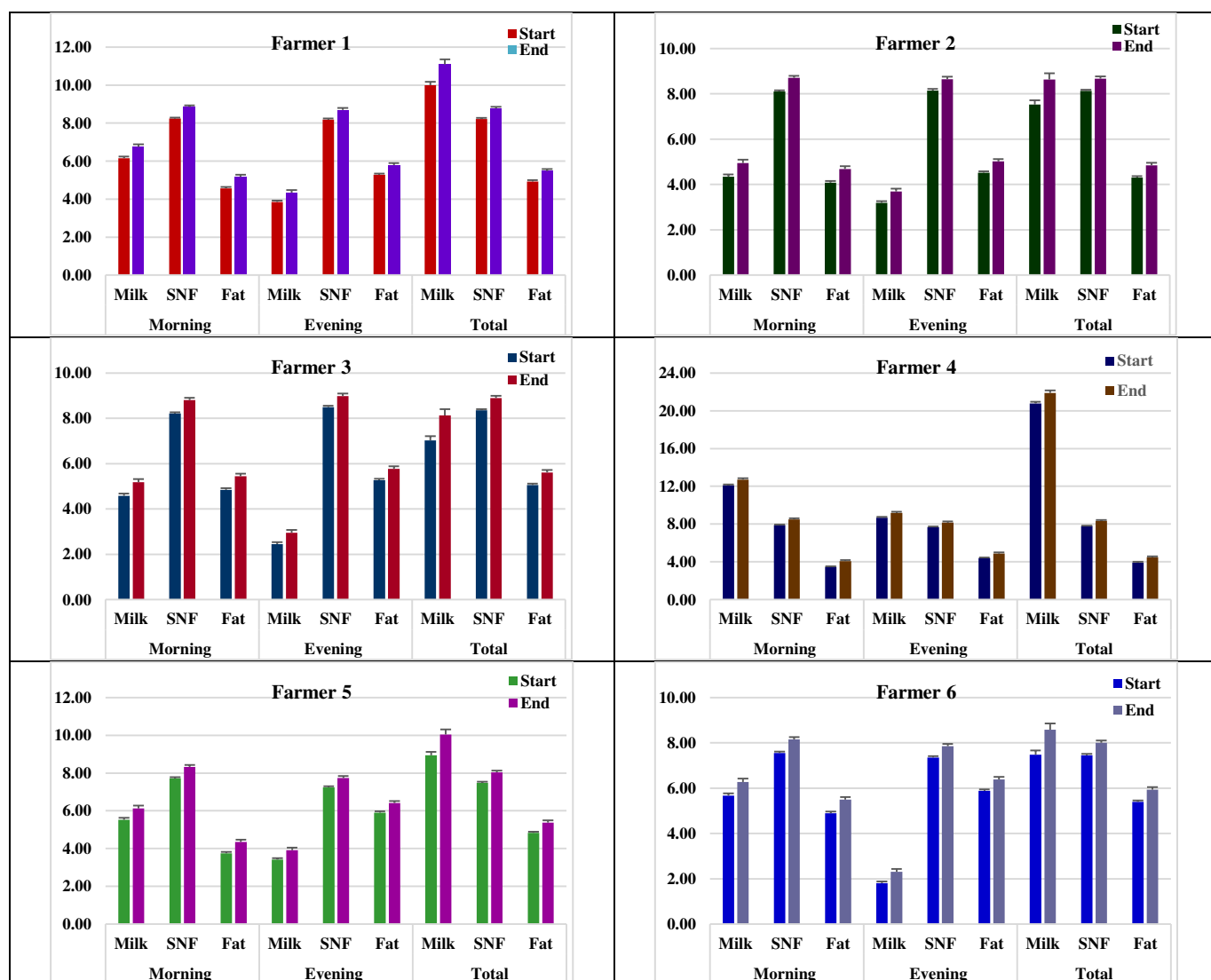
The data collectively suggest that TANUVAS mineral mixture supplementation under field conditions leads to tangible and significant enhancements in both the quantity and quality of milk, regardless of the starting yield or herd composition. These findings substantiate earlier controlled studies, reaffirming the relevance of mineral nutrition in unorganised smallholder systems typical of Tamil Nadu.

