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dairy dimension

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LEADING FROM GRASSROOTS

Dr. Manvir Singh

Effect of Climate Change on Food Security of Dairy Animals and Their Performance

Dr. Sudhindra Tatti

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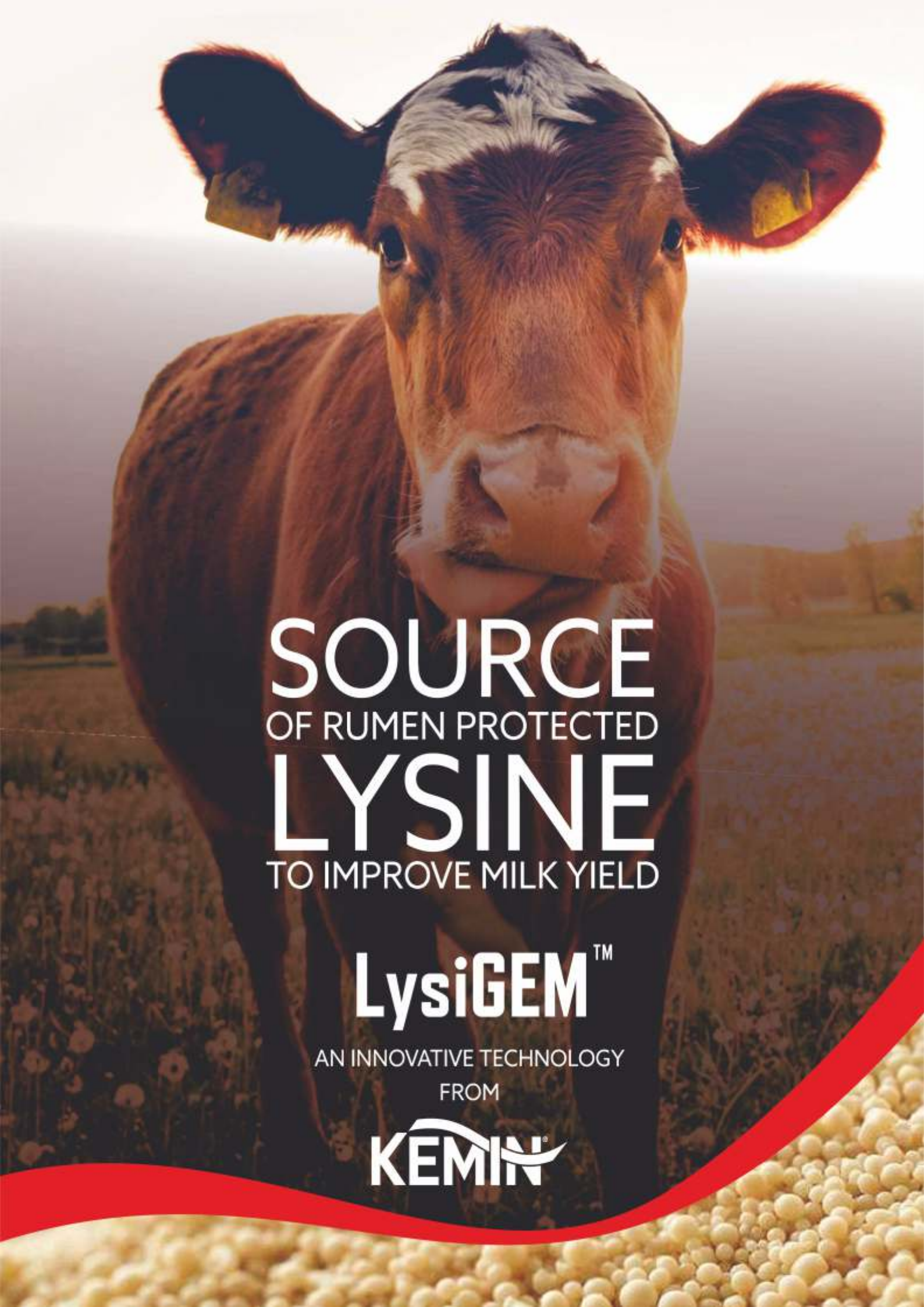
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CONTENT

SUSTAINABILITY FORCUS

ARTICLES

INTERVIEW

GLOBAL & INDIAN NEWS

SUBSCRIPTION INFORMATION

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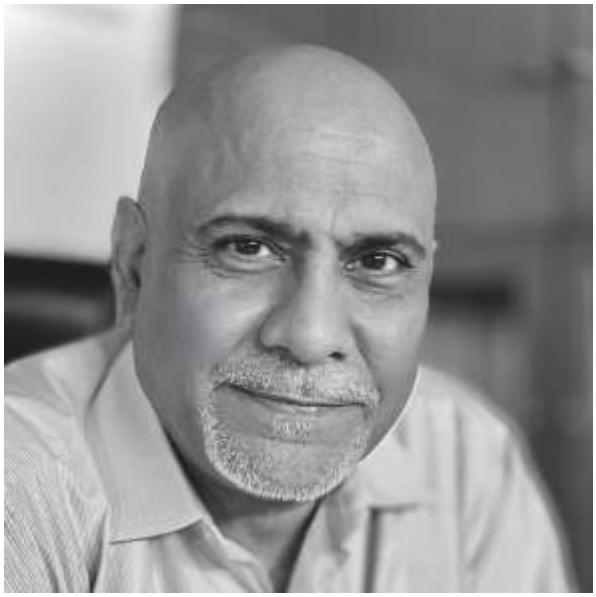
Non-Biofouling Membranes Using Positive and Negative Charges for Dairy Wastewater Streams



Prof. Lalit Vashista
Diva Envitec

Dairy wastewater management presents a significant challenge due to its complex composition, high organic load, and potential for biofouling in conventional treatment systems. The presence of fats, proteins, lactose, and other suspended solids contributes to rapid membrane fouling, which reduces efficiency and increases operational costs. Biofouled membranes require frequent cleaning, increased chemical usage, and have shorter lifespans, all of which raise overall treatment expenses.

To address these challenges, non-biofouling membranes with positive and negative charge configurations have emerged as an effective solution. These membranes mitigate fouling by leveraging electrostatic interactions that prevent the adhesion of organic and biological contaminants. This innovative approach enhances membrane longevity, reduces maintenance costs, and improves water recovery—making it a sustainable and economically viable solution for dairy wastewater treatment.

Dairy Wastewater Streams

Dairy wastewater is generated from various stages of processing and cleaning operations within dairy plants. The primary sources include:

1. **Ultrafiltration (UF) Permeate and Nanofiltration (NF) Permeate**

   These streams contain lower concentrations of organics but still pose a risk of membrane fouling if not properly managed. UF permeate typically consists of small molecules such as lactose and minerals, while NF permeate includes slightly larger organic compounds and dissolved solids. Effective treatment of these streams is essential to maintain high water recovery rates and prevent secondary contamination.

2. **General Plant Wastewater**
   - This category includes a mixture of several waste streams such as Clean-in-Place (CIP) solutions, CIP flush water, product losses from silos, and NF permeate.
   - The variability in composition makes it difficult to implement a uniform treatment approach.
   - Depending on the processing stage, this wastewater can exhibit fluctuating pH levels, high chemical oxygen demand (COD), and varying concentrations of fats, proteins, and lactose.

Challenges in Dairy Wastewater Treatment

1. **Protein Denaturation and Biofouling**

   Proteins in dairy wastewater tend to denature when exposed to heat or chemicals. Upon denaturation, they form hydrophobic aggregates that strongly adhere to membrane surfaces, causing biofouling. This increases filtration resistance, lowers permeate flux, and requires frequent cleaning, thus raising operational costs.

2. **Variability in Wastewater Composition**

   The composition of dairy wastewater varies based on product type, processing methods, and cleaning protocols. This variability necessitates a flexible treatment system capable of adapting to different contaminant loads and pH conditions while maintaining high efficiency.

3. **Membrane Fouling and Cleaning Requirements**

   Conventional membranes require frequent cleaning due to irreversible fouling caused by organic matter, microorganisms, and inorganic scaling. Repeated cleaning reduces membrane lifespan and increases downtime and operational expenses.

4. **High Chemical and Operational Costs**

   Traditional membrane systems rely on chemical dosing to control fouling, resulting in higher use of detergents, acids, and alkalis. Energy-intensive processes like high-pressure filtration also contribute to rising operational costs.

Solution: Non-Biofouling Membranes with Positive and Negative Charges

Non-biofouling membranes are engineered to resist organic and biological fouling through surface charge modifications. These membranes use alternating positive and negative charges to prevent contaminant adhesion via electrostatic repulsion. This mechanism significantly reduces fouling buildup and enhances membrane performance.

PROMEM-B membranes, for instance, are designed for high-strength wastewater applications with minimal risk

of irreversible fouling. They offer superior separation efficiency while requiring less frequent cleaning and maintenance. Their robustness and long operational life make them particularly well-suited for dairy wastewater treatment.

Key Mechanisms of Non-Biofouling Membranes

1. **Electrostatic Repulsion**

   The alternating charge pattern repels oppositely charged contaminants, preventing their accumulation on the membrane surface.

