

CELEBRATING DAIRY: SUSTAINING HEALTH, HERITAGE AND THE PLANET

Himsikha Chakravarty¹, Dipan Rudra Paul¹, Piyush Rajput¹, Rahul Katiyar² and Sourabh Deori²

¹ICAR-IVRI, Izatnagar, Bareilly, UP (243122)

²ICAR-RC for NEH Region, Umiam, Meghalaya (793103)

DOI: <https://doi.org/10.5281/zenodo.15706379>

ABSTRACT

From the comforting warmth of a morning cup of milk to the rich celebratory aroma of sweets made with ghee during festivals, dairy has long held a cherished place in human culture, cuisine and daily life. Its presence spans continents and civilizations, woven deeply into the tapestry of our traditions, rituals and nourishment. For thousands of years dairy has been more than just a source of sustenance; it has been a symbol of fertility, prosperity and shared heritage. In ancient societies from the Indus Valley to Mesopotamia, dairy was revered not only for its nutritional value but also for its economic and spiritual significance. Today in an era marked by pressing global challenges ranging from escalating food insecurity and malnutrition to the mounting impacts of climate change and non-communicable diseases, the role of dairy is being reexamined and revalued. Far from being a relic of the past, dairy continues to be a dynamic force in modern food systems. It stands at the intersection of nutrition, agriculture and sustainability offering vital contributions to public health, rural livelihoods and ecological stewardship. In this context, dairy is emerging not merely as a traditional food product but as a powerful catalyst in the journey toward a healthier, more resilient and more equitable world. Its potential to nourish both people and the planet places it at the heart of global strategies aimed at achieving food security, promoting sustainable agriculture and combating the double burden of undernutrition and obesity.

KEYWORDS: Precision farming, probiotics, food security, environmental impact, dairy innovation

INTRODUCTION

Dairy products such as milk, yogurt and cheese are far more than simple dietary staples; they are nutritional cornerstones in balanced diets across the globe. Revered for their dense and diverse nutrient profile, dairy foods deliver an impressive range of essential macro and micronutrients critical to human health. They are particularly rich in high-quality, complete proteins containing all nine essential amino acids, making them ideal for growth, tissue repair and muscle maintenance across the life span. In addition to protein, dairy is a primary source of calcium vital for strong bones and teeth as well as potassium which helps regulate blood pressure and vitamin D which enhances calcium absorption and supports immune function. Vitamin B12, another key component of dairy plays a crucial role in red blood cell formation and neurological function. These nutrients are often under-consumed in many populations, especially in developing regions where dairy serves as a practical and affordable means to fill nutritional gaps. According to the Food and Agriculture Organization (FAO), milk is among the most nutrient-dense foods available, offering a unique combination of energy, essential fats and bioavailable vitamins and minerals that support life at every stage; from infancy to old age (FAO, 2022). Its consumption is not only widespread but also deeply embedded in cultural dietary patterns from school lunch programs to traditional meals. Scientific evidence consistently reinforces the health benefits of dairy. Numerous studies have demonstrated that regular dairy intake is positively associated with bone mineral density and skeletal development especially in children, adolescents and postmenopausal women. Dairy's protective role extends beyond the bones. It may help in managing blood pressure, improving insulin sensitivity and reducing the risk of metabolic

disorders such as type 2 diabetes and cardiovascular disease (Pfeuffer *et al.*, 2007; Bruno *et al.*, 2021). Furthermore, fermented dairy products like yogurt and kefir have gained recognition for their probiotic content. These beneficial bacteria promote gut health by supporting a balanced microbiota, enhancing digestion and potentially improving immune responses. In many traditional diets fermented dairy plays a dual role both as a culinary delight and a health-promoting agent.

In essence, dairy remains a vital component of global nutrition strategies capable of addressing both nutrient deficiencies in vulnerable populations and promoting overall well-being in diverse dietary settings. As we face rising concerns around malnutrition in all its forms, dairy continues to stand out as a time-tested, science-supported and culturally adaptable solution.