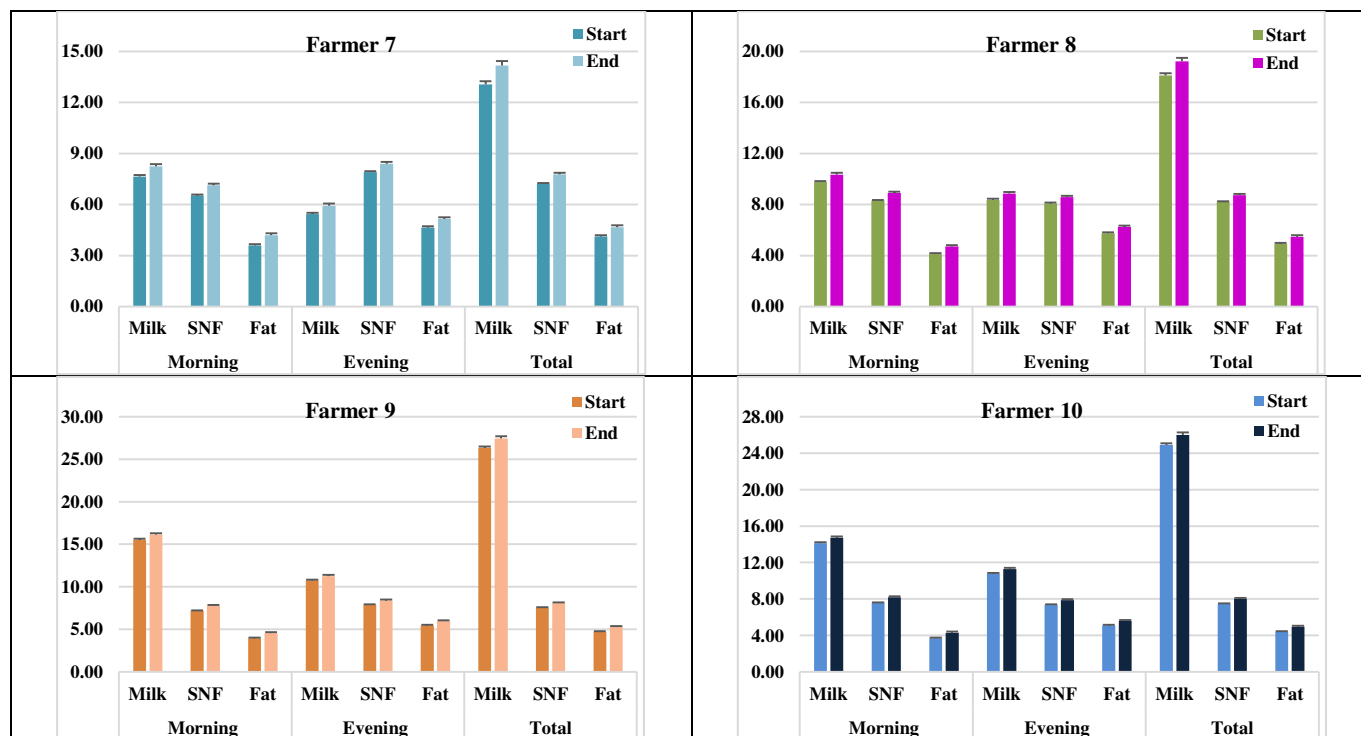
Even among high-yielding animals (e.g., those producing above 18–26 L/day), statistically significant improvements were noted in both milk quality and yield, signifying that strategic mineral optimization benefits not only nutrient-deficient animals but also those under metabolic strain from

high production. This aligns with findings from Bhandari *et al.* (2016)^[2] and Muwel *et al.* (2020)^[9], who reported similar enhancements in high-producing cows after supplementation with balanced mineral mixes.

Notably, improvements in fat percentage were especially pronounced in most cases—rising from an average of ~4.6% to ~5.3%. Fat being a critical determinant of milk price in most procurement systems, this increase has direct economic implications for the farmer. Enhanced SNF percentages, ranging from initial levels of ~7.5–8.3% to ~8.0–8.9%, indicate a better nutrient profile, which contributes to consumer quality and milk preservation.

Fig 1: Assessment of TANUVAS Mineral Mixture Supplementation on Milk Yield, Fat, and SNF in Crossbred Dairy Cows under Varied Field Conditions. Data represent average values from three days at the start (Day 1–3) and end (Day 28–30) of the trial, including morning and evening milk collections from different farmers with variable feeding patterns and lactation periods.





Overall Statistical Outcome

When aggregated, the data showed a statistically significant ($p < 0.01$) increase in:

- **Total daily milk yield:** from 14.59 ± 2.29 L to 16.11 ± 2.52 L
- **Fat percentage:** from $4.63 \pm 0.42\%$ to $5.29 \pm 0.34\%$
- **SNF percentage:** from $7.79 \pm 0.32\%$ to $8.37 \pm 0.30\%$

These results are presented in Table 2 and validate the hypothesis that mineral deficiencies were likely limiting factors in milk productivity. The paired t-test confirmed that these changes were not due to random variation but rather the result of the dietary intervention.

Table 2: Effect of TANUVAS Mineral Mixture Supplementation on Milk Yield (Litres), Solids-Not-Fat (%) and Fat Content (%) in Cows: Comparison Between Day 1–3 and Day 28–30.