2. **Hydrophilic Surface Modification**

   A hydrophilic membrane surface minimizes organic adhesion and reduces the risk of protein denaturation and fouling.

3. **Self-Cleaning Properties**

   Some advanced membranes exhibit self-cleaning capabilities, allowing for faster recovery with minimal chemical intervention.

4. **Selective Permeability**

   These membranes effectively separate fats, proteins, and lactose while allowing clean water to pass through, producing high-quality effluent suitable for reuse.

Key Benefits of Non-Biofouling Membranes

1. **Enhanced Wastewater Treatment Efficiency**
   - Effective Removal of Fats, Oils, and Grease (FOG): Charged membrane surfaces prevent FOG deposition, ensuring consistent filtration.
   - Prevention of Protein and Lactose Accumulation: Electrostatic repulsion reduces biofouling rates by minimizing adhesion.
   - Reduced Pre-Treatment Needs: These membranes can handle high-strength dairy wastewater without complex pre-treatment, simplifying operations.
2. **Lower Operating Costs**
   - Reduced Cleaning and Maintenance: Minimal fouling leads to fewer cleaning cycles and lower chemical/labor costs.
   - Extended Membrane Lifespan: Less exposure to harsh cleaning agents increases membrane durability.
   - Lower Hauling and Disposal Costs: Enhanced treatment efficiency reduces sludge production and off-site disposal needs.
3. **Sustainability and Water Reuse**
   - Enables Water Recycling: Treated effluent can be reused in non-potable applications, reducing freshwater consumption.
   - Supports Environmental Goals: These membranes help meet sustainability targets by minimizing wastewater discharge and carbon footprint.
   - Regulatory Compliance: Consistently high-quality effluent helps facilities meet stringent discharge regulations.

Case Study: Implementation in a Dairy Processing Plant

A large dairy processing facility adopted non-biofouling membrane technology to combat persistent fouling issues in its wastewater treatment system. Previously, the plant experienced frequent membrane clogging due to high protein content and FOG accumulation. Cleaning was required every 2–3 days, resulting in excessive downtime and chemical use.

Post-implementation results included:

- Cleaning frequency reduced by 70%, lowering chemical and labor costs.
- Membrane lifespan extended by 50%, reducing replacement costs.
- Water recovery improved by 30%, increasing reuse for cleaning and cooling.
- Overall treatment efficiency enhanced by 40%, ensuring regulatory compliance.

This successful upgrade transformed the facility's wastewater management strategy, demonstrating the long-term economic and environmental benefits of non-biofouling membranes.

Conclusion

Non-biofouling membranes with positive and negative charge configurations represent a significant advancement in dairy wastewater treatment. By reducing biofouling, lowering operational costs, and improving water recovery, these membranes provide a transformative solution for dairy processing facilities.

Their resistance to organic and biological fouling ensures consistent performance with minimal maintenance—supporting efficient, sustainable wastewater management. As the dairy industry continues to pursue innovation in treatment technologies, the adoption of non-biofouling membranes will be essential for achieving water conservation goals, regulatory compliance, and cost-effective operations. This technology not only reduces environmental impact but also turns wastewater into a resource, aligning with global efforts toward sustainable industrial practices.

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Effect of Climate Change on Food Security of Dairy Animals and Their Performance

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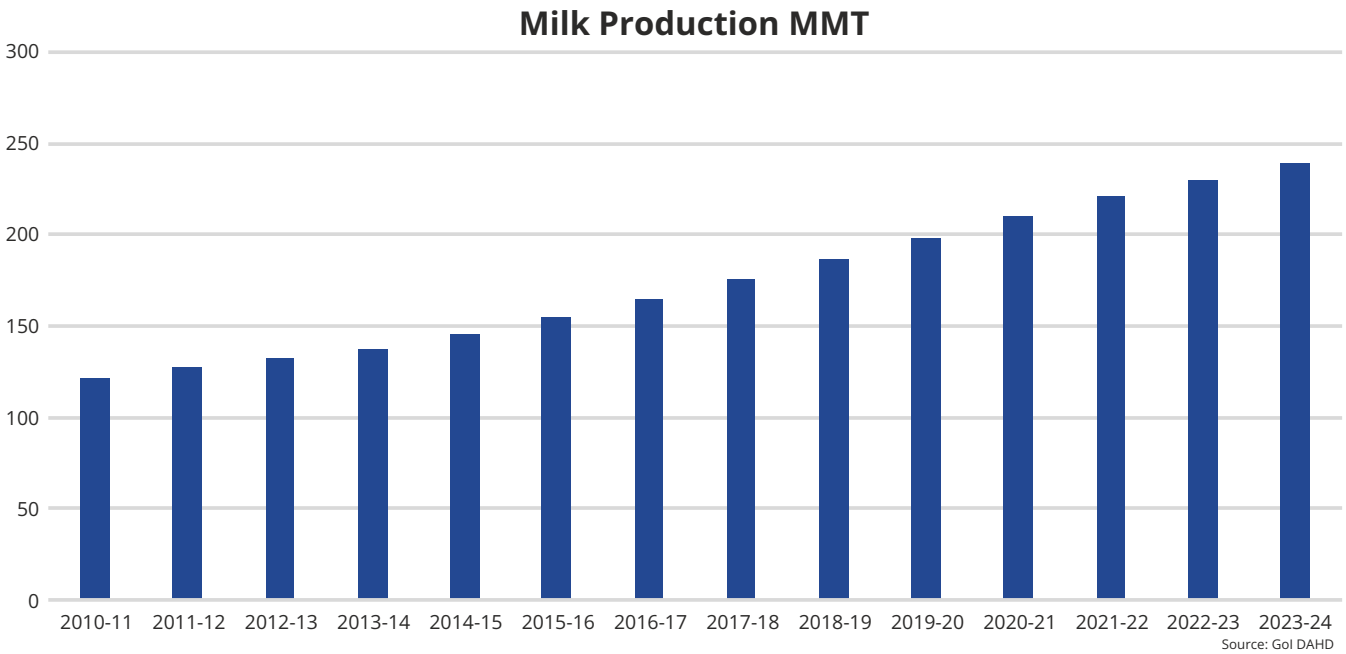

Climate Change: A Growing Threat to Global Agriculture and Food Security

Climate change refers to long-term changes in global weather patterns, primarily characterized by rising temperatures, altered precipitation, and an increase in extreme weather events such as droughts, floods, and heat waves. These changes are largely driven by human activities such as deforestation, industrial emissions, and the burning of fossil fuels, which contribute to the buildup of greenhouse gases in the atmosphere. As a result, global temperatures have risen, disrupting ecosystems and climatic stability.

According to the Intergovernmental Panel on Climate Change (IPCC), the Earth's average temperature has increased by about 1°C above pre-industrial levels and is expected to rise by an additional 1.5°C to 2°C by mid-century if current emission levels persist. These temperature changes have serious implications for agriculture, affecting crop yields, water availability, and livestock health. In countries like India, where agriculture is heavily dependent on climate factors such as monsoons and temperature patterns, climate variability poses a direct threat to food production, farmer livelihoods, and national food security. The consequences include increased food prices, malnutrition, and potential social unrest.

India, being the world's top milk producer, is especially vulner able to such climatic changes. The dairy sector not only contributes significantly to the national economy but also serves as a vital nutritional source especially for the country's large vegetarian population, for whom milk is the primary source of animal protein. Climate change is likely to disrupt milk production potential, which could have far-reaching effects on nutrition and health of both dairy animals and humans as well as overall income security.

Understanding Food Security

The Food and Agriculture Organization (FAO) defines food security as a situation where all people, at all times, have physical, social, and economic access to sufficient,

safe, and nutritious food to meet their dietary needs and preferences for an active and healthy life. Food security is built upon four key pillars:

1. **Availability** – Sufficient food supply at local, national, and global levels.
2. **Access** – Economic and physical means to obtain food.
3. **Utilization** – Proper use of food, including its nutritional quality and how the body absorbs nutrients.
4. **Stability** – Consistent availability and access to food over time, without disruptions.

Climate change threatens all these pillar—disrupting production through extreme weather, reducing access by harming agricultural incomes, compromising nutrition through lower-quality crops, and undermining system stability.

1. Direct Effects of Climate Change on Dairy Animals

- **Heat Stress and Reduced Milk Production**

  One of the most immediate effects of climate change on dairy animals is heat stress, particularly when temperatures exceed 25–30°C. Cows and buffaloes struggle to regulate their body temperature under such conditions, resulting in reduced feed intake, lower milk yield, and impaired reproduction. In regions like northern and central India, where summer temperatures can exceed 40°C, the effects are more severe.

- Studies (Mader et al., 2006) indicate that milk production may decline by 10–30% due to heat stress. Cows also show behavioural changes, such as increased resting time and reduced grazing, which leads to lower food intake (Singh et al., 2019). Elevated cortisol levels from stress negatively affect reproduction, causing delayed estrus and higher stillbirth rates

- **Animal Health and Disease Risks**

  Heat stress compromises the immune system, making animals more susceptible to diseases such as mastitis, respiratory infections, and foot rot. Ghosh and Samui (2020) found that stressed animals are at increased risk of infections, escalating veterinary treatment costs. Additionally, rising temperatures and altered rainfall also promote vector-borne diseases such as foot-and-mouth disease and bluetongue. ICAR reports highlight the growing risk by increased mosquito and tick activity in hotter regions.

