

DAIRY PLANET DIGEST

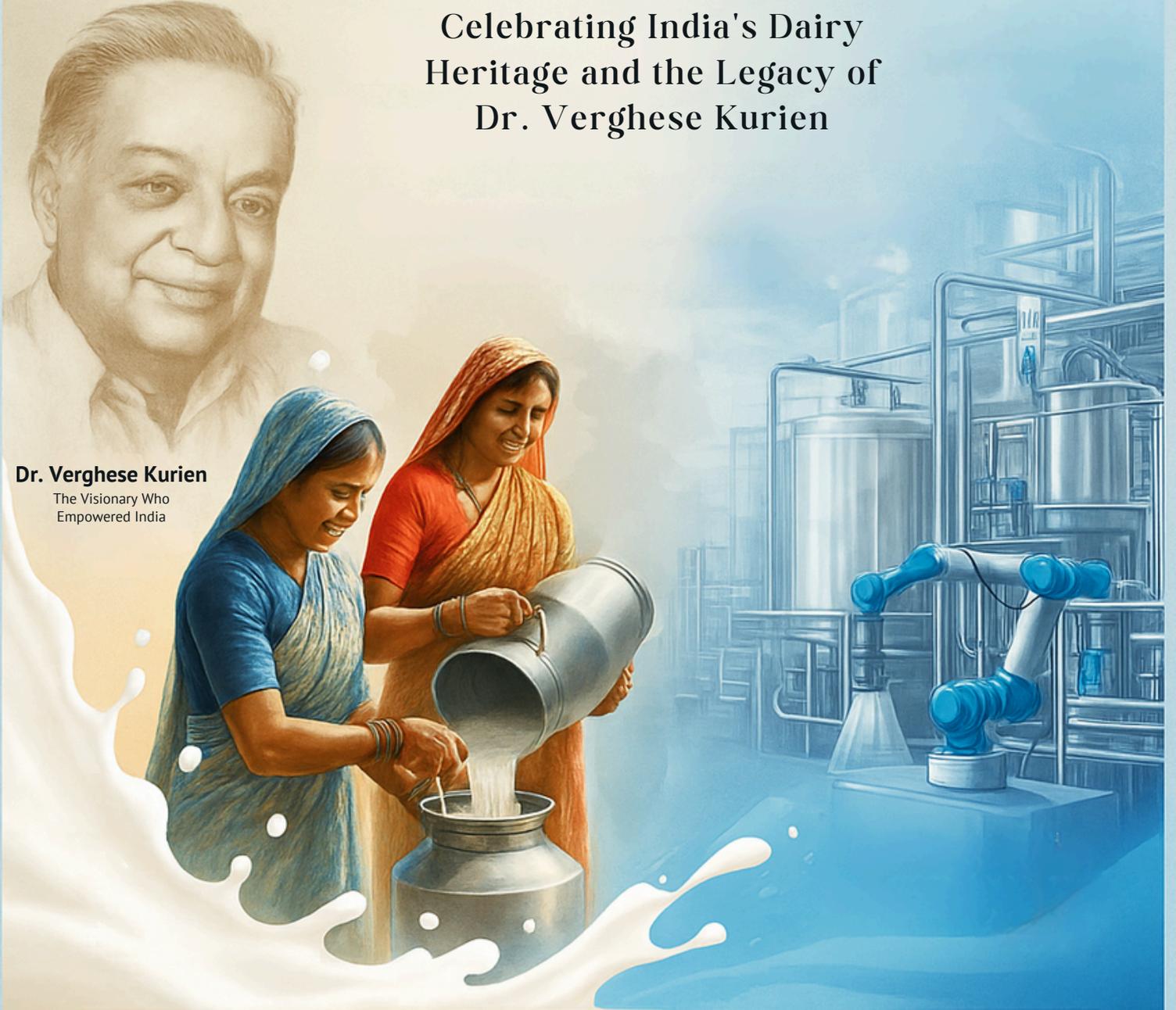
National Milk Day Special

Volume I Issue 3 | November 2025

Celebrating India's Dairy Heritage and the Legacy of Dr. Verghese Kurien

Dr. Verghese Kurien

The Visionary Who
Empowered India



White Revolution 2.0:
Reimagining India's Dairy
Destiny



**The Role of the Dairy
Industry** in Making India
a Developed Country by
2047



**श्वेत क्रांति से विज्ञान, छात्र और
किसान तक**



Artificial Intelligence In Dairy:
The Future of Smart Farming &
milk Production



About Us



Dairy Planet is an educational and knowledge-based digital platform committed to empowering students, professionals, and stakeholders in the dairy and food technology sectors. The initiative bridges the gap between academic theory and industry practice through curated content, e-learning resources, expert mentorship, and collaborative community engagement.

