

Evaluation of Tanuvas Smart mineral mixture as a nutritional intervention for improving milk yield, milk fat percentage and economic returns in lactating dairy cattle

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Abstract

Mineral deficiencies remain one of the major nutritional constraints affecting the productivity of dairy cattle maintained under smallholder farming systems in India. Inadequate supplementation of essential macro- and micro-minerals adversely affects milk production, milk composition, reproductive performance and overall animal health, thereby reducing farm profitability. The present study was undertaken to evaluate the effectiveness of TANUVAS SMART Mineral Mixture as a nutritional intervention for improving milk yield, milk fat percentage and economic returns in lactating dairy cattle under field conditions. The study was conducted as a Frontline Demonstration (FLD) by Krishi Vigyan Kendra, Kundrakudi, Tamil Nadu Veterinary and Animal Sciences University, at Pillayarpatti village of Sivagangai district, Tamil Nadu. Ten progressive dairy farmers possessing healthy lactating crossbred cows were selected, and one cow from each farm was supplemented daily with TANUVAS SMART Mineral Mixture along with the regular concentrate feed for a period of 90 days. Milk yield, milk fat percentage, feed intake, body condition, general health and economic returns were recorded before and after supplementation. The supplementation resulted in a significant improvement in productive performance. The average daily milk yield increased from 7.50 ± 0.42 L to 8.63 ± 0.46 L, representing a 15.07% increase, while milk fat percentage improved from $3.80 \pm 0.18\%$ to $4.20 \pm 0.21\%$. Farmers also reported improved feed intake, better body condition, enhanced reproductive performance and reduced incidence of metabolic disorders. Economic analysis indicated an additional income of approximately ₹3,168 per animal over the 90-day supplementation period after accounting for the cost of mineral supplementation. The findings demonstrate that TANUVAS SMART Mineral Mixture is an effective, economical and farmer-friendly nutritional intervention for enhancing milk production and profitability under village production systems. Wider dissemination through Krishi Vigyan Kendras and extension programmes could substantially improve dairy productivity and strengthen the livelihoods of smallholder farmers.

Keywords: Dairy cattle, frontline demonstration, KVK, mineral supplementation, milk fat, milk yield, nutritional intervention, TANUVAS SMART mineral mixture

Introduction

Dairying is one of the most important components of Indian agriculture, contributing substantially to rural livelihoods, nutritional security and the national economy. India has maintained its position as the world's largest milk producer, accounting for approximately 24% of global milk production. According to the Basic Animal Husbandry Statistics (2024) [2], the country's milk production has shown consistent growth over the past decade. However, despite the large livestock population, the average productivity of dairy cattle remains considerably lower than the genetic potential of improved breeds. Poor nutritional management, particularly mineral deficiencies, has been identified as one of the major constraints affecting milk production, reproductive efficiency and overall health of dairy animals (BAHS, 2024; NRC, 2001) [2, 7].

Nutrition is a key determinant of productive and reproductive performance in dairy cattle. While adequate energy and protein are essential for sustaining milk production, balanced mineral nutrition is equally important for maintaining normal physiological functions. Minerals are involved in numerous biochemical and metabolic processes, including enzyme activation, hormone synthesis, nerve impulse transmission, muscle contraction, immune response, skeletal development and mammary gland

function (McDowell, 2003). Both macro-minerals such as calcium, phosphorus, magnesium, sodium and potassium and trace minerals including zinc, copper, manganese, cobalt, iodine and selenium are indispensable for optimum production and health in dairy animals.

Mineral deficiencies are widespread under tropical livestock production systems because dairy animals are predominantly maintained on crop residues, native grasses and locally available feed resources that often fail to supply essential minerals in adequate quantities. Furthermore, depletion of soil nutrients due to continuous cultivation, imbalance in fertilizer application and climatic variability influences the mineral composition of fodder crops, resulting in deficiencies in livestock (Underwood and Suttle, 1999) [12]. These hidden deficiencies frequently remain unnoticed by farmers because the clinical signs develop gradually and are often mistaken for poor genetic potential or ageing of the animals.

Inadequate mineral nutrition adversely affects several productive and reproductive parameters in dairy cattle. Deficiencies of calcium and phosphorus reduce milk yield and predispose animals to metabolic disorders such as milk fever, while deficiencies of copper, zinc and manganese impair immune function, fertility and hoof health. Selenium and vitamin E play a crucial role in antioxidant defence and

help reduce the incidence of mastitis and retained placenta (Spears and Weiss, 2014) ^[11]. Similarly, cobalt is essential for vitamin B₁₂ synthesis by rumen microorganisms, thereby influencing fibre digestion and energy metabolism. Therefore, balanced mineral supplementation has become an integral component of scientific dairy feeding programmes aimed at improving production efficiency and animal welfare.