2. Impact on Forage and Feed Availability

India's dairy sector relies heavily on natural forages such as grasses, legumes, and crop residues. Climate change—through erratic rainfall patterns, rising temperatures, and frequent droughts—threatens the supply and quality of these feed sources.

- **Decline in Forage Quality and Quantity**

  In drought-prone states like Rajasthan, Maharashtra, and Gujarat, changing monsoon patterns have led to declining fodder availability. Chakravarty et al. (2020) observed that repeated droughts are shrinking grazing lands, forcing farmers to rely on expensive feed alternatives.

  Moreover, elevated temperatures reduce forage quality by degrading nutrient content and increasing indigestible fiber, thereby compromising dairy animal health, productivity, and milk yield.

- **Rising Dependence on Commercial Feeds**

  With natural forage becoming scarce, many farmers are switching to commercial feeds, which are often costly and not easily accessible to smallholder farmers. Climate change also impacts global grain production, leading to price volatility and supply issues. Kumar et al. (2018) noted that fluctuating grain prices linked to weather events in exporting countries have increased feed costs and further strained dairy farm profitability.

3. Economic Pressures on Smallholder Farmers

- India's dairy industry is largely made up of smallholder farmers with limited livestock and minimal resources. These farmers are especially vulnerable to climate change

- **Rising Costs and Reduced Incomes**

  Increased expenses for feed, water, and veterinary care are cutting into already-thin profit margins. Singh et al. (2019) estimated that climate-related losses in productivity and rising costs could reduce small farm incomes by 15–25%.

  Additionally, irrigation-dependent fodder crops are being affected by water scarcity, escalating local tensions over water usage and threatening long-term sustainability.

- **Threats to Food Security**

  Milk remains a vital source of nutrition for many Indians, especially in rural areas. Disruptions in milk production can lead to supply shortages and price

hikes, making dairy products unaffordable for low-income households. This poses a serious food security risk, particularly for children and other vulnerable groups. While the National Dairy Development Board (NDDB) notes a steady rise in per capita milk consumption, future climate-related disruptions could reverse this trend.

4. Strategies for Adaptation and Mitigation

Addressing climate change impacts on dairy farming requires a multi-pronged strategy involving improved farming practices, animal management, and policy support.

- **Climate-Smart Agricultural Practices**
  - Diversified Feed Sources: Growing drought-resistant fodder crops such as Napier grass and sorghum can reduce reliance on rain-sensitive forages.
  - Water Management: Implementing rainwater harvesting and water-saving irrigation systems can help secure water for both crops and livestock.
- **Improved Animal Management**
  - Heat Stress Mitigation: Providing shade, ventilation, and cooling systems like fans or mist sprayers can reduce thermal stress in animals.
  - Climate-Resilient Breeds: Indigenous cattle breeds such as Gir, Sahiwal, and Kankrej are naturally more heat-tolerant and disease-resistant. Chauhan et al. (2020) advocate for focused breeding programs to enhance resilience.
- **Policy and Institutional Support**
  - Subsidies and Incentives: Government support for climate-resilient technologies and inputs can ease the financial burden on small holders.
  - Education and Extension Services: Farmers need access to training, early warning systems, and information on climate-smart practices and sustainable resource management to make informed decisions.

हम अपने हिस्से का खा गए, और इनके हिस्से का जला दिया, प्रलय नही आएगा तो और क्या आएगा।

Agro-Climatic Zones of Punjab and the Fodder Scenario

Though geographically small, Punjab exhibits diverse agro-climatic conditions that significantly impact cropping patterns, soil types, and the availability of fodder. The state is divided into three primary agro-climatic zones, each with distinct characteristics and fodder-related challenges:

1. Sub-Mountain Undulating Zone

Districts Covered: Parts of Gurdaspur, Hoshiarpur, and Rupnagar

Topography: Rolling terrain at the base of the Shivalik hills

Soil Type: Light-textured, erosion-prone

Rainfall: 1000–1200 mm (highest in Punjab)

Fodder Scenario: While natural grasses are present, cultivated fodder is limited due to the uneven landscape. Introducing silvipasture systems (integration of trees and grasses) and promoting drought-resistant fodder crops can improve productivity in this zone.

2. Central Plain Zone

Districts Covered: Ludhiana, Jalandhar, Kapurthala, Patiala, Sangrur, Barnala, and parts of Amritsar and Fatehgarh Sahib

Topography: Flat, fertile plains are ideal for intensive agriculture

Soil Type: Rich alluvial soils

Rainfall: 700–1000 mm

Fodder Scenario: This zone is the most suitable for fodder cultivation. Major fodder crops include berseem, maize, bajra, jowar, and oats. Due to abundant irrigation and fertile soils, dairy farming is highly concentrated here.

3. South-Western Dry Zone

Districts Covered: Bathinda, Mansa, Fazilka, Muktsar, and parts of Ferozepur and Faridkot

Topography: Arid to semi-arid with salinity and water logging issues

Soil Type: Sandy loam to loamy; often saline

Rainfall: 300–500 mm (lowest in Punjab)

Fodder Scenario: Fodder scarcity is a serious concern. Traditional grasses like sewan and dhaman are used, but productivity is limited. To combat scarcity, promoting drought-tolerant species such as guar, sorghum, and fodder bajra is essential. Ensuring a year-round supply of fodder remains a major challenge (Chaudary and Singh 2019).

Overall Fodder Scenario in Punjab

As one of India's top dairy-producing states, Punjab places strong emphasis on livestock feed availability. Despite this focus, the state faces a **fodder deficit of approximately 20–25%**, especially during lean seasons (May–June and December–January).

Major Fodder Crops:

- Winter (Rabi): Berseem (Trifolium alexandrinum) and oats (Avena sativa)
- Summer (Kharif): Maize, bajra, and jowar

Several challenges limit consistent fodder availability:

- Excessive focus on cereal crops like wheat and paddy, reducing land for fodder cultivation
- Declining water table and deteriorating soil health
- Limited adoption of fodder conservation practices such as silage and haymaking, especially among small holders
- Inadequate infrastructure for fodder storage, leading to seasonal shortages and income loss

Addressing these issues requires a strategic approach:

- Promote crop rotation that includes fodder crops alongside cereals
- Educate farmers on modern conservation techniques
- Develop and distribute high-yielding, drought-resistant fodder varieties
- Enhance infrastructure for fodder storage and preservation (e.g., silos, hay barns)

Fodder Availability and Deficit in Punjab

Punjab's livestock population is approximately 5.85 million Adult Cattle Units (ACUs), which collectively require about 14.94 million tonnes of feed and fodder annually. The estimated annual availability stands at 24.24 million tonnes, suggesting an overall surplus of 62.18%. However, this apparent surplus overlooks critical regional shortages in fodder availability.

District-Level Variations: Regions such as Amritsar and SAS Nagar experience notable fodder shortages despite

the state-wide surplus, underscoring the importance of localized planning and resource allocation.

Green Fodder Deficiency: Punjab faces a green fodder deficit of 28.57%, equivalent to 22.99 million tonnes (Tanwar and Verma, 2017).

Recommendations to Improve Fodder Security

- Crop Diversification: Integrate fodder crops into existing cereal-dominated cropping systems to ensure balanced land use.
- Farmer Training: Educate farmers on silage and haymaking to store surplus fodder for periods of scarcity.
- Drought-Resistant Varieties: Develop and promote climate-resilient, high-yield fodder crops tailored for arid and semi-arid zones.
- Efficient Irrigation: Encourage water-saving technologies such as drip irrigation and sprinkler systems to enhance fodder productivity in water-stressed regions.
- Fodder Banks: Establish community-level fodder banks to store and distribute feed during critical shortages and natural calamities.

Conclusion

Climate change poses a significant threat to India's dairy industry—impacting livestock health, reducing feed availability, and undermining farm profitability. In Punjab, where dairy farming plays a vital role in rural livelihoods and the state economy, the dual challenges of climate variability and fodder scarcity demand immediate and sustained attention.

Adopting climate-smart practices, promoting resilient livestock breeds, and providing institutional support are essential to safeguarding the livelihoods of millions of smallholder dairy farmers. Building fodder security through better crop management, conservation, and infrastructure will be key to ensuring a stable supply of milk and nutrition for India's growing population.

References are available upon request

Leadership & Vision

Dr. Sudhindra Tatti

Building Trust, Transforming Dairy, and Championing Quality

Known in the industry as the man who pushed for QUALITY in Indian dairy, Dr. Sudhindra Tatti, CEO of Prompt Innovations, is a rare leader who combines deep tech expertise with a grassroots understanding of agriculture. Under his leadership, Prompt has redefined what's possible for India's fragmented dairy supply chain, placing transparency, sustainability, and farmer empowerment at the core of dairy transformation.

Dr. Tatti, as CEO of Prompt Innovations, you've been at the forefront of transforming dairy through technology. Could you share your journey into the sector and how it led you to helm one of India's most innovative dairy tech companies?

