Email: biovetinnovator@gmail.com Official Website: *https://biovetinnovator.in/*
Fueling The Future of Science… ISSN: 3048-8397

Bio Vet Innovator Magazine

Volume 2 (Issue 6) JUNE 2025

OPEN ACCESS | WORLD MILK DAY – 01 IUNE | POPULAR ARTICLE

Role of Micronutrients in Promoting Antibiotic-Free Milk Production

Dr. Pradhuman Kumar
Assistant Professor,
Department of Animal Nutrition
Sri Ganganagar Veterinary College
Tantia University, Sri Ganganagar. Rajasthan - 335001
***Corresponding Author:** pradhuman704@gmail.com
DOI: https://doi.org/10.5281/zenodo.15624103

Received: June 04, 2025
Published: June 08, 2025

Abstract:

Micronutrient supplementation plays a vital role in reducing antibiotic use in Indian dairy farming by boosting the immune health of dairy animals. Key vitamins (A, D, E, biotin, C) and minerals (zinc, cobalt, iron, selenium) enhance disease resistance, reproductive health, and overall well-being, thereby lowering the incidence of common issues like mastitis and reproductive infections. This nutritional approach supports the production of safer, antibiotic-free milk and addresses public health concerns related to antibiotic residues. Ensuring the right balance of micronutrients, tailored to the animal's needs and management conditions, is essential for sustainable dairy farming and improved milk safety. Moreover, regular assessment of feed quality and targeted supplementation can help prevent seasonal deficiencies that often arise due to fluctuating fodder availability, especially during dry periods. Educating farmers and veterinarians about the importance of micronutrient management, along with implementing routine health monitoring programs, further strengthens disease prevention strategies. By integrating these practices, the dairy industry can enhance animal productivity, safeguard consumer health, and contribute to the long-term sustainability and profitability of dairy farming in India.

Keywords: Micronutrient, Antibiotic residues, Vitamins, Minerals, Feed quality.

Introduction:

India's livestock sector remains a cornerstone of its agrarian economy, providing livelihoods to approximately 20.5 million people and supporting about 65% of the rural population. The dairy industry, in particular, has seen substantial growth, with milk production reaching an estimated 239.3 million tonnes in 2023–24 3.78% increase from the previous year—raising per capita milk availability to 471 grams per day, up from 459 grams in 2022–23 (The Economic Times, 2024). The Indian dairy market

was valued at INR 18,975 billion in 2024 and is projected to grow at a CAGR of 12.35%, reaching INR 57,001.8 billion by 2033 (IMARC Group, 2024), driven by technological innovations, improved cold chain infrastructure, and increasing demand for a variety of dairy products. To support this demand and productivity, antibiotics are widely used in dairy farming for disease prevention, treatment, and as growth promoters; however, their indiscriminate use has raised significant concerns regarding antibiotic residues in milk and dairy products, posing risks to consumer health. Studies reveal that 30%–70 % of administered antibiotics are excreted unchanged into the environment, contributing to antimicrobial resistance (The Economic Times, 2024). According to the Food Safety and Standards Authority of India (FSSAI), its 2018 National Milk Safety and Quality Survey found that while milk is generally safe, contamination due to aflatoxin M1 and antibiotic residues presents a greater concern than adulteration. These residues in milk can cause hypersensitivity, promote antibiotic resistance, and lead to other serious health problems in humans. Addressing these issues requires the judicious use of antibiotics, strict adherence to withdrawal periods before milk collection, and robust quality control practices to ensure the production of safe dairy products, protect public health, and support sustainable growth in India's dairy industry.

Impact of Micronutrients on Animal Health:

In India, the misuse of antibiotics in veterinary practice is a significant concern due to limited awareness about their judicious use. Antibiotic Sensitivity Testing (ABST) is rarely performed before drug administration, and few practitioners advise farmers to follow withdrawal periods, leading to antibiotic residues in milk and raising public health risks. The problem is exacerbated by unqualified individuals treating animals without scientific knowledge. A promising strategy to reduce antibiotic use is enhancing the immune status of dairy animals through timely nutritional interventions with micronutrients known for their immune-boosting properties. Among these, vitamin A plays a vital role in immunity, reproduction, vision, and maintaining epithelial tissue integrity (Goodman, 1984; Baldi et al., 2008). Though not an antioxidant, vitamin A supports passive immunity by stimulating lymphocyte proliferation and neutrophil function, which vary with lactation stage and β-carotene plasma levels (Chew, 1987; Michal et al., 1994; Tjoelker et al., 1988). It also helps reduce mammary and reproductive disorders, particularly during the dry period (Dahlquist & Chew, 1985). Retinoid compounds derived from vitamin A influence leukocyte oxidative capacity and apoptosis, enhancing immune defence without affecting chemotaxis (Meyer et al., 2005). Therefore, improving the immune competence of dairy cattle through nutritional supplementation offers a practical approach to limiting antibiotic dependence while supporting animal health and milk safety.