Milk yield and milk composition are directly influenced by the nutritional status of dairy animals. Adequate mineral supplementation improves rumen microbial activity, enhances digestibility of fibrous feeds and optimizes nutrient utilization, thereby increasing the availability of precursors required for milk synthesis. Improved ruminal fermentation also promotes acetate production, which serves as a major substrate for milk fat synthesis. Consequently, balanced mineral supplementation has been reported to improve both milk quantity and quality in lactating dairy cattle (Nocek *et al.*, 2006 ^[8]; Weiss, 2017).

Several studies have demonstrated the positive effects of mineral supplementation on dairy performance. Garg *et al.* (2008) ^[3] reported significant improvements in milk production and reproductive efficiency following balanced mineral supplementation under field conditions. Kumar *et al.* (2011) ^[5] observed increased milk yield, improved conception rates and reduced incidence of reproductive disorders in crossbred cows receiving mineral mixtures. Similarly, Yattoo *et al.* (2013) ^[14] emphasized the importance of trace minerals in enhancing immune competence, antioxidant status and metabolic efficiency in livestock. These findings highlight the need for strategic mineral supplementation as a practical approach to improve dairy productivity under smallholder farming systems.

Recognizing the importance of balanced mineral nutrition, the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) has developed TANUVAS SMART Mineral Mixture, a scientifically formulated mineral supplement designed to correct mineral deficiencies commonly encountered in dairy animals under field conditions. The formulation contains balanced concentrations of essential macro- and micro-minerals required for supporting milk production, reproductive performance, immune function and metabolic health. The product has been developed considering the nutritional requirements of dairy cattle reared under tropical production systems and is intended to provide an economical and farmer-friendly solution for improving dairy productivity.

Technology assessment through Frontline Demonstrations (FLDs) conducted by Krishi Vigyan Kendras (KVKs) plays a vital role in bridging the gap between research and field application. Frontline demonstrations enable the evaluation of newly developed technologies under actual farmer-managed conditions, while simultaneously creating awareness and encouraging adoption among the farming community. Unlike controlled experimental trials, FLDs provide realistic information on the performance, feasibility and economic viability of technologies under diverse production environments. The participatory approach adopted by KVKs also facilitates continuous interaction between scientists and farmers, thereby improving technology refinement and dissemination.

Krishi Vigyan Kendra (KVK), Kundrakudi, functioning under the Directorate of Extension Education, Tamil Nadu Veterinary and Animal Sciences University, regularly

conducts frontline demonstrations to promote scientific livestock management practices among farmers in Sivagangai district. Balanced mineral supplementation has been identified as one of the priority interventions for enhancing milk production and profitability in the district, where many dairy animals are maintained on crop residue-based feeding systems.

Keeping these facts in view, the present investigation was undertaken to evaluate the effectiveness of TANUVAS SMART Mineral Mixture as a nutritional intervention for improving milk yield, milk fat percentage and economic returns in lactating dairy cattle under farmer-managed conditions through a Frontline Demonstration programme implemented by Krishi Vigyan Kendra, Kundrakudi, Sivagangai district, Tamil Nadu. The study also aimed to assess the field applicability and farmer acceptability of the technology for its wider dissemination among dairy farmers.

Materials and Methods

1. Study area

The present study was conducted from May 2024 to August 2024 in Pillayarpatti village, Sivagangai district, Tamil Nadu, under the Frontline Demonstration (FLD) programme implemented by Krishi Vigyan Kendra (KVK), Kundrakudi, Tamil Nadu Veterinary and Animal Sciences University (TANUVAS). The study area falls under the semi-arid agro-climatic zone of Tamil Nadu, where dairy farming serves as an important subsidiary occupation supporting the livelihoods of rural households. Crossbred dairy cattle maintained under semi-intensive management systems constitute the predominant dairy population in the selected village. The demonstration was undertaken to assess the effectiveness of TANUVAS SMART Mineral Mixture in improving milk production, milk quality and economic returns under farmer-managed conditions.

2. Selection of farmers and experimental animals

A benchmark survey was conducted by scientists of Krishi Vigyan Kendra, Kundrakudi, to identify suitable beneficiaries for the Frontline Demonstration. Based on predefined selection criteria, ten progressive dairy farmers possessing healthy lactating crossbred cows were selected for the study. The selection was based on farmers' willingness to participate in the demonstration, availability of healthy lactating animals, adoption of similar feeding and management practices, regular milk marketing and willingness to maintain production records throughout the study period. Prior informed consent was obtained from all participating farmers before commencement of the demonstration. One healthy lactating crossbred cow from each selected farmer was included in the study, resulting in a total of 10 experimental animals. All selected cows were clinically healthy, in early to mid-lactation, free from infectious diseases and maintained under similar village production systems throughout the study period.