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Mission

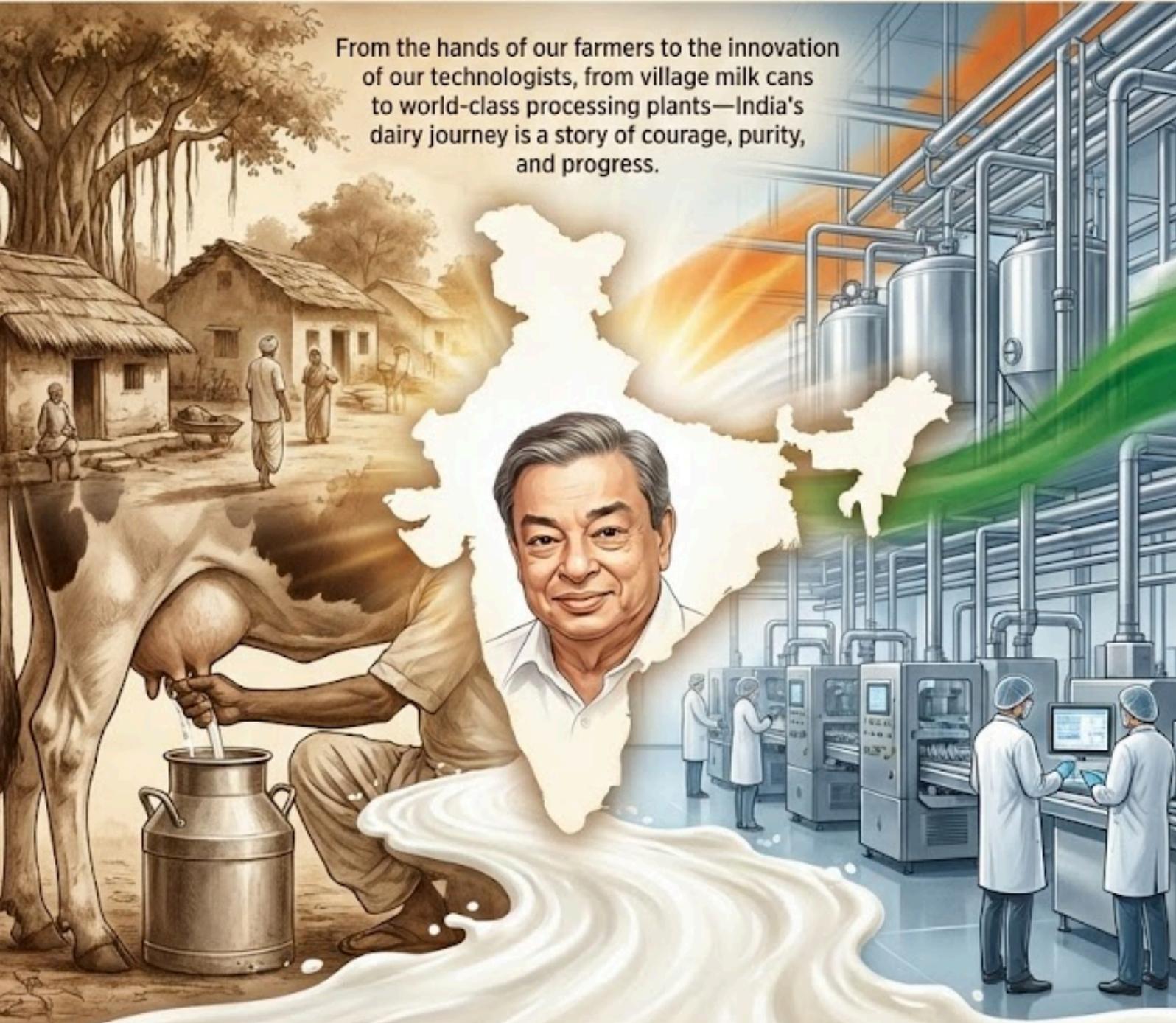
Dairy Planet is dedicated to transforming dairy education and empowerment through innovation, collaboration, and accessibility. We provide Dairy Technology students with syllabus-based e-learning resources, practical tools, and industry insights, while also empowering farmers through scientific training and modern dairy practices. By connecting students, professionals, startups, and institutions, we're building a unified ecosystem that fosters skill development, research, and entrepreneurship. With multilingual and interactive content, Dairy Planet aims to make quality education and innovation accessible to all — from classrooms to cowsheds — driving sustainable growth in India's dairy sector.

Vision

To become India's most trusted digital ecosystem for dairy and food technology education, enabling academic excellence, innovation, and inclusive growth in the dairy sector.