DAIRY AND PLANETARY HEALTH: CHALLENGES AND SOLUTIONS

As the global conversation around climate change intensifies, the environmental footprint of food systems has come under increasing scrutiny and dairy production is often a focal point. A primary concern lies in the greenhouse gases emitted by dairy cattle especially methane (CH₄), a potent gas produced during enteric fermentation in the digestive systems of ruminants. In addition land use, water consumption and nutrient runoff associated with dairy farming have raised alarms among environmentalists and policy-makers alike. According to a landmark report by the Food and Agriculture Organization (FAO), the livestock sector as a whole is responsible for approximately 14.5% of global greenhouse gas emissions with the dairy industry contributing around 4% of that total (Gerber *et al.*, 2013). This includes emissions not only from animals themselves but also from feed production, manure management and energy used in processing and transportation. However, these figures must be viewed within a broader context. Dairy is unique in its ability to deliver a high density of essential nutrients with a relatively modest environmental impact per unit of nutrition. In fact when measured per gram of protein or per kilocalorie, dairy often compares favorably to many other animal-based foods. Moreover, the industry is not standing still in the face of ecological challenges. Across the globe, dairy producers are investing in **sustainable**

intensification boosting productivity while minimizing environmental harm. These innovations include:

- **Enhanced feed efficiency** through the use of additives like seaweed and enzymes that reduce enteric methane emissions.
- **Improved manure management** via anaerobic digesters that convert waste into biogas reducing both emissions and odor while generating renewable energy.
- **Selective breeding and genetics** to produce animals with better feed conversion rates and lower emission intensity.
- **Rotational grazing** and integrated pasture management to enhance soil carbon sequestration and biodiversity.

These advancements are yielding tangible results. For example, a study on U.S. dairy production revealed that the carbon footprint per unit of milk has dropped by 63% since 1944, thanks to technological and management improvements (Capper *et al.*, 2009). Similar trends are being observed in countries like New Zealand and Denmark, where national dairy strategies emphasize climate-smart practices. Importantly dairy animals especially in low- and middle-income countries often graze on marginal lands unsuitable for crop production, consuming grasses and agricultural by-products that humans cannot digest. This upcycling process converts inedible biomass into high-quality nutrition effectively turning waste into food and contributing to the circularity of food systems. Furthermore, mixed crop-livestock systems common in many developing regions enhance resilience by integrating dairy farming with crop production. Manure enriches soils reducing dependency on synthetic fertilizers while milk provides year-round income and food security. In such systems dairy acts not as a burden on the planet but as a bridge between nutrition, livelihoods and environmental stewardship.

In sum, while dairy production poses legitimate environmental challenges it also presents numerous opportunities for climate-smart transformation. By embracing innovation and optimizing resource use, the dairy sector can continue to feed billions while becoming a model for sustainable agriculture in the Anthropocene.

PRESERVING CULTURAL HERITAGE AND RURAL LIVELIHOODS

Dairy is not merely a source of nutrition but a vibrant thread in the social, spiritual and economic fabric of human civilization. Across continents and cultures, dairy has shaped traditions, rituals and livelihoods for thousands of years. In many societies, it carries a value far beyond its physical properties, symbolizing purity, prosperity and nurturing care. Nowhere is this more evident than in India, where dairy is profoundly interwoven with religion, culture and daily life. Milk and its derivatives like ghee, curd, butter and paneer are integral to religious offerings, sacred ceremonies and festive cuisines. Pongal, a harvest festival in Tamil Nadu features sweetened milk-rice cooked in earthen pots. During Holi, a joyous celebration of colours, people traditionally consume “thandai” and “lassi” both being dairy-based drinks. On Janmashtami, which marks the birth of Lord Krishna, a deity famously fond of butter, devotees recreate scenes of his childhood mischief involving stolen dairy treats. This spiritual and symbolic connection to dairy also extends beyond South Asia. In Europe, centuries-old practices of cheese-making and butter churning are deeply embedded in local identities. In France, Italy and Switzerland, specific dairy products are linked to regions with names protected under geographical indications (GIs). In Ethiopia, sour milk is a staple at community feasts while in Mongolia, fermented mare’s milk “airag” is central to hospitality and social bonding. Cultural heritage aside, dairy plays a vital role in supporting rural economies. According to the FAO, over 1 billion people worldwide rely on dairy for their income, with the majority engaged in smallholder and subsistence farming systems (FAO, 2020). In many developing countries, dairy is more than an agricultural enterprise; it is a lifeline, providing regular cash flow, nutrition and food security in remote areas where alternative income sources may be scarce. Furthermore, dairy fosters agro-ecological resilience. Integrated crop-livestock systems, where animals and land are managed together enable smallholder farmers to diversify income, recycle nutrients and reduce vulnerability to climate and market shocks. Dairy cooperatives like India’s Amul model have demonstrated how

collective action can strengthen market access, ensure fair prices and uplift millions from poverty.

SUSTAINABLE DAIRY: THE WAY FORWARD

As the world faces the urgent task of feeding a growing population while staying within planetary boundaries, the dairy sector is at pivotal crossroads. To remain relevant and responsible the industry must evolve; adopting practices that reduce environmental impact, promote animal welfare, ensure food safety and support rural economies. Fortunately, the dairy sector is increasingly embracing innovation and sustainability at every stage of production and supply chain.