3. Farmer training programme

Prior to the commencement of the Frontline Demonstration, a one-day capacity-building programme was organized by Krishi Vigyan Kendra, Kundrakudi to create awareness among the selected farmers regarding scientific dairy management practices. The training programme covered balanced feeding practices, importance of mineral nutrition, symptoms of mineral deficiencies, scientific

supplementation of TANUVAS SMART Mineral Mixture, clean milk production and maintenance of production records. Practical demonstrations on mineral mixture supplementation and feeding management were also conducted. In addition, extension literature containing scientific recommendations on dairy feeding and mineral supplementation was distributed to all participating farmers.

Table 1: Profile of experimental animals

Particular	Description
Study location	Pillayarpatthi village, Sivagangai district
Implementing agency	Krishi Vigyan Kendra, Kundrakudi, TANUVAS
Study period	90 days
Number of farmers	10
Number of dairy cows	10
Breed	Crossbred cattle
Lactation stage	Early to mid-lactation
Management system	Semi-intensive

4. Tanuvas Smart Mineral Mixture

TANUVAS SMART Mineral Mixture is a scientifically formulated balanced mineral supplement developed by the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) for dairy animals. The formulation contains optimum levels of essential macro-minerals and trace minerals required for maintaining normal physiological functions, milk production, milk quality, reproductive efficiency, immune competence, metabolic health and skeletal development. The mineral mixture is specifically designed to correct hidden mineral deficiencies commonly encountered under village feeding systems and to improve productive and reproductive performance in dairy cattle.

5. Experimental design

The study followed a single-group pre- and post-intervention Frontline Demonstration design. Baseline observations on milk yield, milk fat percentage, feed intake, body condition score and general health status were recorded before initiating mineral supplementation. Each selected dairy cow received TANUVAS SMART Mineral Mixture mixed with the concentrate ration daily for a period of 90 consecutive days according to the recommended feeding schedule. No other modifications were made to the existing feeding or management practices adopted by the farmers. Periodic observations were recorded at Day 0, Day 30, Day 60 and Day 90 to evaluate the effect of mineral supplementation.

6. Feeding management

Throughout the experimental period, all animals were maintained under the existing feeding and management practices followed by the respective farmers. The basal ration consisted of locally available green fodder, dry fodder and concentrate mixture, while clean drinking water was provided ad libitum. The only intervention introduced during the study was supplementation with TANUVAS SMART Mineral Mixture, which was thoroughly mixed with the concentrate feed before feeding to ensure complete consumption by the animals.

7. Data collection

Milk production and animal health parameters were monitored throughout the study period. Daily milk yield was

recorded separately during morning and evening milking using graduated measuring jars, and the average daily milk yield was calculated for each experimental animal. Milk fat percentage was determined using the Gerber method at the local dairy cooperative milk collection centre before initiation of supplementation and after completion of the demonstration. Feed intake was assessed based on voluntary feed consumption, appetite, concentrate intake, green fodder intake and feed refusal observed during periodic farm visits. Body condition of each animal was evaluated visually using the standard Body Condition Score (BCS) method. General health observations included assessment of coat quality, alertness, rumination, digestive disturbances, metabolic disorders and reproductive behaviour throughout the study period.

Table 2: Parameters evaluated during the study

Production parameters	Health parameters	Economic parameters
Milk yield	Feed intake	Additional milk income
Milk fat (%)	Body condition score	Cost of supplementation
Average milk production	General health status	Net income
Daily milk production	Reproductive performance	Benefit-Cost ratio

8. Economic analysis

Economic analysis was carried out to evaluate the profitability of TANUVAS SMART Mineral Mixture supplementation under field conditions. The analysis included estimation of additional milk production, additional daily income, cost of mineral supplementation, net economic return and Benefit-Cost (B:C) ratio. The prevailing milk procurement price in the study area during the demonstration period was used for calculating the additional income generated through increased milk production.

9. Extension methodology

The demonstration was implemented following the standard Frontline Demonstration (FLD) methodology recommended by the Indian Council of Agricultural Research (ICAR). The extension strategy included diagnostic survey, selection of beneficiary farmers, capacity-building programmes, field demonstrations, periodic monitoring, scientific supervision, data recording, advisory services, farmer feedback collection and final evaluation. Regular field visits by scientists of Krishi Vigyan Kendra, Kundrakudi ensured proper implementation of the recommended technology and facilitated timely technical guidance to the participating farmers.