NATIONAL MILK DAY – A TRIBUTE TO INDIA’S WHITE STRENGTH

From the hands of our farmers to the innovation of our technologists, from village milk cans to world-class processing plants—India's dairy journey is a story of courage, purity, and progress.



**NOURISHMENT
& NUTRITION**



**EMPOWERMENT
& LIVELIHOOD**



**WHITE HEARTBEAT
OF OUR NATION**

As we honor Dr. Verghese Kurien... we also celebrate the millions...

Here's to innovation. Here's to resilience. Here's to the spirit of milk.

Team Dairy Planet proudly salutes everyone contributing to India's dairy strength.

Let's continue to learn, innovate, and transform the future of dairy-together.



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SUBMIT YOUR WORK AND BE FEATURED!

FROM FOUNDER'S DESK

Dear Readers,

Every glass of milk carries a story — of hard work, innovation, and transformation. Decades ago, one visionary, **Dr. Verghese Kurien**, redefined India's destiny by turning scarcity into self-sufficiency. His dream gave birth to the **White Revolution**, a movement that not only nourished a nation but also empowered millions of rural families.

As we celebrate **National Milk Day 2025**, we stand at the crossroads of a new era — **White Revolution 2.0**, where tradition meets technology, and rural empowerment blends with digital innovation. Today, India isn't just the world's largest milk producer; it's a symbol of how community-driven enterprise and scientific progress can shape inclusive growth.

This issue of **Dairy Planet Digest** pays tribute to Dr. Kurien's vision while exploring how India's dairy sector continues to evolve — from empowering women through cooperatives to embracing automation, sustainability, and global trade opportunities. The journey from a village milk can to a world-class dairy plant is not merely industrial progress; it's a story of human resilience, scientific curiosity, and national pride.

Through these pages, we bring voices from the field and insights from experts to celebrate the real heroes — the **farmers, dairy technologists, entrepreneurs, and young innovators** who are shaping India's dairy future. Together, they represent a movement that is not just about producing milk, but about **nurturing livelihoods, health, and hope**.

As Dairy Planet continues its mission to connect, educate, and empower the dairy community, we invite you to be part of this ongoing revolution — because the **future of India's dairy lies in every inspired mind and every determined hand** that works toward purity, prosperity, and progress.



FOUNDER
DAIRY PLANET

प्रिय पाठकों,

हमें अत्यंत हर्ष है कि हम Dairy Planet Digest के Volume 1, Issue 3 को “श्वेत क्रांति 2.0: दूध से सशक्त भारत” जैसे प्रेरणादायी और परिवर्तनकारी विषय पर समर्पित कर रहे हैं। भारत की पहली श्वेत क्रांति ने देश को आत्मनिर्भर बनाया—लेकिन समय की मांग है कि हम तकनीक, नवाचार, मूल्यवर्धन और युवा शक्ति के साथ एक नई दुग्ध क्रांति का निर्माण करें। यही है White Revolution 2.0, जो किसानों, उद्यमियों, वैज्ञानिकों, छात्रों और ग्रामीण भारत के हर सपने को नई उड़ान देने वाली है।

आज का भारतीय डेयरी उद्योग केवल दूध उत्पादन का क्षेत्र नहीं रहा—यह रोजगार, पोषण, स्वास्थ्य, तकनीक और आर्थिक प्रगति का एक विशाल स्तंभ बन चुका है। AI-आधारित फार्मिंग, स्मार्ट प्रोसेसिंग, वैल्यू-ऐडेड मिल्क, मिलेट-इनफ्यूज्ड प्रोडक्ट्स, स्वचालित पनीर निर्माण, और FDI के नए अवसर—ये सभी मिलकर एक सशक्त, आधुनिक और वैश्विक भारत की ओर संकेत करते हैं। इस अंक में, हमने 2030 से 2047 तक के डेयरी परिदृश्य, किसानों की उन्नति, तकनीक की प्रगति, ग्रामीण विकास की संभावनाओं और युवाओं की भूमिका को गहराई से समझने की कोशिश की है। साथ ही, Spotlight Series में प्रेरक कहानियों के माध्यम से यह दिखाया गया है कि सफलता न उम्र देखती है न सीमाएँ—बस जुनून और प्रयास की जरूरत है।

Quiz Result और Student Corner जैसे सेक्शन इस पत्रिका को और भी जीवंत बनाते हैं, क्योंकि हमारा उद्देश्य केवल जानकारी देना नहीं, बल्कि छात्रों, युवा तकनीशियनों और Dairy Planet समुदाय को जोड़ना, प्रेरित करना और आगे बढ़ाना है। अंत में, मैं Dairy Planet टीम, लेखकों, डिज़ाइनरों, और सभी पाठकों का हृदय से आभार व्यक्त करता हूँ।

आपके समर्थन से ही हम हर अंक को और बेहतर बना पाते हैं।

आइए, मिलकर श्वेत क्रांति 2.0 को न केवल एक विचार, बल्कि एक राष्ट्रीय आंदोलन बनाएं। भारत के प्रत्येक गाँव से लेकर वैश्विक मंच तक—दूध की यह शक्ति हमें एक नई दिशा देगी, एक नया भविष्य देगी।

संपादक,
Dairy Planet Digest

White Revolution 2.0 – क्यों ज़रूरी है भारत को एक नई दुग्ध क्रांति?