Precision Farming and Smart Technologies

Modern dairy farms are integrating digital agriculture tools to enhance efficiency and reduce waste. Precision feeding systems for instance, allow farmers to tailor nutrition to the needs of individual animals improving productivity while minimizing resource use. **Sensor-based monitoring**, wearable devices and automated milking systems track animal health, behaviour and milk yield in real time. This technology not only reduces labour demands but also helps prevent disease, lowers methane emissions and improves animal welfare.

Dairy Recycling and Circular Resource Use

Sustainable dairy systems are also becoming more circular. Manure, once viewed as waste, is now a valuable resource. It can be processed in anaerobic digesters to produce biogas which provides renewable energy for farms and rural communities. The remaining digestate is a nutrient-rich slurry that serves as an effective organic fertilizer, reducing dependence on synthetic inputs and closing nutrient loops. This integrated waste-to-energy approach is already transforming dairy sustainability in countries like the Netherlands, Germany, and India.

Improved Genetics and Animal Welfare

Selective breeding and genomic technologies are creating healthier, more resilient and higher-yielding animals. By improving feed efficiency and reducing disease susceptibility, these advancements reduce the environmental footprint per liter of milk produced. At the same time, global attention to animal welfare has led to better housing conditions, pasture access and veterinary care, aligning productivity goals with

ethical standards. Happy healthy animals produce better-quality milk with fewer interventions.

Sustainable Packaging and Cold Chain Innovation

Post-harvest losses can negate much of the environmental effort at the farm level. That's why sustainable dairy also focuses on innovations beyond the farm gate. Eco-friendly packaging such as biodegradable cartons and recyclable materials is gaining traction. Meanwhile, advances in cold chain infrastructure including solar-powered milk chillers and smart logistics are helping reduce spoilage and ensure milk safety from farm to consumer especially in tropical and remote regions.

Global Collaboration for Sustainability

Sustainable dairy development is gaining preference—it represents a vital intersection of momentum through global collaborations such as nutrition, culture, livelihoods, and environmental the Global Dairy Platform (GDP) and the Dairy Stewardship. Across the world, it has shaped culinary Sustainability Framework (DSF), which unite traditions, supported rural economies, empowered industry leaders, scientists, farmers and women, and provided essential nourishment across all policymakers to align dairy practices with the UN life stages. As we celebrate the role of dairy in our Sustainable Development Goals (SDGs). Dairy lives, it is crucial that we also look to the future with responsibility and innovation. By investing in sustainable practices, science-driven solutions, and inclusive policies, we can amplify the positive impact of dairy while addressing its ecological challenges. In doing so, we are not only preserving a cherished food group, but also safeguarding a living legacy—one that has nourished humanity for millennia and holds immense promise for feeding a healthier, more equitable, and sustainable world for generations to come.

- **Zero Hunger (SDG 2)** by delivering accessible, nutrient-rich food
- **Good Health (SDG 3)** through support for balanced diets
- **Climate Action (SDG 13)** via emission-reducing technologies and circular farming and
- **Decent Work (SDG 8)** by empowering rural economies and inclusive livelihoods.

In India, efforts such as the National Dairy Plan, Rashtriya Gokul Mission and Kamdhenu Yojana focus on genetic improvement, milk yield enhancement and animal welfare. Initiatives like solar-powered milk chillers, bio-digesters for manure and farmer producer organizations (FPOs) are helping improve sustainability, reduce losses and increase income at the grassroots. Together these global and local strategies underscore dairy's role as a climate-smart sector. With innovation and shared commitment dairy is evolving into a model for regenerative, resilient and inclusive food systems.

CONCLUSION

Dairy is far more than just a dietary

REFERENCES

- FAO (2022). *Milk and dairy products in human nutrition*. <https://www.fao.org/3/cb7982en/cb7982en.pdf>
- Pfeuffer, M., & Schrezenmeir, J. (2007). Milk and the metabolic syndrome. *Obesity reviews*, 8(2), 109-118.
- Bruno, R. S., Pokala, A., Torres-Gonzalez, M., & Blesso, C. N. (2021). Cardiometabolic health benefits of dairy-milk polar lipids. *Nutrition reviews*, 79(Supplement_2), 16-35.
- Gerber P. J., et al. (2013). *Tackling climate change through livestock: A global assessment*. FAO. <https://www.fao.org/3/i3437e/i3437e.pdf>

Cite this article:

Himsikha Chakravarty¹, Dipan Rudra Paul¹, Piyush Rajput¹, Rahul Katiyar² and Sourabh Deori². (2025). Celebrating dairy: sustaining health, heritage and the planet. *Vet Farm Frontier*, 02(05), 74–77. <https://doi.org/10.5281/zenodo.15706379>