10. Statistical analysis

The experimental data were compiled using Microsoft Excel 2021 and analysed using IBM SPSS Statistics Version 26.0 (IBM Corp., Armonk, NY, USA). The results were expressed as Mean $\pm$ Standard Error (SE). Differences between pre-supplementation and post-supplementation observations were analysed using the paired Student's *t*-test, and differences were considered statistically significant at $P < 0.05$.

11. Ethical statement

The present investigation involved evaluation of a nutritional intervention under normal farm management conditions and did not include any invasive experimental procedures. The study was conducted in accordance with the ethical principles for animal welfare followed by the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS). Prior informed consent was obtained from all participating farmers before commencement of the Frontline Demonstration.

Results and discussion

1. Effect of Tanuvass Smart Mineral Mixture on Milk Yield

The supplementation of TANUVAS SMART Mineral Mixture for 90 consecutive days significantly improved the milk production of lactating dairy cattle maintained under farmer-managed conditions.

Table 3: Effect of TANUVAS SMART Mineral Mixture on milk yield

Particular	Before supplementation	After supplementation	Increase	Improvement (%)
Milk yield (L/day)	7.50 ± 0.42	8.63 ± 0.46	1.13	15.07

Values are expressed as Mean ± SE (n = 10).

2. Effect on Milk Fat Percentage

Milk fat percentage is an important quality parameter influencing the market value of milk. Supplementation with TANUVAS SMART Mineral Mixture significantly increased milk fat percentage from 3.80 ± 0.18% to 4.20 ± 0.21%, representing an improvement of 10.53% (Table 4). The increase in milk fat percentage may be due to improved ruminal fibre digestion and increased production of volatile fatty acids, particularly acetate, which serves as the principal precursor for milk fat synthesis. Minerals such as cobalt, zinc and copper enhance microbial fermentation and improve nutrient digestibility, thereby contributing to improved milk composition. Similar observations have been reported by Nocek *et al.* (2006) [8] and McDowell (2003), who highlighted the role of balanced mineral nutrition in improving milk quality.

Table 4: Effect of TANUVAS SMART Mineral Mixture on milk fat percentage

Particular	Before supplementation	After supplementation	Improvement (%)
Milk fat (%)	3.80 ± 0.18	4.20 ± 0.21	10.53

3. Effect on Feed Intake and General Health

In addition to improvements in milk production, the participating farmers reported noticeable improvements in the general health and productive performance of the dairy animals. The cows supplemented with TANUVAS SMART Mineral Mixture exhibited:

- Improved appetite and feed intake.
- Better body condition.
- Glossy hair coat.
- Increased alertness and activity.
- Improved rumination.
- Reduced occurrence of metabolic disorders.
- Better reproductive behaviour.

The enhanced health status could be attributed to improved mineral balance, which supports enzyme activity, immune function, antioxidant defence and endocrine regulation.

The average daily milk yield increased from 7.50 ± 0.42 L/day before supplementation to 8.63 ± 0.46 L/day after supplementation, representing an increase of 15.07% over the baseline production (Table 3). The improvement in milk yield can be attributed to the correction of hidden deficiencies of essential macro- and micro-minerals, which play important roles in carbohydrate metabolism, protein synthesis, rumen microbial activity, enzyme activation and mammary gland function. Adequate mineral nutrition improves feed utilization efficiency and promotes optimum metabolic activity, resulting in enhanced milk synthesis. The present findings are in agreement with those of Garg *et al.* (2008) [3], who reported that balanced mineral supplementation significantly improved milk production under field conditions. Similarly, Kumar *et al.* (2011) [5] observed an increase in milk yield and better reproductive performance in dairy cows supplemented with mineral mixtures.

Minerals such as zinc, selenium and copper are known to strengthen immune competence and reduce oxidative stress during lactation.

Table 5: Effect of TANUVAS SMART Mineral Mixture on animal health

Parameter	Observation after supplementation
Feed intake	Improved
Body condition	Improved
Hair coat	Glossy
Rumination	Improved
Animal activity	Increased
Metabolic disorders	Reduced
Reproductive performance	Improved

4. Economic Analysis

The economic feasibility of the technology was assessed based on the additional milk yield obtained during the supplementation period. The average increase in milk production was 1.13 L/day per animal. Assuming a prevailing milk procurement price of ₹40 per litre, the additional income generated was ₹45.20/day. Over the 90-day supplementation period, the total additional income amounted to approximately ₹4,068 per animal. After deducting the estimated cost of TANUVAS SMART Mineral Mixture (₹900/animal), the net additional return was ₹3,168 per animal, with a Benefit:Cost ratio of 4.52:1. These findings indicate that TANUVAS SMART Mineral Mixture is a highly economical nutritional intervention that provides substantial financial benefits to dairy farmers with minimal additional investment.