– A Theme Introduction for Dairy Planet Digest

भारत ने 1970 के दशक में ऑपरेशन फ़्लड के माध्यम से जिस सफ़ेद क्रांति को जन्म दिया, उसने देश को दूध की कमी से उठाकर विश्व का सबसे बड़ा दुग्ध उत्पादक बना दिया। डॉ. वर्गीज़ कुरियन की दूरदर्शिता और सहकारी मॉडल ने करोड़ों ग्रामीण परिवारों को आर्थिक मज़बूती दी और भारत की पोषण सुरक्षा को नई दिशा दी।

लेकिन आज, पाँच दशक बाद, भारत एक नए मोड़ पर खड़ा है। बदलती जनसंख्या, बढ़ती मांग, खाद्य सुरक्षा, जलवायु परिवर्तन और तकनीकी उन्नति—इन सभी ने संकेत दिया है कि देश को अब White Revolution 2.0 की आवश्यकता है।

क्यों ज़रूरी है नई दुग्ध क्रांति?

- उत्पादन बढ़ रहा है, लेकिन गुणवत्ता और मूल्य संवर्धन की चुनौती भी उतनी ही बड़ी है।
- आधुनिक उपभोक्ता सुरक्षित, ट्रेसबल और ऑर्गेनिक उत्पाद चाहते हैं।
- पशुधन का वैज्ञानिक प्रबंधन, हार्ड-जेनेटिक ब्रीडिंग और प्रिसिजन डेयरी की जरूरत महसूस हो रही है।
- महिलाओं और छोटे पशुपालकों के लिए आय बढ़ाने का सबसे तेज़ मार्ग आज भी दुग्ध क्षेत्र ही है।
- दूषित दही, नकली घी और मिलावटी पनीर जैसी चुनौतियां नई तकनीक, कठोर नियमन और फूड-सेफ्टी संस्कृति की मांग करती हैं।

White Revolution 2.0 सिर्फ उत्पादन बढ़ाने का अभियान नहीं है — यह भारत के दूध को सुरक्षित, टिकाऊ, तकनीकी और वैश्विक स्तर पर प्रतिस्पर्धी बनाने का संकल्प है।

यही वह समय है जब भारत को अपनी दुग्ध विरासत को आधुनिक विज्ञान, डेटा, नवाचार और किसानों की नई पीढ़ी की महत्वाकांक्षाओं से जोड़कर एक नई श्वेत क्रांति का निर्माण करना होगा।

क्योंकि भारत में दूध सिर्फ भोजन नहीं — भविष्य है।



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FEATURE | White Revolution 2.0



White Revolution 2.0: Reimagining India's Dairy Destiny

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Introduction

India's dairy sector stands at a historic crossroads. More than five decades after Dr. Verghese Kurien's White Revolution transformed the nation from a milk-deficient country into the world's largest milk producer, a new transformation is now essential. White Revolution 2.0 is not just about increasing production—it is about reimagining the entire dairy ecosystem through innovation, digitalization, sustainability, and global competitiveness. This new revolution aims to uplift rural livelihoods, strengthen nutrition security, and position Indian dairy as a global powerhouse.

India produces over 230 million tonnes of milk annually, accounting for nearly 24% of the global milk output. Yet, challenges persist—productivity gaps, climate pressure, fragmented value chains, feed scarcity, and post-harvest losses continue to affect profitability. White Revolution 2.0 addresses these issues through a modern, inclusive, and technology-driven framework that empowers farmers, consumers, and the national economy simultaneously.

At the core of this vision lies the belief that dairy is not merely an economic activity; it is a rural empowerment engine. With more than 80 million rural families connected to dairying—many of them small and marginal farmers—the sector has the potential to become India's most powerful tool for equitable development. The next era of dairy development must therefore focus on enhancing per-animal productivity, promoting value-added products, ensuring climate resilience, and creating transparent, technology-enabled supply chains.