My journey into the dairy tech sector was unplanned, but in hindsight, it feels like it was meant to be. At the time, I was serving as the Chief Operating Officer at the National Centre for Flexible Electronics at IIT Kanpur. My role was to act as a bridge between cutting-edge academic research and industry applications. I was deeply passionate about solving real-world problems through technology. Still, I had never imagined that passion would one day take me to the heart of India's dairy sector, through being introduced to PROMPT.

What began as helping them develop an instant milk chiller quickly became much more meaningful. As I spent more time understanding the dairy ecosystem, I realised the massive potential for technology to transform this space. There was a clear need for sustainable, energy-efficient solutions that could empower farmers and bring greater transparency and quality assurance to the dairy value chain.

I saw an opportunity to make a real difference at the grassroots level, using technology to support one of the most essential sectors of our economy. We decided to create Prompt Innovations.

Today, I'm proud to be part of a team purposefully driving change. At Prompt, we are not just building products—we are building trust, improving livelihoods,

and strengthening the bond between farmers and dairies. We're committed to ensuring transparency, quality, and sustainability across the dairy ecosystem.

Looking back, what seemed accidental initially has become a very rewarding chapter of my career.

Looking ahead, what is your vision for the Indian dairy ecosystem over the next five years? Where do you see the most critical inflexion points—and opportunities—for innovation and impact?

Our first focus will be improving milk quality. While we can be proud to be the largest producer of milk in the world, we have a long way to go. With innovations like MilkoChill and other cold chain solutions, we intend to contribute significantly to this goal.

Our vision is to make dairy farming climate-conscious and offer a range of sustainable, innovative solutions to help decarbonise the dairy supply chain. I think the dairy industry is staring at many challenges, and milk quality will become increasingly important. Also, there will be pressures for carbon footprint reduction and dairy sector contribution towards the national goal of Net Zero. These will become opportunities for innovators and startups to develop innovative products and services. There are lots of opportunities to improve cattle productivity, and solutions for feeds, genetics, pregnancy detection, and disease treatment will become increasingly important.

TECHNOLOGY & INNOVATION

Prompt DairyTech has built a reputation for practical, scalable solutions for India's fragmented dairy sector. What innovations are you most proud of, and how are they reshaping farmer engagement and milk collection?

Our core innovations directly address the critical needs of India's dairy sector through advanced milk quality preservation systems, comprehensive testing, and robust supply chain transparency.

Our integrated approach, powered by our digital platform and chilling infrastructure, revolutionises farmer engagement and milk collection by prioritising milk quality and transparency at every stage.

- **Milk Quality Preservation Systems:** Our energy-efficient Instant Milk Chiller, MilkoChill, is specifically designed for rural conditions. It ensures optimal milk temperature from the point of collection, prevents spoilage, and maintains quality. Integrated smart monitoring systems provide real-time temperature data, enabling proactive intervention to safeguard milk integrity.
- **Comprehensive Milk Testing Systems:** Our digital platform integrates with automated milk testing devices at collection centres, providing instant and accurate measurements of key quality parameters (fat, SNF, adulteration, etc). This ensures transparent quality-based pricing for farmers and provides processors with reliable data for quality control. All test results are digitally recorded and accessible, fostering trust.
- **Robust Supply Chain Transparency Systems:** Our digital platform provides end-to-end traceability of the milk supply chain, from the farmer to the processing plant. Every transaction and quality check is digitally recorded, offering complete visibility and accountability.

Speaking of MilkoChill, could you share more about how this innovation impacts milk quality, sustainability, and smallholder farmers?

MilkoChill represents a game-changing shift for dairy quality preservation. It chills 250 litres of milk from 35°C to 7°C within just an hour, with the lowest energy consumption in the industry—only about 12 units of electricity per day.

MilkoChill can run on solar power, drastically reducing dependence on diesel generators and cutting carbon emissions. Its unique heat recovery system also supplies hot water for cleaning-in-place (CIP), optimising resource use.

In real-world installations across Gujarat, Rajasthan, Assam, and Jammu, MilkoChill has extended milk shelf life by improving MBRT (microbial quality) up to four times and significantly enhanced farmer income by reducing spoilage. It's not just a chiller; it's a catalyst for sustainability, resilience, and inclusive rural growth.

MilkoChill is truly an example of how innovative technology can align with the ESG (Energy, Sustainability, Growth) framework and help the dairy sector fight climate change while uplifting small farmers.

India's dairy supply chain is highly decentralised. How does Prompt design affordable and adaptable technology to smallholder realities without compromising on quality or data integrity?

Our approach is to democratise technology for the dairy sector. We achieve this by focusing on solutions that are:

- **Economically Viable:** Affordable for smallholders

and cooperatives.

- **Operationally Simple:** Easy to use and maintain in rural environments.
- **Technologically Sound:** Ensuring accuracy, reliability, and security of data.
- **Locally Relevant:** Adaptable to the specific needs and contexts of different regions and farm sizes.

By adhering to these principles, Prompt DairyTech empowers even the smallest stakeholders in India's decentralised dairy supply chain to participate in a technologically advanced ecosystem without compromising the quality of their operations or the integrity of the crucial data that drives it.

INDIA TO THE WORLD

As global demand for robust, cost-effective dairy tech rises, how is Prompt positioning itself in international markets? What sets Indian-born innovation apart when serving diverse global dairy landscapes?

This is the biggest opportunity, and the time is right for us to grab a large market share of the global market. So far, we have been inward-focused, but over the years, we have become experts at creating "affordable" solutions to a variety of problems—adulteration, disease detection, disease cure, analytical and testing equipment, software, etc.

All these solutions are equally required for parts of the world with demographics similar to India (smallholder farmers, small collection centres, large distances, extreme climate conditions), and we are best suited to take our products overseas.

In the context of 'Make in India' and global trade realignments, do you believe Indian dairy technology can lead the world? What's needed to accelerate that journey?

At Prompt, we have always believed in **"Making in India"**, and our in-house manufacturing has always been a distinguishing feature compared to our competitors. This will enable us to spread our wings across the globe. What will be required is further focus on quality, international certifications, and superior service.

SUSTAINABILITY & RESILIENCE

Sustainability is often seen as a premium concern, but it's a necessity in India. How is the sector adapting and enabling environmentally responsible practices within a smallholder-dominated sector?

Yes, absolutely! The impact of climate change will be most felt by smallholder farmers and their cattle. Hence, it is important that we take sustainability seriously—not just because it is a global requirement. Adoption of distributed Renewable Energy solutions will be key to the sector's energy transition.

We must ensure that our villages have clean, safe drinking water and reliable energy resources for organic agriculture and the circular economy.

INSPIRATION & OUTLOOK

As a leader in dairy tech, what advice would you give to young professionals and entrepreneurs who want to contribute meaningfully to the future of Indian agriculture and food systems?

Indian agriculture and dairy are at the cusp of transformation, and there has never been a better time to innovate.

I want to offer the following challenges:

- Move from jugaad and low-cost fixes to creating real, scalable value-added products and services for India and the world.
- Don't be afraid of failure—embrace it. The ecosystem today is more supportive than ever.
- Focus on fundamental problems at the grassroots—solutions must be scalable and sustainable.
- Invest in collaboration. Agriculture today requires a multidisciplinary approach that combines engineering, biology, data science, economics, and empathy.

Finally, remember that agriculture and food are not just economic activities—they are about livelihoods, dignity, the environment, and health.

If you succeed in this space, you'll be building a business and impacting lives at the most fundamental level.

Closing Thoughts: One truth stands out from this conversation with Dr. Sudhindra Tatti: real transformation in dairy begins with a relentless commitment to **quality, sustainability, and farmer empowerment.**

From advancing milk chilling at the grassroots with **MilkoChill** to pushing for a climate-smart, data-driven ecosystem, Dr. Tatti shows that technology can truly uplift lives when built with purpose.

At **Dairy Dimension**, we believe leaders like him are shaping a future where Indian dairy is not just the largest but also the most trusted in the world.

We are proud to share his vision—and inspired to champion the future it represents.

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Advancing Dairy Science with Metabolomics and Analytical Techniques in Goat Milk and Milk Products

by Pratiksha, Heena Sharma, Gaurav Kr Deshwal, A K Singh and Hency Rose
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Introduction

Milk and milk products are an important part of the human diet in both developing and developed nations. Goats are multi-utility, easy-to-maintain, and prolific animals that efficiently convert minimal feed resources into valuable products. In India, the goat is often referred to as the "poor man's cow," serving as a major source of livelihood and nutritional security for small and marginal farmers.

Goat milk is a rich source of essential nutrients, including water, protein, fat, sugar, minerals, and vitamins, all of which contribute to its high nutritional value. It is characterized by low allergenicity, alkalinity, high buffering capacity, and bioactive properties such as anti-inflammatory, antimicrobial, and anticancer activities, making it highly beneficial in human nutrition and medicine. Compared to cow milk, goat milk has smaller fat globules and a higher proportion of short- and medium-chain fatty acids, which enhance its digestibility and impart a distinctive flavor.