Parameter	t-value	p-value	Significance
Milk (litres)	2.97×10^5	2.81×10^{-13}	Highly significant ($p < 0.05$)
SNF (%)	2.40×10^5	1.94×10^{-13}	Highly significant ($p < 0.05$)
Fat (%)	3.89×10^5	2.50×10^{-13}	Highly significant ($p < 0.05$)

Statistical comparison was performed using Student's paired t-test to evaluate the significance of changes in milk yield, SNF, and fat content before and after 30 days of

supplementation. A p value < 0.05 was considered statistically significant.

Effect of Mineral Mixture Supplementation on Milk Yield and Quality

Overall percentage-level differences were calculated based on feedback and field constraints. Most farmers are illiterate and prefer simple, comprehensible results. After one month of supplementation, a consistent improvement was noted across all farmers. The mean percentage increase in morning milk yield was $8.52 \pm 1.21\%$; SNF increased by $7.80 \pm 0.20\%$, and fat by $14.84 \pm 0.59\%$. Evening values showed milk yield rising by $12.16 \pm 2.56\%$, SNF by $6.40 \pm 0.11\%$, and fat by $9.67 \pm 0.36\%$. Overall daily values showed increases of $9.66 \pm 1.51\%$ for yield, $7.08 \pm 0.12\%$ for SNF, and $11.91 \pm 0.40\%$ for fat content. These findings suggest mineral mixture supplementation significantly improved both milk quantity and quality at the field level.

Scientific Interpretation of Results

The effect of TANUVAS mineral mixture supplementation on milk yield and composition was assessed by comparing the percentage increases in milk yield, SNF, and fat content across 10 dairy farmers over a one-month period. The observed percentage changes were subjected to one-sample t-tests to determine whether the mean increases across the cohort were significantly different from zero (Table 3).

Table 3: Statistically Significant Improvements After Mineral Mixture Supplementation

Parameter	Time	Average % Increase	Statistical Significance (p-value)
Milk Yield	Morning	$8.52 \pm 1.21\%$	$p < 0.001$
SNF	Morning	$7.80 \pm 0.20\%$	$p < 0.001$
Fat	Morning	$14.84 \pm 0.59\%$	$p < 0.001$
Milk Yield	Evening	$12.16 \pm 2.56\%$	$p < 0.001$
SNF	Evening	$6.40 \pm 0.11\%$	$p < 0.001$
Fat	Evening	$9.67 \pm 0.36\%$	$p < 0.001$
Milk Yield	Total	$9.66 \pm 1.51\%$	$p < 0.001$
SNF	Total	$7.08 \pm 0.12\%$	$p < 0.001$
Fat	Total	$11.91 \pm 0.40\%$	$p < 0.001$

Milk Yield Improvements

The average percentage increase in milk yield was statistically significant across all time points. Morning milk yield increased by $8.52 \pm 1.21\%$ ($p < 0.00005$), evening yield by $12.16 \pm 2.56\%$ ($p = 0.00072$), and total daily yield by $9.66 \pm 1.51\%$ ($p = 0.000085$). These results confirm a consistent and meaningful enhancement in milk productivity following mineral supplementation.

Supporting our findings, Chitra (2021)^[4] conducted a study on the effect of TANUVAS mineral mixture supplementation on milk yield and composition of crossbred dairy cattle in Tiruppur district of Tamil Nadu and observed a milk yield increase of 18.59%. Similarly, other studies have shown that dietary supplementation with mineral mixtures in dairy cattle positively impacts milk production. For instance, Islam *et al.* (2023)^[8] reported that supplementation over a period of 120 days increased milk production by an average of 1.45 L (13.48%) per animal per day (equivalent to 43.5 L/animal/month).

SNF Improvements

SNF, a crucial quality parameter influencing both milk processing and pricing, showed a significant increase in morning ($7.80 \pm 0.20\%$, $p < 2.0 \times 10^{-11}$), evening ($6.40 \pm 0.11\%$, $p < 6.0 \times 10^{-13}$), and total daily ($7.08 \pm 0.12\%$, $p < 5.0 \times 10^{-13}$) collections. The extremely low p-values indicate high reliability of the observed improvements. These gains may reflect improved rumen function and nutrient absorption attributable to balanced mineral intake. In line with our findings, Chitra (2021)^[4] observed an increase in SNF content by 8.95% in crossbred dairy cattle supplemented with the TANUVAS mineral mixture.

Fat Content Improvements

Fat content, the most economically important trait in milk pricing, also improved significantly. Morning fat increased by $14.84 \pm 0.59\%$ ($p < 8.0 \times 10^{-10}$), evening fat by $9.67 \pm 0.36\%$ ($p < 4.0 \times 10^{-10}$), and overall fat by $11.91 \pm 0.40\%$ ($p < 2.0 \times 10^{-10}$). This suggests an enhancement in lipid metabolism and mammary gland function due to improved trace mineral adequacy. Chitra (2021)^[4] similarly reported a substantial increase in milk fat content, with a 32.52% improvement following TANUVAS mineral mixture supplementation.