White Revolution

The original White Revolution in India (also known as Operation Flood) was launched in 1970 and led by Verghese Kurien. It turned India from a milk-deficient country into one of the world's largest milk producers. Its core ingredients were: cooperative societies at the village level, linkages between producers and markets, large-scale procurement and processing infrastructure, and technology for milk processing and transport. The Anand-headquartered

National Dairy Development Board (NDDB) comes as India's total milk production grew from 137.7 million tonnes. NDDB chairman Meenesh Shah estimated that the roadmap for White Revolution 2.0 includes creating 75,000 new dairy cooperatives, strengthening 46,422 existing ones, and diversifying into fodder, honey, manure and horticulture to boost farmer incomes. The target is to scale up procurement in the cooperative sector to 1,007 lakh kg per day by 2028-29.

From being a milk-deficient country to becoming the world's largest milk producer in 1998, India's dairy sector—powered the White Revolution accounts for 25% of global milk output major component of this expansion is the Sardar Patel Co-operative Dairy Federation (SPCDF), a multi-state cooperative federation formed by Amul Union home and cooperation minister Amit Shah launched SPCDF on 6th July. It aims to expand the cooperative movement across 20 states. GCMMF and its 18 member unions currently connect 36 lakh farmers across 18,600 villages, procuring 300 LLPD. Through SPCDF, we aim to bring together 20 lakhs more farmers from 20,000 mandalis in 20 states, procuring 100 LLPD within two years.

India's household consumption patterns have changed remarkable over the past three decades, but one food item continues to hold its ground in both rural and urban budgets: milk.

The latest consumption expenditure data released by the National Sample Survey Organization (NSSO) shows that monthly per capita consumption expenditure (MPCE) rose substantially between 1987 and 2023. Alongside this rise, spending on milk and milk products increased manifold in absolute terms, underscoring dairy's enduring role in the Indian diet.

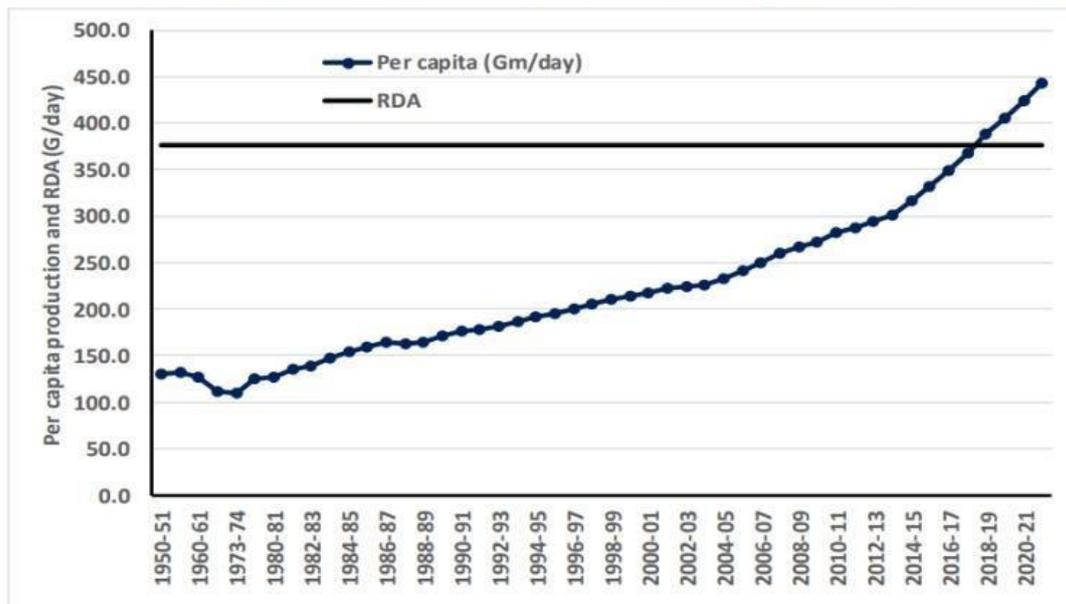
In rural households, monthly per-person expenditure on milk grew from Rs 14 in 1987-88 to Rs 314 in 2022-23. In urban households, it rose from Rs 24 to Rs 466 over the same period. Despite this increase, the share of milk in the food budget remained stable — 13-18% in rural areas and 17-20% in urban areas — over several decades.

Milk's share in total household consumption expenditure has moderated in recent years, largely because non-food spending on transport, healthcare, housing, education, and communication now takes a larger share of the household budget.

Milk output in India increased by a meagre 1.36 per cent per year during 1950-51 to 1973-74, which was lower than the population growth rate. As a result, per capita availability of milk in the country dropped by 15 per cent in this period, resulting into an increase in milk deficiency in the country. The shortage was met partly through imports and aid in the form of milk powder.