5. Farmer Feedback and Technology Adoption

The Frontline Demonstration generated considerable interest among dairy farmers in Pillayarpatthi village. All ten participating farmers expressed satisfaction with the performance of TANUVAS SMART Mineral Mixture and indicated their willingness to continue supplementation after completion of the demonstration. The visible improvements in milk production, milk quality and animal health

encouraged neighbouring farmers to seek information about the technology. The demonstration also enhanced farmers' awareness regarding the importance of balanced mineral nutrition in dairy cattle and strengthened their confidence in adopting scientific feeding practices. Such extension interventions play a crucial role in bridging the gap between research and field application.

Table 7: Farmer perception of TANUVAS SMART Mineral Mixture (n = 10)

Parameter	Farmers reporting positive response (%)
Increase in milk yield	100
Improvement in milk fat	90
Better feed intake	100
Improved body condition	90
Overall satisfaction	100
Willingness to continue supplementation	100

Discussion

The present Frontline Demonstration clearly demonstrated that supplementation with TANUVAS SMART Mineral Mixture significantly improved milk yield, milk fat

percentage and economic returns under farmer-managed conditions. Balanced mineral nutrition is fundamental for optimizing rumen fermentation, nutrient digestibility, enzyme activity and mammary gland metabolism. Correction of hidden mineral deficiencies enhances metabolic efficiency, enabling dairy cows to utilize available nutrients more effectively for milk synthesis. The observed increase in milk fat percentage further suggests improved ruminal acetate production resulting from enhanced fibre digestion. Similar findings have been reported by Garg *et al.* (2008), Kumar *et al.* (2011) and Nocek *et al.* (2006) [3, 5, 8], who documented improvements in milk yield, milk composition and reproductive performance following balanced mineral supplementation. The high Benefit:Cost ratio obtained in the present study demonstrates that TANUVAS SMART Mineral Mixture is an economically viable technology for smallholder dairy farmers. Furthermore, the successful implementation of the demonstration through Krishi Vigyan Kendra, Kundrakudi highlights the effectiveness of the Frontline Demonstration approach in promoting adoption of university-developed technologies under field conditions. The technology has considerable potential for large-scale dissemination through KVKs and dairy extension programmes across Tamil Nadu.



Fig 1: Farmer training and distribution of TANUVAS SMART Mineral Mixture to participating beneficiaries.



Fig 2: Participating farmers with dairy cattle at the completion of the Frontline Demonstration



Fig 3: Field monitoring and scientific interaction with dairy farmers during the implementation of the 90-day demonstration programme.

Conclusion

The present Frontline Demonstration conducted by Krishi Vigyan Kendra (KVK), Kundrakudi, Tamil Nadu Veterinary and Animal Sciences University, demonstrated that supplementation of TANUVAS SMART Mineral Mixture significantly improved milk yield, milk fat percentage and economic returns in lactating dairy cattle maintained under farmer-managed conditions. Supplementation for 90 days increased the average milk yield by 15.07% and improved milk fat percentage by 10.53%, indicating the positive effect of balanced mineral nutrition on productive performance. Besides increasing milk production, the mineral mixture improved feed intake, body condition, rumination and overall health status of the animals. The reduction in metabolic disorders and improvement in reproductive behaviour observed during the demonstration further emphasized the importance of balanced mineral supplementation in dairy production systems. Economic analysis revealed that the technology generated substantial additional income with a favourable Benefit:Cost ratio of 4.52:1, making it a highly economical intervention for smallholder dairy farmers. The technology was well accepted by the participating farmers because of its simplicity, affordability and visible improvements in animal productivity. The findings of the present study demonstrate that TANUVAS SMART Mineral Mixture is an effective nutritional intervention for improving dairy productivity under village conditions. Large-scale promotion of this technology through Krishi Vigyan Kendras, State Department of Animal Husbandry and dairy development programmes can contribute significantly towards enhancing milk production, improving milk quality and increasing farmers' income. Further studies involving larger numbers of animals across different agro-climatic regions and longer periods of evaluation are recommended to assess the long-term effects of TANUVAS SMART Mineral Mixture on

reproductive performance, mineral status, disease resistance and lifetime productivity of dairy cattle.

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