Goat milk also contains a lower concentration of $\alpha_{s}1$-casein, resulting in smaller casein micelles and reduced hydrated pores, which contribute to its hypoallergenic properties. The lower casein content, compared to cow milk, is associated with slower coagulation and lower yield during cheese manufacturing.

Advanced analytical techniques used for compositional analysis of milk

Metabolomics is a truly interdisciplinary field that combines analytical chemistry, platform technologies, mass spectrometry (MS), nuclear magnetic resonance (NMR), and advanced data analysis. It offers a platform for the comparative analysis of metabolites that reflect dynamic cellular processes and homeostasis.

Metabolomics is a rapidly evolving "omics" field that focuses on the comprehensive identification and quantification of small molecules (<1500 Da) within biological systems. These include fatty acids, peptides, amino acids, carbohydrates, nucleic acids, vitamins, organic acids, and polyphenols, all of which play vital roles in metabolism and physiological functions (Wishart, 2008).


Pratiksha

Advanced analytical techniques used in metabolomics include:

- NMR (Nuclear Magnetic Resonance)
- GC-MS (Gas Chromatography-Mass Spectrometry)
- LC-MS (Liquid Chromatography-Mass Spectrometry)
- CE-MS (Capillary Electrophoresis-Mass Spectrometry)
- HPLC-UV (High-Performance Liquid Chromatography with UV Detection)
- ICP-MS (Inductively Coupled Plasma Mass Spectrometry)

Metabolomics approaches can be categorized as **targeted** (focusing on known metabolites) and **untargeted** (providing a broader overview, including unknown metabolites). Among these, GC-MS is widely used due to its efficiency and reproducibility. GC-MS-based metabolomics requires high-throughput capabilities for sample handling and accurate peak identification using standard retention times and mass spectra.

To enable separation on a GC column, derivatization is required to create volatile compounds. This allows the simultaneous profiling of several hundred metabolites, including organic acids, amino acids, sugars, sugar alcohols, aromatic amines, and fatty acids.

LC-MS techniques employ soft ionization, making MS more robust for daily use. LC-MS can generate lists of m/z values, retention times, and relative abundances of metabolites—some of which may remain unidentified.

Its high-resolution and reproducibility form the foundation for multivariate data analysis.

NMR is emerging as a powerful tool in metabolomics, offering unbiased information about metabolite profiles. It is straightforward, largely automated, and non-destructive, allowing further analysis of samples. NMR is widely used for metabolite fingerprinting, profiling, and flux analysis. However, its primary limitation is relatively low sensitivity, making it less suitable for detecting low-abundance metabolites.

GC-MS-Based Metabolomics of Goat Milk and Milk Products

Metabolomics has become essential for evaluating the nutritional quality, authenticity, and safety of goat milk. Using advanced techniques such as GC-MS, researchers have identified key metabolites that define the unique properties of goat milk. These studies help assess bioactive compounds with potential health benefits and provide insights into how genetic and environmental factors influence milk composition.

Nutritional Quality and Bioactive Compounds in Goat Milk

One major finding from metabolomic studies is the presence of bioactive compounds in goat milk that offer hypoallergenic and other health-promoting properties. Ballabio et al. (2011) showed that goat milk contains lower levels of α_s1-casein—often responsible for allergic reactions in cow milk. The study also highlighted the presence of medium-chain fatty acids, such as capric, caprylic, and caproic acids, which support easier digestion and have potential antibacterial effects. These properties make goat milk a preferred alternative for individuals with cow milk protein allergies (CMPA) or lactose intolerance.

Metabolite Profiling of Goat vs. Bovine Milk

Comparative metabolomic studies between goat and cow milk have identified species-specific metabolites. Scano et al. (2014) found that valine and glycine are prominent in goat milk, whereas talose and malic acid are more characteristic of cow milk. These metabolites influence sensory attributes, digestibility, and nutritional value, making goat milk suitable for individuals with dietary restrictions.

GC-MS has also identified biomarkers such as choline, citrate, valine, hippuric acid, 2-butanone, and lactate, which serve as indicators of milk quality and traceability (Suh *et al*., 2022). These markers are crucial for ensuring milk quality, product traceability, and preventing adulteration in dairy products.

Goat Milk Yogurt

GC-MS-based metabolomics has revealed how fermentation conditions, starter cultures, and post-fermentation storage affect yogurt composition. Rehman *et al*. (2023) identified 102 metabolites in goat milk yogurt, with 15 showing differential expression ($p < 0.05$), including 2-hydroxyethyl palmitate, α-mannobiose, and myo-inositol. Regression analysis highlighted methylamine ($R^2 = 0.669$) and myo-inositol ($R^2 = 0.947$) as key influencers of yogurt firmness and techno-functional properties.

Sun *et al*. (2021) used GC-MS to study metabolic changes during fermentation. They observed dynamic shifts in volatile compounds, including 2-hydroxy-3-pentanone, benzaldehyde, octanoic acid,3-methyl-2-buten-1-ol, 2,3-butanedione, 2-decenal, hexanoic acid, hexanal, decanoic acid, 1-nonanol, and 3,7-dimethyl-1,6-octadien-3-ol. Notably,metabolites, 2-nonanol and 5-methyl-1-hexanol were mainly detected during post-fermentation, indicating ongoing metabolic activity even after fermentation ended.

Conclusion and Future Prospects

Goat milk metabolomics offers a comprehensive understanding of its chemical composition, bioactivity, and functional potential. Techniques like GC-MS, LC-MS, and NMR have significantly enhanced quality control, authenticity assessment, and the development of functional dairy products. Species-specific metabolic differences underscore goat milk's unique advantages over cow or sheep milk.

Furthermore, fermentation and storage significantly shape the metabolic profile of goat milk products, affecting sensory attributes, texture, and product stability. Future research integrating metabolomics with genomics and proteomics will deepen our understanding of goat milk's health benefits and optimize its use in dairy technology and human nutrition.

Standardizing metabolomic methods, validating milk quality biomarkers, and exploring metabolic pathways will be essential for advancing dairy science. These efforts will help the dairy industry improve processing, ensure traceability, and create high-value goat milk products that meet evolving consumer needs.

References are available upon request.

Impact of Whole Cottonseed By-product on Milk Fat in Dairy Cows

A recent study led by researchers at Penn State has found that supplementing dairy cow diets with 15% whole cottonseed — a byproduct of cotton fiber processing — significantly boosts milk fat content and yield, making it more suitable for butter and cheese production. This is especially important given that, although overall milk consumption in the U.S. has declined, demand for high-fat dairy products like cheese and butter has increased.

Whole cottonseed is rich in unsaturated fatty acids and protein, both critical components for milk fat production. According to Kevin Harvatine, a professor of nutritional physiology and lead researcher, the shift in consumer demand has led dairy farmers to focus on increasing milk fat, which is now a key factor in how they are compensated. Over the past decade, selective breeding and cow management have raised average milk fat content from 3.75% to 4.2%.

The study, published in the Journal of Dairy Science, involved 16 multiparous cows (cows with at least two lactations) over 21-day test periods. Those fed the cottonseed-enriched diet produced milk with 0.2% higher fat and 5% more total milk fat daily, with no decrease in feed intake or changes in milk protein levels.

A key advantage of whole cottonseed is its slow release of unsaturated fats in the cow's rumen, which minimizes the risk of milk fat depression — a condition where fat content in milk drops significantly. Most other fat sources negatively affect the rumen environment, but cottonseed avoids this issue.

The study also addressed concerns about gossypol, a pigment in cottonseed that can be toxic at high levels. Testing revealed gossypol levels were well below toxicity thresholds, and digestion analysis showed that less than 3% of the cottonseed was undigested.

Interestingly, despite other studies linking unsaturated fat supplementation to reduced methane emissions in cows, this research did not observe changes in methane output.

The research team included graduate students and faculty from Penn State's Department of Animal Science and received support from Cotton Incorporated and the USDA.

Bel Group and Standing Ovation Turn Cheese Waste into Sustainable Protein

French dairy company Bel Group has partnered with biotech firm Standing Ovation to develop a groundbreaking precision fermentation process that converts acid whey — a waste by-product of cheese production — into casein, a vital milk protein. This innovation is aimed at reducing food waste and improving sustainability in the dairy sector.

Using its patented fermentation technology, Standing Ovation extracts functional caseins from acid whey, a dairy effluent that typically goes underutilized. These recovered proteins can be reintegrated into the food production cycle, promoting a circular economy model and reducing reliance on traditional dairy sourcing.

The collaboration aligns with Bel Group's goals of eliminating edible waste, enhancing resource efficiency, and advancing food sovereignty by promoting local protein production. The companies plan to scale up the process for industrial use and explore its applications in various food products.

Caroline Sorlin of Bel Group emphasized that the partnership merges Bel's cheese-making expertise with Standing Ovation's innovation to create future-ready, responsible, and accessible dairy products. Romain Chayot, co-founder of Standing Ovation, highlighted that this technology enables manufacturers to reuse whey in production, strengthening local supply chains and addressing global food sovereignty concerns.

Standing Ovation CEO Yvan Chardonnens noted that acid whey contains minimal protein, but their fermentation process transforms it into a new, sustainable protein source. He praised the partnership with Bel as a reflection of shared values: innovation, circular economy, and sustainable food systems in Europe and beyond.