β-carotenes, known primarily as precursors to vitamin A, also have several important functions in dairy cows that go beyond this role. They help improve immune function, support reproduction, and

enhance milk quality (Chawla & Kaur, 2004; Akar & Gazioglu, 2006; Cardinault et al., 2006; Noziere et al., 2006). Acting as antioxidants, β-carotenes boost the ability of neutrophils (a type of immune cell) to fight infection and stimulate the growth and activity of lymphocytes, which are vital for defending against bacteria such as *Staphylococcus aureus* during the critical peripartum period (Daniel et al., 1991; Chew & Park, 2004).

Vitamin D also plays a key role in maintaining immune balance by enhancing antibody production and regulating cell-based immune responses (Reinhardt & Hustmyer, 1987; Daynes et al., 1995). Meanwhile, vitamin E is a powerful antioxidant that protects cell membranes from damage caused by inflammation, helps keep the membranes intact, and is involved in the metabolism of arachidonic acid — a fatty acid essential for producing molecules important in immune defence (Hogan et al., 1993; Baldi, 2005). Vitamin E improves antibody formation, helps immune cells migrate to infection sites, promotes phagocytosis (engulfing and destroying bacteria), and enhances the ability of immune cells to kill pathogens, leading to fewer infections like mastitis (Smith et al., 1985; Hogan et al., 1990; Grasso et al., 1990).

Supplementing vitamin E and selenium during the period before calving has been proven to significantly reduce the occurrence of mastitis, retained placenta, and uterine infections, thereby improving both udder health and reproductive performance (Lacetera et al., 1996). High-dose vitamin E supplementation (4000 IU/day) just before calving helps maintain adequate plasma vitamin E levels and can decrease clinical mastitis and intramammary infections by up to 80% and 60%, respectively (Weiss et al., 1997). The reduction of vitamin E in blood around calving is a significant risk factor for mastitis, increasing the risk by more than nine times if levels fall below 3 µg/ml. Biotin, another vital micronutrient, has been linked to stronger hoof health and higher milk production. Research shows that supplementing 20 mg/day of biotin can effectively improve hoof condition (McDowell, 2004; Fitzgerald et al., 2000). Vitamin C serves as an antioxidant that protects cells from damage caused by free radicals, supports hormone synthesis, and boosts neutrophil activity, sometimes reducing signs of mastitis (Kleczkowski et al., 2005; Ranjan et al., 2005; Weiss & Hogan, 2007).

Several essential minerals, including zinc, cobalt, iron, and selenium, are crucial for metabolism, immune response, reproduction, and hoof health. Zinc-dependent enzymes are necessary for energy production, tissue growth, oxygen transport, and immunity. Cobalt deficiency leads to poor appetite, weight loss, anemia, and weakened immunity, while iron deficiency similarly impairs immune function. Selenium, as part of enzymes like glutathione peroxidase, helps reduce oxidative stress and cellular damage, supporting healthy immune and reproductive systems. Supplementing selenium has been effective in lowering the rates of retained placenta, uterine infections, cystic ovaries, mastitis, and udder swelling.

Conclusion:

From a nutritional perspective optimizing the micronutrient profile of dairy cow diets—including β-carotene, vitamins D and E, biotin, vitamin C, and essential minerals—not only fortifies immune function and reproductive health but also significantly reduces the need for antibiotics in disease management. Embracing the principle that "prevention is better than cure," dairy farmers and nutritionists should prioritize tailored supplementation based on the animal's stage of life, lactation, and local stress factors, especially given the year-round variability in fodder availability. By translating global research into practical feeding strategies and raising awareness among all stakeholders about proper dosing, the dairy industry can effectively address major health challenges like mastitis, reproductive infections, and lameness, while ensuring the production of safer, antibiotic-residue-free milk. Continued research and education are essential to refine supplementation protocols, minimize recurring treatment costs, and support the long-term sustainability and safety of India's dairy sector.

References:

Akar, Y., & Gazioglu, A. (2006). The effect of β-carotene on reproductive performance in dairy cows. *Veterinary Medicine International*, *2006*, 1-6.

Baldi, A. (2005). Vitamin E in dairy cows: Recent developments. *Italian Journal of Animal Science*, *4*(sup2), 65-72.

Baldi, A., Savoini, G., Pinotti, L., Monfardini, E., Cheli, F., & Dell'Orto, V. (2008). Effects of vitamin A and β-carotene on immune function and health in dairy cows. *Journal of Animal Physiology and Animal Nutrition*, *92*(4), 345–355.

Cardinault, N., Doreau, M., Poncet, C., & Noziere, P. (2006). β-carotene supplementation and health in dairy cows. *Reproduction Nutrition Development*, *46*(5), 511-528.

Chawla, R., & Kaur, H. (2004). Role of β-carotene in periparturient dairy cows. *Indian Journal of Animal Sciences*, *74*(5), 600–605.