Biological and Scientific Relevance

The biological plausibility of these improvements is supported by the well-established roles of trace minerals such as zinc, copper, cobalt, and manganese in enzymatic processes related to feed utilization, immunity, and metabolic efficiency. Improved mineral status likely enhanced microbial fermentation in the rumen and metabolic conversion into milk components.

The improvement in fat content further suggests enhanced fiber digestibility and better volatile fatty acid (VFA) production, especially acetate, a key precursor for milk fat synthesis. Minerals like magnesium and sulfur are known to support rumen fermentation and microbial stability. The observed rise in SNF values, which include lactose, casein, and water-soluble vitamins, indicates improved metabolic function and protein turnover, likely facilitated by zinc, manganese, and B-complex co-factors. Importantly, consistent responses across a variety of baseline production levels suggest that the effect of mineral supplementation is

robust and scalable. Even high-yielding animals showed improvement, highlighting that subclinical mineral deficiencies may be present even in apparently healthy, productive cows.

These findings align with those of Burman *et al.* (2020)^[3], who reported increases in milk yield, milk fat percentage, and SNF percentage in dairy cows following mineral mixture supplementation. Singh *et al.* (2020)^[3, 13] also reported increased milk production and lactation length in cattle following area-specific mineral mixture supplementation. Hackbart *et al.* (2010)^[6] observed increases in milk production when dairy animals in mid-lactation were supplemented with organic zinc, manganese, copper, and cobalt.

Sahoo *et al.* (2021)^[12] demonstrated that mineral supplementation improved nutrient utilization, mineral bioavailability, and milk production while enhancing farm family income by 30%. Singh *et al.* (2020)^[3, 13] found an average increase of 0.5 L of milk per day per animal with area-specific mineral supplementation. Vinothraj *et al.* (2021)^[14] reported an increase of 1.06 L of milk/day/animal, milk fat by 1.73%, and SNF by 0.77%, with an economic gain of ₹788 per animal per day with TANUVAS mineral mixture. Ram Niwas *et al.* (2021)^[11] also noted that dietary inclusion of mineral mixtures enhances milk composition, production, and fertility. The benefit-cost ratio indicates that mineral supplementation in dairy animals is profitable and improves overall productivity, enabling farmers to gain more from existing animals.

Key Message for Farmers

Incorporating a mineral mixture into the daily feed of dairy cows has been demonstrated to significantly improve both the quantity and quality of milk within just one month of supplementation. This simple and affordable intervention leads to noticeable increases in milk yield, along with enhanced levels of milk fat and SNF, which are critical factors determining milk's nutritional value and market price.

By improving milk fat and SNF content, farmers can achieve higher earnings due to better pricing, as milk buyers often pay premiums for richer milk. Additionally, the increased milk volume supports greater availability for household consumption, contributing directly to family nutrition and food security.

This approach is especially valuable because it addresses common subclinical mineral deficiencies that can limit milk production and animal health, without requiring expensive or complex inputs. The mineral mixture improves rumen function and overall metabolism, resulting in healthier cows that produce more nutrient-rich milk.

Importantly, this practice is practical and scalable — suitable for small, medium, and large dairy operations. It empowers farmers to enhance productivity sustainably, with minimal extra effort or cost. Given the consistent positive outcomes observed across diverse farming conditions, adopting mineral supplementation should be considered a cornerstone strategy in dairy management for improving livelihoods and dairy sector profitability.

Conclusion

The present study demonstrates that supplementation of the TANUVAS mineral mixture significantly improves key milk quality parameters, specifically milk fat and SNF

content, in crossbred dairy cows under field conditions in Krishnagiri district. The mineral mixture effectively addressed the micronutrient deficiencies commonly observed in the region, contributing to enhanced metabolic functions and overall health status of the cows. This nutritional intervention not only improved the nutritive value of milk but also holds potential for increasing the economic returns for dairy farmers by producing higher-quality milk that meets consumer preferences and market standards.

The observed improvements in milk fat and SNF highlight the critical role of balanced mineral supplementation in sustaining optimal lactation performance and reproductive efficiency. Moreover, the findings underscore the importance of region-specific mineral mixtures tailored to local soil and forage mineral profiles to maximize animal productivity. Given the positive outcomes, integration of the TANUVAS mineral mixture into routine dairy management practices is recommended for small and marginal farmers in Krishnagiri and similar agro-climatic zones. Overall, this study provides strong evidence supporting the strategic use of mineral supplementation as a practical and sustainable approach to enhance milk quality and profitability in crossbred dairy herds.

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Conflict of Interest

There is no conflict of interest.

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