GOI launched Operation Flood in 1970 to achieve a breakthrough in milk production. This produced quick results, and milk production outpaced population growth after 1973/74 (Fig.1). Fast growth in milk output enabled India to raise per capita milk production to 387 grams per person per day by 2018-19, which is higher than the average Recommended Dietary Allowance for the country. Now White Revolution 2.0 is being implemented to adapt to current challenges and opportunities in the dairy sector.

Fig.1: Per capita milk production in India 1950-51 to 2021-22, and RDA for milk. Gram/person/day



Source: Basic Animal Husbandry Statistics, 2022 and other issues, GOI

The recent data on milk output shows an annual growth rate of 5.3 per cent. It is important to mention that growth rate in milk production accelerated after 2005, when the emphasis shifted from exotic breeds to indigenous breeds. What is special about the growth of the dairy sector is the nature and quality of growth. The growth of the dairy sector has been pro-poor and pro-women, besides being resilient. Second, the growth of milk did not require particular endowments, like irrigation, good soil, etc. It only required efficient marketing of milk.

Indian Dairy Sector: Existing Scenario

Since 1970, India's milk production has grown by an average of nearly 4% per year, and in 2006 became the largest milk-producing country in the world (Muhammad et al, 2009). At the national level, 57% of the milk production consists of buffalo milk and 43% of cow's milk. Each year, buffalo milk production rises by 4% and that of cow milk by 1.2% (Brouwers, 2006). Between buffaloes and cows, the Indian buffalo herd is expanding by 1.2% per annum, while the dairy cow herd is decreasing by 1% per year. The population of buffalo increased from

43.2 million in 1951 to 93 million in 2003 (Stall et al, 2008). Raw cow milk production has increased from 8.74 million MT in 1970 to 44.10 million MT in 2008, corresponding to an increase in the population of milking cows from 21.8 million heads in 1970 to nearly double at 38.5 million heads in 2008 (Muhammad et al, 2009). It is, however, interesting to note that during this period, the milk yield has seen an increase from 400 to 1150 kg/head (Muhammad et al, 2009), indicating the enhancement in productivity of the animals. This increase in production potential notwithstanding, the present potential is far below the averages reported from Asian countries like Japan (9270 kg/head), Korea (9480 kg/head), and even China (3990 kg/head), not to speak of the European countries. The Indian dairy industry has come a long way over the years, from a milk production of 17 million tons in 1951 to 112 million tons in 2010 (GOI, 2010). In 2000, India had about 27% of Asia's population and more than 50% of Asia's dairy production (Meyfroidt et al, 2010). The production of milk from 1950-51 to 2011-12 is presented in Table 2.

Year	Milk (Million Tonnes)	Year	Milk (Million Tonnes)
1950-51	17.0	1993-94	60.6
1955-56	19.0	1994-95	63.0
1960-61	20.0	1995-96	66.2
1968-69	21.2	1996-97	69.1
1973-74	23.2	1997-98	72.1
1979-80	30.4	1998-99	75.4
1980-81	31.6	1999-2000	78.3
1981-82	34.3	2000-01	80.6
1982-83	35.8	2001-02	84.4
1983-84	38.8	2002-03	86.2
1984-85	41.5	2003-04	88.1
1985-86	44.0	2004-05	92.5
1986-87	46.1	2005-06	97.1
1987-88	46.7	2006-07	102.6
1988-89	48.4	2007-08	107.9
1989-90	51.4	2008-09	112.2
1990-91	53.9	2009-10	116.4
1991-92	55.7	2010-11	121.8
1992-93	58.0	2011-12	127.3

Table 1: Milk production in India (Source: State/UT Animal Husbandry Departments)

The Dairy Sector: India's Rural Backbone

The dairy sector holds a unique and irreplaceable position in India's rural economy, functioning as both an economic stabilizer and a socio-development catalyst. Unlike most agricultural activities that are seasonal and highly dependent on monsoon conditions, dairying provides a consistent, reliable, and year-round income source for millions of households. This distinct characteristic makes the dairy sector the financial backbone of rural India, supporting

livelihoods, enhancing nutritional security, and driving inclusive growth across diverse geographies.

India's dairy ecosystem is fundamentally shaped by its smallholder-dominant structure, where over 80% of farmers own fewer than five cattle. For such farmers, dairy farming is not merely an occupation but a survival strategy—one that ensures daily liquidity through milk sales. The availability of a daily revenue stream enables families to meet essential expenses for food, healthcare, and education. Hence, dairying functions as a shock absorber, mitigating financial risks associated with crop failures, market volatility, or climate uncertainties.