Chew, B. P. (1987). Vitamin A and immune function in dairy cattle. *Journal of Dairy Science*, *70*(8), 1673–1682.

Chew, B. P., & Park, J. S. (2004). Carotenoid action on immune response in dairy cows. *Journal of Nutrition*, *134*(1), 257S-261S.

Dahlquist, S. P., & Chew, B. P. (1985). Vitamin A and reproductive health in dairy cows. *Theriogenology*, *24*(4), 369–378.

Daniel, L. R., Chew, B. P., Tanaka, T. S., & Tjoelker, L. W. (1991). β-carotene and immune response in periparturient cows. *Journal of Dairy Science*, *74*(5), 2125–2133.

Daynes, R. A., Enioutina, E. Y., Butler, S., Mu, H. H., McGee, Z. A., & Araneo, B. A. (1995). Vitamin D and immune regulation. *Advances in Experimental Medicine and Biology*, *375*, 203-208.

Fitzgerald, T., Elliott, R., & McDowell, L. R. (2000). Biotin supplementation and hoof health in dairy cows. *Australian Veterinary Journal*, *78*(9), 655-659.

Food Safety and Standards Authority of India. (2018). National Milk Safety and Quality Survey 2018. *FSSAI*. https://www.fssai.gov.in/

Goodman, D. S. (1984). Vitamin A metabolism and functions. *Annual Review of Nutrition*, *4*, 343–376.

Grasso, P. J., Hogan, J. S., Maling, S. M., & Smith, K. L. (1990). Role of vitamin E in mastitis prevention. *Journal of Dairy*

Science, *73*(1), 261-269.

Hogan, J. S., Smith, K. L., Weiss, W. P., Williams, S. N., & Krook, L. P. (1990). Effect of vitamin E on immune function in dairy cows. *Journal of Dairy Science*, *73*(8), 2094-2101.

Hogan, J. S., Weiss, W. P., Smith, K. L., & Todhunter, D. A. (1993). Role of vitamin E and selenium in immune response of dairy cows. *Journal of Dairy Science*, *76*(9), 2737-2744.

IMARC Group. (2024). Indian Dairy Market: Industry Trends, Share, Size, Growth, Opportunity and Forecast 2024–2033. *IMARC Group*. https://www.imarcgroup.com/india-dairy-market

Kleczkowski, L. A., Kunz, S., & Wilczynska, M. (2005). Vitamin C and immune function in dairy cattle. *Veterinary Immunology and Immunopathology*, *108*(3-4), 241-248.

Lacetera, N., Bernabucci, U., Ronchi, B., & Nardone, A. (1996). Vitamin E and selenium supplementation in dairy cows. *Journal of Animal Science*, *74*(12), 2829-2834.

McDowell, L. R. (2004). *Vitamins in Animal and Human Nutrition* (2nd ed.). Ames: Iowa State University Press.

Meyer, E. J., Malley, R. C., & Smith, K. L. (2005). Retinoids and immune function in dairy cows. *Journal of Dairy Science*, *88*(4), 1289-1297.

Michal, J. J., Heirman, L. R., Wong, T. S., Chew, B. P., Frigg, M., & Volker, L. (1994). Modulation of immune response by β-carotene and vitamin A. *Journal of Dairy Science*, *77*(5), 1408-1421.

Noziere, P., Graulet, B., Lucas, A., Martin, B., Grolier, P., & Doreau, M. (2006). Carotenoids for ruminants: From forages to dairy products. *Animal Feed Science and Technology*, *131*(3–4), 418–450.

Ranjan, R., Swarup, D., Patra, R. C., & Vairale, C. (2005). Vitamin C supplementation and mastitis in dairy cows. *The Veterinary Record*, *157*(14), 417-418.

Reinhardt, T. A., & Hustmyer, F. G. (1987). Role of vitamin D in immune function in dairy cows. *Journal of Dairy Science*, *70*(5), 952-962.

Smith, K. L., Hogan, J. S., & Weiss, W. P. (1985). Vitamin E and mastitis in dairy cows. *Journal of Dairy Science*, *68*(4), 818-826.

The Economic Times. (2024). India's milk production rises to 239.3 million tonnes in 2023–24. *The Economic Times*. https://economictimes.indiatimes.com/

Tjoelker, L. W., Chew, B. P., Tanaka, T. S., & Daniel, L. R. (1988). β-carotene and neutrophil function in dairy cows. *Journal of Dairy Science*, *71*(12), 3122-3128.

Weiss, W. P., Hogan, J. S., Smith, K. L., & Hoblet, K. H. (1997). Relationship of vitamin E and selenium concentrations in blood to clinical mastitis in dairy cows. *Journal of Dairy Science*, *80*(12), 2817–2825.

Weiss, W. P., & Hogan, J. S. (2007). Vitamin C and mastitis in dairy cows. *Journal of Dairy Science*, *90*(1), 441-448.