Leading from the Grassroots

Farmer's employee

Dr. Manvir Singh
Chief Executive and Director
Paayas Milk Producer Organisation

Context

As India's dairy sector marches toward greater formalisation, Farmer Producer Organisations (FPOs) — especially Milk Producer Organisations (MPOs) — are emerging as game-changers. Anchored in rural realities but guided by professional management, these farmer-owned institutions are transforming how milk is produced, aggregated, and marketed. They not only bring transparency and efficiency to the system but also place power directly into the hands of smallholder dairy farmers, many of whom are women. In this interview, we speak with one of the most passionate champions of this movement.

About the Leader

Dr. Manvir Singh is more than just a dairy executive — he proudly calls himself a "farmer's employee." With over 23 years of techno-managerial experience in livestock and dairy development, Dr. Singh currently serves as the Chief Executive & Director of Paayas Milk Producer Organisation, one of India's most successful MPOs, based in Rajasthan.

From launching the innovative "Fodder Bank" concept in Uttarakhand to building high-tech dairy farms and shaping dairy cooperatives under NDDB Dairy Services, Dr. Singh has walked the talk across the breadth of the Indian dairy landscape. His academic foundation — spanning Pantnagar University, IVRI Bareilly, and IRMA Anand — has empowered him to bridge grassroots insights with strategic execution.

Today, he stands at the helm of Paayas, helping transform over a lakh dairy farmer — many of them women — into empowered shareholders and climate-

resilient milk entrepreneurs.

Why This Matters

At a time when climate pressures, global trade shifts, and urban demand are reshaping India's dairy sector, leaders like Dr. Singh are on the frontlines. His journey exemplifies how rural innovation, women's leadership, and mission-driven institutions can redefine the future of food together.

"We Are No Longer Advisors—We are Partners": Dr. Manvir Singh on Two Decades with India's Dairy Farmers

1. **You often describe yourself as a "farmer's employee." With over two decades in the dairy sector, what are the most significant changes you've witnessed on the ground? Any farmer story that left a lasting impression?**

Yes, I say this with conviction and pride: I am a farmer's employee. That identity has shaped my entire professional life. Over the past 20 years, I have seen the Indian dairy sector evolve from traditional, subsistence-led practices to a far more market-aware and resilient industry.

Back when I began, dairy farming was a household activity—often informal and undervalued. But today, we are witnessing a quiet revolution. Farmers are adopting scientific feeding practices, improving breeding through AI services, and using mobile-based advisory platforms. Village-level chilling infrastructure, once a distant dream, is now common.

Sumitra Devi
Dairy Farmer, Jaitpura

But what strikes me most is the mindset shift, especially among women. Earlier, women were perceived as helpers in dairy households. Today, they are decision-makers, shareholders, and even board members of Milk Producer Organisations (MPOS). Some have even risen to lead as CEOs. That's more than change—it's transformation.

Let me share a story. Sumitra Devi, a farmer from a small village in Rajasthan, started her dairy journey with a single local cow, walking miles to sell milk at whatever rate local traders offered. After the establishment of a Paayas Milk Pooling Point in her village, she gained access to AI services, training, and direct payments. Today, she owns four crossbred cows, sends her daughters to school, and sits on the Village Contact Group. I'll never forget her words to me:

"Aap kehte hain aap kisan ke karamchari hain. Toh yeh bhi batayein, hum bhi CEO hain—apne ghar aur apne sapno ki."

("You say you are a farmer's employee. Then let me tell you—we are also CEOs, of our homes and our dreams.")

That, to me, is the true face of progress.

2. **How do Milk Producer Organizations (MPOs) differ from traditional Farmer Producer Organizations (FPOs)? And how widespread are MPOs in India?**

It's an important distinction. FPOs are an umbrella category—farmer-owned collectives that can span a variety of crops or commodities. An FPO might deal in vegetables, pulses, or grains. The goal is aggregation, cost reduction, and better market access. These are typically registered under the Companies Act and supported by NABARD, SFAC, and others.

MPOs, on the other hand, are a specialised form of FPOs focused entirely on dairy. Born from the NDDB-promoted model, particularly under the National Dairy Plan, MPOs are structured as milk producer companies—private in structure, but farmer-owned in spirit. They handle not just milk procurement but also veterinary care, breeding services, feed supply, and training.

So yes, **all MPOs are FPOs, but not all FPOs are MPOs.**

As of early 2024, India has over 400 functional MPOs, mostly in Rajasthan, Gujarat, Uttar Pradesh, Bihar, and Maharashtra. These organisations have empowered millions of smallholder farmers, especially women, and are evolving into professionally managed, self-sustaining dairy businesses. Success stories like Paayas, Maahi, Shreeja, and Saahaj reflect this growth.

3. **Thousands of FPOs have been established across India—but are they truly successful? Can you share a standout example?**

Success is a layered concept. Many FPOs are still navigating their early phases—struggling with governance, working capital, or market linkages. But

there are bright spots that prove what's possible.

Paayas Milk Producer Company, based in Rajasthan, is one such example. It began with a few thousand members in 2012 under the NDDB's guidance. Today, it has scaled to over 100,000 milk producers—predominantly small and marginal farmers, with women forming a substantial portion of the membership.

Paayas operates on three pillars: **transparency, member ownership, and market access**. Farmers are not just suppliers—they are shareholders. Payments are quality-linked and directly credited. Over time, this has built a rare level of trust and loyalty.

What truly defines Paayas' success is not just turnover—it's empowerment. Farmers who once operated at the mercy of middlemen now control their produce, their prices, and their futures. With a professional team and a farmer-elected board, the company balances grassroots needs with business acumen. It's a blueprint worth replicating.

4. **Rajasthan is among India's most climate-vulnerable regions. How is Paayas equipping farmers to adapt to the realities of climate change?**

Climate resilience is no longer an option—it's imperative. At Paayas, we are building sustainability into the core of our operations.

We promote climate-smart practices such as water-efficient fodder cultivation, silage making, and heat-resistant animal shelters. Our breeding strategy focuses on local and crossbred cattle that can withstand rising temperatures.

Infrastructure is another focus. We have deployed solar-powered milk chilling units and supported the establishment of biogas plants. These not only reduce emissions but also lower energy costs for rural households.

But the most important investment is Knowledge. We are training farmers in climate-resilient dairy practices and encouraging peer-led learning models. The goal is simple: sustainability must be a shared and ongoing effort.

5. **What challenges do smallholder dairy farmers face today, and how can startups help bridge the gap?**

Smallholder farmers face constraints that large, capital-intensive farms don't— limited access to capital, technology, and consistent veterinary care. But that also makes them fertile ground for innovation.

Startups can—and should—design for this segment. The need is for **frugal, scalable, and intuitive solutions**. Be it AI-based heat detection, real-time milk quality testing, digital payment platforms, or input delivery—there is immense scope.

What excites me is the potential of partnerships. When FPOs like Paayas collaborate with agri-tech innovators, the results can be transformative. We bring scale and trust; they bring technology and agility. Together, we can co-create products that work for the last mile.

6. **The U.S. tariff war has been making global headlines. What does it mean for Indian dairy?**

The direct impact on Indian dairy has been minimal. Our exports to the U.S.—mostly ghee and casein—are limited. While increased tariffs can affect competitiveness in niche segments, India remains a predominantly domestic dairy market.

Our strength lies in policy safeguards. Import duties between 30% and 60%, combined with strict non-tariff conditions (like the ban on animal-derived feed inputs), protect our rural livelihoods. And rightly so—over 100 million Indian households depend on dairy.

The concern, however, is the **indirect ripple effect**. If U.S. dairy players are locked out of India, they will pivot to other global markets, increasing competition. We also need to monitor input costs and broader economic fluctuations.

That said, India's dairy ecosystem is resilient. Grounded in local demand, farmer ownership, and a robust cooperative tradition, we are not easily shaken by external shocks. But vigilance, as always, is key.

Closing Thoughts

Dr. Manvir Singh's work at Paayas Milk Producer Organisation is a compelling example of what happens when purpose-driven leadership meets grassroots empowerment. His commitment to transparency, community-led development, and climate resilience make him not just a leader in the dairy sector, but a change maker shaping its future. As India's dairy economy becomes more formalised, inclusive, and tech-enabled, the vision of leaders like Dr. Singh will ensure that growth is measured not just in litres of milk but in lives transformed.

Britannia Launches Greek Yogurt, Aiming to Redefine India's Premium Dairy Market

Britannia Industries Ltd has officially entered India's Greek yogurt segment, marking a significant expansion in its premium dairy offerings. More than just a new product launch, the initiative reflects Britannia's commitment to innovation, nutritional integrity, and modern consumer preferences.

The newly launched Greek yogurt range is designed to offer authentic taste, bold flavors, and clean-label formulations that appeal to health-conscious urban consumers. As the functional dairy category gains momentum in India—driven by rising interest in gut health and protein-rich diets—Greek yogurt remains underpenetrated. Britannia aims to address this gap and become a mass-market leader in the segment.

The success of this launch stems from a robust cross-functional effort. Teams across R&D, marketing, operations, and logistics collaborated closely to ensure a high-quality product and timely market execution. From product texture to brand positioning, every detail was meticulously crafted.