Economically, the dairy sector contributes approximately 5% to India's national GDP and accounts for over one-fourth (28–30%) of the agricultural GDP, making it one of the largest and most influential components of the agricultural economy. The value of milk produced in India is higher than the combined value of wheat, rice, and pulses, underscoring its massive economic weight. This immense value chain creates employment for more than 8 crore rural households, making the dairy sector the largest self-sustaining rural employment system in the country. One of the greatest strengths of India's dairy sector is the cooperative model, pioneered during the White Revolution. Successful examples like AMUL, Nandini, Milma, Verka, Saras, Sudha, and numerous regional cooperatives have created a transparent and inclusive supply chain that links village-level producers with urban consumers. Through fair price mechanisms, elimination of middlemen, and farmer-centric governance, cooperatives have ensured that even tiny producers with 1–2 animals receive equitable market access. This has not only enhanced rural incomes but also promoted social equity and democratic participation within villages. Additionally, the dairy sector plays a crucial role in women's empowerment, as more than 70% of dairy-related tasks are managed by women. The income earned from milk—often deposited directly into women's accounts—enhances their financial autonomy and strengthens their role in household decision-making. Dairy-based self-help groups (SHGs) and women's dairy cooperatives have further advanced gender equity, leading to improvements in family well-being, children's education, and community development.

Future Trends and Prospects in the Dairy Industry

The dairy industry is entering a transformative phase driven by technological innovation, data-driven systems, and advanced scientific tools that are reshaping production efficiency, animal health, and product quality. Modern dairy farms are increasingly integrating sensor-based monitoring tools that capture real-time information on milk yield, body condition, rumination,

feeding behavior, and environmental factors. These sensor systems generate large datasets that allow farmers to make informed decisions, optimize feeding schedules, detect diseases early, and improve overall herd management. The availability of continuous data has also enabled predictive modelling, allowing dairy operations to foresee health issues before they become critical and reduce economic losses. Machine learning and artificial intelligence are emerging as powerful engines of innovation in dairy production. Algorithms capable of learning from vast datasets can classify animal behavior patterns, identify health abnormalities, and support automated decision systems. Advanced techniques such as supervised learning help improve milk quality prediction, reproductive performance assessment, and detection of mastitis or lameness with greater accuracy than traditional methods. Unsupervised learning techniques such as clustering have become valuable for identifying natural groupings within herds, understanding variability in milk composition, and differentiating animals based on genetic potential, production efficiency, or metabolic status. These analytical tools help researchers and farmers unlock hidden patterns that would be impossible to detect manually.

Alongside data-driven approaches, smart dairy systems use wearable devices, biosensors, imaging technologies, and mobile applications to improve the precision of dairy management. Automated milking systems and robotic parlors have reduced labor dependency while enhancing milk quality through controlled hygiene practices and standardized milking routines. Precision feeding systems adjust nutrient supply according to individual animal needs, reducing waste and improving feed efficiency. These innovations not only increase farm productivity but also support sustainable practices by minimizing the carbon footprint and improving resource utilization.

The future of dairy processing also lies in adopting non-thermal preservation techniques such as high-pressure processing, pulsed electric field, and ultrasonication, which retain the nutritional integrity of milk while extending shelf life. Digitalization of the supply chain, including blockchain-based traceability, ensures food safety and transparency from farm to consumer. Furthermore, research in functional dairy products, bioactive peptides, and probiotic-rich formulations is expanding the potential of dairy as a health-promoting sector.

Employment Opportunities in the Dairy Sector

Employment in dairy farming systems is one of the strongest pillars of India's rural livelihood structure. Dairy provides regular and year-round work, unlike crop farming, which is seasonal and uncertain. Farmers and their family members remain engaged every day in activities such

as feeding animals, cleaning sheds, milking, preparing feed, and managing animal health. This continuous work cycle makes dairying a reliable source of daily income, especially for small and marginal farmers who own only a few animals.

Dairy farming also creates a wide range of indirect employment opportunities. Fodder cultivation, feed production, veterinary services, artificial insemination, milk collection centers, transportation, dairy processing plants, and marketing networks all depend on rural labour. Cooperatives and private dairies provide jobs for technicians, quality control workers, machine operators, drivers, and sales staff. With the rise of technology, new employment roles are emerging—such as digital milk testing operators, farm data managers, AI-based cattle health technicians, and young entrepreneurs running small dairy product units like paneer, cheese, flavored milk, and whey-based beverages. This makes the dairy sector a growing avenue for youth employment and rural entrepreneurship. Overall, dairy farming systems generate steady jobs, empower women, support small farmers, and expand rural business opportunities. This makes dairy not just an economic activity but a key engine of employment and rural development in India.