“This wasn't just a launch—it was the realisation of a shared dream,” said a senior executive, highlighting the project's ambition to set new standards in the category.

Industry experts are already calling Britannia's Greek yogurt a potential category catalyst, bringing scale and sophistication to a market with growing demand but limited mainstream presence.

Behind the scenes, the project's success is credited to a high-performing team, with special recognition for Mike La Grange's leadership and drive.

Looking ahead, Britannia sees this launch as a first step toward reshaping India's dairy landscape, with a strong team and a clear vision to lead the evolution.

Arla and DMK Merger to Create Dairy Powerhouse

Arla Foods, Denmark's leading dairy producer, has entered into a strategic merger with Germany's DMK Group to form Europe's largest dairy cooperative. With a combined annual revenue of €19 billion, this merger will allow both companies to better compete against global dairy giants like Nestlé and Lactalis. The new entity will benefit from an expanded product range, improved global distribution networks, and increased market leverage. The merger is a response to declining European milk production, which has created opportunities for larger, more efficient players in the dairy sector.

New Zealand's Dairy Production Set to Drop

New Zealand, known for its dominance in global dairy exports, is forecasting a decline in milk production for the upcoming season. Due to a combination of environmental regulations, labor shortages, and adverse weather conditions, New Zealand's dairy farmers are expecting a 3% decrease in milk production in 2025. This reduction could have significant consequences for global dairy markets, as New Zealand typically supplies around 30% of the world's dairy exports. The country's farmers are also under pressure to reduce their carbon emissions in line with New Zealand's ambitious climate goals.

Latin America Emerging as Key Dairy Export Market

Latin America has emerged as a significant growth market for global dairy exports. With milk production struggling in countries like Brazil and Argentina, the region is increasingly turning to external suppliers, particularly from the U.S. and Europe, for powdered milk, cheese, and butter. The growing middle class in Latin America is driving demand for dairy products, and international dairy companies are capitalizing on this opportunity by increasing their exports to the region.

7. Global Milk Price Volatility Intensifies

Global milk prices have experienced significant volatility over the past month, with both rising and falling trends observed in different regions. Factors such as changing feed costs, fluctuating fuel prices, and geopolitical tensions are contributing to the unpredictability of milk prices. While some countries, particularly in the EU, have seen a decline in milk prices due to oversupply issues, others, such as the U.S., have witnessed price increases as a result of tightening supply.

European Dairy Producers Explore Alternative Protein Sources

With increasing consumer demand for plant-based diets, major European dairy producers such as Nestlé, Danone, and Lactalis are exploring the addition of plant-based proteins to their products. These companies are experimenting with blends of traditional dairy and plant-based proteins from sources like peas, soy, and oats to create hybrid dairy products. The goal is to capture the growing market of consumers who are reducing their dairy intake for health or environmental reasons but still desire dairy-like products.

Global Milk Shortage Could Reach 30 Million Tons by 2030, Warns IDF

The International Dairy Federation (IDF) has warned that global milk demand could outpace supply by 30 million tons by 2030. Factors contributing to this potential shortage include climate change, land pressure, and changing dietary preferences. The IDF emphasizes the need for strategic action to address the widening milk deficit.

Global Dairy Giants Focus on Sustainability

Major global dairy companies such as Nestlé and Lactalis are ramping up their sustainability efforts in response to increasing consumer demand for eco-friendly products. These companies are focusing on reducing their carbon footprint, adopting renewable energy for production, and developing carbon-neutral packaging solutions. With environmental concerns becoming a significant factor in consumer purchasing decisions, dairy companies are incorporating sustainability into their core strategies to maintain market relevance.

U.S. Dairy Exports Face Decline Amid Tariff Woes

U.S. dairy exports have taken a hit in recent months due to ongoing trade tensions and tariff disputes, particularly with China. Exports of key dairy items such as milk powders, cheese, and butter have fallen as a result of

retaliatory tariffs, causing a shift in purchasing behavior. Countries like New Zealand and European nations are now emerging as preferred suppliers for many international buyers. The U.S. dairy industry is facing increasing competition, and exporters are working with the U.S. government to negotiate lower tariffs and open up new markets.

India's Dairy Production Growth Outpaces Global Trends

India's dairy production is growing at a rate faster than most other countries, positioning India as the largest milk producer in the world. With India accounting for over 23% of global milk production, the country's output continues to increase, largely driven by improvements in dairy farming practices, better veterinary care, and investments in milk processing infrastructure. The Indian government is also working to boost exports to capitalize on this growth, particularly targeting markets in the Middle East and Southeast Asia.

China's Dairy Demand Slows Amid Economic Downturn

China's dairy demand has slowed significantly as the country faces an economic downturn. This slowdown has impacted both domestic milk production and imports, with premium dairy products such as yogurt, cheese, and butter seeing the most significant declines. As consumer spending tightens, many Chinese households are cutting back on non-essential food items, including higher-priced dairy goods. This has caused dairy companies, both domestic and international, to adjust their pricing strategies to maintain consumer interest in a more cost-sensitive market.

EU Dairy Sector Faces Labor Shortage

The European Union's dairy sector is facing a growing labor shortage, particularly in countries like France, Germany, and the Netherlands. As dairy farms struggle to find skilled workers to handle tasks such as milking and herd management, production costs are rising. The shortage is exacerbated by the low wages offered in the dairy industry compared to other agricultural sectors. In response, EU policymakers are pushing for better training programs, higher wages, and labor-saving technologies to address the issue.

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Maximizing Milk: How Technology Drives Valorisation Across the Dairy Chain

by **Shreesh Kashyap,** Neologic Engineers

Shreesh Kashyap

Shreesh Kashyap is a seasoned Mechanical Engineer from COEP Pune with over 40 years of experience in the dairy processing industry. He has held key leadership roles at Alfa Laval, Larsen & Toubro (L&T), and Tetra Pak, contributing extensively to project engineering, commissioning, and end-to-end solutions in dairy, UHT, beverages, and cheese processing. Currently, he serves as an advisor to Neologic Engineers, focusing on optimized process solutions, innovation, and industry consulting.

In today's dairy industry, every drop of milk holds untapped potential. With global demand for dairy products evolves, producers face a dual challenge of meeting consumer expectations while optimizing operational efficiency. Fortunately, advancements in technology and smart processing systems are transforming how dairies extract greater value from every liter of milk. From whey protein recovery to by-product utilization and product diversification, these innovations are redefining the dairy chain.

Unlocking Value Through Whey Protein Recovery

Whey is the liquid dairy by-product produced during the when making of Cheese, Casein and Paneer. Before gaining popularity, whey extracted from cheese and paneer was typically used as low-value ingredient for baking or as animal feed or often drained off resulting in high effluent loads.

Today, whey protein is a cornerstone of Dairy Valorisation, thanks to sophisticated separation and filtration technologies. Membrane filtration systems enable dairies to precisely isolate high-quality whey proteins, transforming what was once waste into high-value products. These proteins, rich in essential amino acids, are in high demand for sports nutrition, infant formula, nutraceuticals, and functional foods.

There are various types of whey products on the market, ranging from demineralized whey to protein isolates, hydrolyzed proteins, and hydrolysates, each catering to specific applications and nutritional needs.

Advancements Through Membrane Filtration Technology

Membrane filtration is a cutting-edge technology used to separate milk into its individual components, such as casein &whey proteins and lactose. Ultrafiltration, Nanofiltration, Microfiltration and Reverse Osmosis are now some of the most commonly used membrane technologies in modern dairy processing.

Key benefits of membrane filtration technology include:

- **Production of high-value dairy ingredients:** Enables the creation of specialized products like whey

protein concentrates (WPC), isolates (WPI), and lactose-free milk.

- **Extended product shelf life:** Improves safety and shelf stability by removing contaminants and spoilage organisms, especially in premium pasteurized milk and extended shelf-life dairy products.
- **Energy and resource efficiency:** Optimally designed systems—such as those by Neologic Engineers using Alfa Laval spiral membranes—reduce energy consumption and the use of water and cleaning chemicals, offering a more sustainable alternative to traditional separation methods.

For dairy processors, whey recovery is more than just an additional revenue stream—it's a shift toward higher plant productivity and overall operational efficiencyModern systems can process fresh whey and integrate seamlessly into existing cheese production lines, boosting yields without major capital investments.

For instance, a mid-sized cheese plant processing 100,000 liters of milk daily can recover whey proteins and lactose to produce demineralized whey powders (DM) or whey protein concentrates (WPC), generating thousands of dollars in additional monthly revenue—depending on market conditions—while also cutting waste disposal costs.

Turning By-Products into Opportunities

Beyond whey proteins, technology is enabling dairies to extract value from other by-products once considered waste. Pharma-grade lactose and whey protein particulates are becoming viable products thanks to innovations in extraction and refining processes.

Technologies like reverse osmosis, nanofiltration, and ultrafiltration allow producers to concentrate lactose for use in pharmaceutical and nutraceutical applications. Dairy processors can evaluate their cheese and paneer whey streams to match them with these emerging technologies, shifting from a single-output model to one that treats milk as a multi-faceted resource.

Diversifying Into Functional and Nutraceutical Categories

Consumer demand is driving the dairy industry beyond traditional offerings. Functional and nutraceutical foods provide health benefits beyond basic nutrition. Techniques such as precision fermentation, enzymatic modification, and spray-drying now enable the creation of dairy-based ingredients tailored to specific health outcomes—such as gut health, muscle recovery, or cognitive enhancement.

Using enzymatic hydrolysis, dairies can break down milk proteins into smaller, more bioavailable peptides with targeted benefits. These can be incorporated into beverages, powders, and even snack bars, allowing processors to diversify their product lines without deviating from their core strengths.

Smart Processing Systems & Packaging Solutions

Valorisation doesn't stop at product innovation—it extends into operational excellence. Smart processing systems use automated controls and real-time monitoring to ensure product consistency, reduce trial-and-error, and minimize costs. IoT-enabled equipment and predictive maintenance tools further enhance throughput and minimize downtime.

Energy efficiency is also key. Advanced heat recovery and regeneration systems reduce the energy needed for pasteurization and drying, lowering environmental impact and operational costs. For large-scale dairy processors, even a 10% energy reduction translates to significant savings that can be reinvested in R&D or new product development.

Smart packaging solutions are emerging as critical tools for product traceability and quality monitoring throughout the supply chain. These include embedded QR codes that provide consumers and retailers with information about processing, quality, and traceability.

Advantages of smart packaging:

- Real-time quality monitoring
- Timely sales before expiry to reduce food waste
- Improved supply chain transparency

Plants equipped with sensors and data analytics can fine-tune temperature, pH, and bioactivity, ensuring consistent results at scale. Today's technologies can flag issues before they escalate, allowing for proactive interventions.

The Future of Dairy Valorisation

As the dairy industry evolves, those who can maximize every liter of milk will stand out. Milk should no longer be viewed as a perishable, single-use commodity, but as a dynamic resource full of potential. From whey proteins to bioactive compounds, the possibilities are vast.

For dairy processors, the message is clear: embrace innovation, optimize your operations, and extract value from every drop. The future of milk lies not just in the jug—but in the ingenuity that surrounds it.

Heritage Foods Raises Prices in Response to Input Costs

Heritage Foods, one of India's leading dairy players, has increased the prices of its key dairy products, including milk, paneer, curd, and butter by 2%–4%. This price hike comes after nearly two years of stable pricing and is being implemented to counteract the rising costs of essential inputs like fuel, cattle feed, and packaging materials. The company has stated that while it is working hard to minimize the impact on consumers, rising operational costs necessitate this adjustment to ensure the continued quality of its products. Despite the price increase, Heritage Foods remains committed to offering competitive pricing compared to other market players.

Amul Expands Product Range to Tap Into Health Trends

Amul, India's dairy behemoth, has announced its expansion into the high-protein dairy product market with the launch of new offerings such as high-protein yogurt and protein-rich cheese. The company has noted the increasing demand for high-protein foods, driven by fitness enthusiasts and health-conscious consumers. Amul is capitalizing on this trend by emphasizing the natural, wholesome ingredients of its products and catering to an emerging market of people who want to boost their protein intake without resorting to processed alternatives. This move also aligns with global dairy trends that emphasize higher protein content in dairy products to meet consumer demand for healthy, functional foods.

India's Dairy Exports to the Middle East Facing Challenges

India, one of the world's largest dairy producers, is encountering several obstacles in exporting dairy products to the Middle East. While the demand for products like butter and ghee remains strong, logistical hurdles such as inadequate cold chain facilities and delays in transport are limiting export volumes. Moreover, competition from European and New Zealand producers is intensifying, as they have better-established supply chains and stronger brand recognition. To tackle these issues, the Indian government is working on expanding air freight options and improving export infrastructure to meet the growing demands from Middle Eastern markets.

India's Milk Consumption Projected to Grow

India's dairy consumption continues its upward trajectory. According to a report by the USDA Foreign Agricultural Service (FAS), India's fluid milk consumption is forecasted to rise to 91 million metric tons (MMT) in 2025, an increase from 89 MMT in 2024. This growth is driven by a combination of factors: rising per capita incomes, an expanding middle class, and increasing urbanization. Additionally, consumers are shifting toward healthier lifestyles, which includes more dairy products in their diets. With milk being a staple food across various Indian states, the demand for processed dairy items like cheese, yogurt, and paneer is also surging.

Milk Production in India Faces Regional Imbalances

India's milk production continues to grow, but it is highly uneven across the country. States like Uttar Pradesh, Madhya Pradesh, and Rajasthan dominate milk production, while regions like Tamil Nadu and Karnataka face stagnation due to various factors such as insufficient infrastructure, lower cattle productivity, and drought conditions. The Indian government is actively seeking to address these regional disparities by promoting dairy farming in underperforming regions, improving milk transportation networks, and increasing investments in dairy cooperatives to enhance production efficiency.

Indian Dairy Farmers Struggling with Rising Input Costs

Dairy farmers across India are facing a challenging economic environment, as input costs, particularly for cattle feed and veterinary care, continue to rise. Many farmers are struggling to maintain profitability, with some even reducing the size of their herds due to the increasing costs of maintaining dairy cattle. While the government has introduced a few subsidies to help with the cost of veterinary care and cattle feed, the overall economic strain on farmers is expected to reduce milk output in the near term. If this trend continues, it could create a shortage of milk in key production areas, affecting both the domestic and export markets.

Vanishing Herds: Punjab's Livestock Down by 8.5%

Prelim census report bares trend; rapid urbanisation to blame

The preliminary findings of the 21st Livestock Census reveal a concerning 8.5% decline in Punjab's livestock population, amounting to a reduction of 5.78 lakh animals since the previous census in 2019. The total livestock count now stands at 68,03,196, down from 73,81,540.

Among the most significant drops are in the buffalo population, which has declined by 5.22 lakh, and cattle, which have reduced by 2.32 lakh. The pig population also saw a decrease of 6,973. In contrast, some categories showed growth: sheep increased by nearly 1 lakh, dogs by 57,000, goats by 21,000, and horses by 5,720.

The data also highlights a steep fall in donkey and camel numbers. Punjab now has only 127 donkeys and 77 camels, a stark contrast to 1977 figures when the state had 22,000 donkeys and 29,000 camels.

Despite the overall decline in livestock, milk production has remained unaffected. This is attributed to dairy farmers increasingly relying on high-yielding breeds like Holstein Friesians, known to produce 10,000–12,000 litres per lactation over five cycles.

Key factors driving the decline include rapid urbanisation, migration abroad, and the 2022 lumpy skin disease outbreak, which led to widespread cattle deaths. Interestingly, the previous census had shown a rise in the indigenous (desi) cow population in Punjab, bucking the national trend.

Final species-wise details are yet to be released. Officials anticipate an increase in the population of the Sahiwal breed once the full report is available.

The enumeration for this census was conducted between October 2024 and February 2025.

What Preliminary Census Report Says

Species	Prelim report of 21st census	Population in 20th census	Species	Prelim report of 21st census	Population in 20th census
Cattle	22.99 lakh	25.31 lakh	Donkey	127	471
Buffalo	34.93 lakh	4015 lakh	Camel	77	120
Sheep	1.06 lakh	85,560	Pig	45,988	52,961
Goat	4.47 lakh	3.47 lakh	Rabbit	2,193	3,077
Horse	19,882	14,243	Dog	3.85 lakh	3.28 lakh
Mule	1,266	1,644	Elephant	1	1

MuscleBlaze Secures US Patent for Protein-Digesting Enzyme, Boosting Indian Sports Nutrition Industry

In a major achievement for India's sports nutrition sector, MuscleBlaze—under parent company HealthKart—has been granted a United States patent for its proprietary enzyme blend, **MB Enzyme Pro®**, designed to improve protein digestion and absorption. The announcement, made by HealthKart CEO Sameer Maheshwari during the company's 14th anniversary, marks a significant milestone in whey protein innovation.

MB Enzyme Pro®, a key component of the Biozyme Whey range, reportedly increases post-meal amino acid levels by 50% compared to standard whey, enabling more efficient protein delivery. With this US patent, MuscleBlaze becomes the only **brand globally with exclusive rights to this enzyme composition, setting it apart in a highly competitive** market.

This patent follows a track record of innovation from MuscleBlaze, which includes:

- **2015:** Implemented anti-counterfeit supply chain authentication.
- **2017:** Secured an Indian patent for MB Enzyme Pro®.
- **2019:** Launched scoop-on-top packaging to enhance user convenience.
- 2024: Received US patent, reinforcing its scientific credibility.

HealthKart has filed over 25 patents to date, reflecting a broader commitment to protecting intellectual property and advancing research-driven nutrition.

Maheshwari, in a LinkedIn post, praised the R&D team—especially Anupam Trehan—for their contribution, reaffirming the brand's mission to deliver world-class sports nutrition to Indian consumers.

The US patent not only boosts MuscleBlaze's global reputation but also positions Indian dairy-based nutrition products as scientifically advanced and competitive on the international stage. Future developments are expected to build on this innovation through new, high-performance formulations.

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