Challenges & Areas to Address

While White Revolution 2.0 is promising, there are hurdles:

- Infrastructure gaps in remote/rural areas (cold chain, processing, transport) still exist.
- Technology adoption among small farmers may be slow due to costs, awareness, or skill gaps.
- By-product processing requires capital investment, market development, and quality assurance (especially for functional foods).
- Balancing scale with sustainability and ensuring equity for marginal farmers will require careful policy and implementation.
- Ensuring data reliability, privacy, and maintenance of technology in rural settings is non-trivial.

The Next Era of Growth, Innovation s Global Competitiveness

India's dairy sector is entering a transformative decade. With rising population, income growth, changing dietary preferences, and rapid technological advancement, the dairy industry is set to witness unprecedented opportunities. The sector, which already contributes significantly to rural employment, national nutrition, and overall GDP, is now evolving from traditional milk

production to a diversified, innovation-driven, value-added ecosystem. These upcoming opportunities will redefine dairy entrepreneurship, boost farmer income, attract global investment, and create new-age dairy enterprises.

Employment through New White Revolution

In the deserts of Rajasthan, before the beginning of oil and natural gas production and refinery installation, a new path has been paved to employ the local rural people.

About 5000 rural youth and women have been given professional training in various fields and activities in the dairy sector. The number of employments to youth will double within a year. Yet, the people of Barmer district became wealthy in 'Black Gold' (oil and gas), but they are not getting a job in this field as they are untrained and unskilled in professional activities. The number of international enterprises has come over here in research oil and gas, Cairn Ltd., and IFC (International Finance Corporation) Agencies send the local rural youth and women to ICECD (Gujarat) for automobiles, mobile repairing, infrastructural and other professional training as well dairy sector. They thought that the world-famous indigenous breeds of cattle of the desert area should be developed. Therefore, the local people of Barmer district have been sent for infrastructure training as testing, collecting, and processing of milk. After this training village, women and youth formed DCS and became members of the dairy cooperative society and started to work. 2751 youth of 13 villages came under this scheme and were assured of job security.

One of the most promising opportunities lies in value-added dairy products. As urban lifestyles change and consumers become more health-conscious, demand for high-protein, low-fat, probiotic-rich, lactose-free, and functional dairy products is exploding. This growth creates space for new products such as Greek yogurt, high-protein milk, whey-based drinks, immunity-boosting beverages, artisanal cheeses, A2 milk, and nutraceutical dairy products. Start-ups and dairy processors that innovate in this space are poised for exponential growth.

Recommendations of the scientist for White Revolution 2.0:

- Embrace modular, scalable processing units suitable for small/marginal farmers or village-level profiles.

- Focus on by-product valorization chains: e.g., convert whey into powders, supplements or bio-energy; use buttermilk for functional foods (as you are already doing); integrate with local agriculture for feed/fodder use of residues.
- Develop smart dairy farm models: sensor-based health monitoring, milk yield tracking, and real-time data for herd management.
- Explore value-added product development: flavoured dairy, probiotics, functional dairy for nutrition, and convenient delivery formats.
- Build cooperative linkages and training modules: Since cooperatives are the backbone of this revolution, skill-building for farmers and technicians is key.
- Integrate sustainability & circular economy thinking: dairy waste → feed → energy; emphasis on water-use, effluent treatment, carbon footprint.
- Stay updated with policy & funding opportunities: many government schemes will support White Revolution 2.0 objectives; aligning projects with these can unlock resources.

Another significant opportunity lies in dairy technology and digital transformation. The integration of artificial intelligence, IoT sensors, machine learning, and blockchain is revolutionizing farm management. Wearable cattle devices monitor health, predict estrus, track nutrition, and detect diseases early. Automated milking systems, digital milk testing units, e-payment platforms, and cloud-based supply chain monitoring are modernizing the dairy value chain. These advancements not only reduce losses but also enhance milk quality and transparency, opening doors for premium pricing and global export competitiveness.

The rise in sustainable and climate-smart dairy practices is also creating opportunities for green entrepreneurship. Methane-efficient feed additives, biogas plants, solar-powered dairy farms, water-efficient processing, and manure-based organic fertilizers are becoming highly valuable. With climate change posing challenges to fodder availability and animal health, innovations like hydroponic fodder units, azolla production, fermented feeds, and fodder conservation offer strong business potential for rural youth.

Global Competitiveness: Towards Dairy Exports

India has huge potential to become a global dairy export hub. White Revolution 2.0 focuses on:

- World-class dairy processing infrastructure, Codex-aligned safety standards
- Export-oriented value-added products like skimmed milk powder, cheese, casein, and ghee Branding India's indigenous breeds and traditional dairy foods.
- The goal is to make India not only the world's largest producer but also a global dairy powerhouse.

Conclusion: A Vision for the Future

White Revolution 2.0 is not merely a dairy program—it is a national movement for innovation, empowerment, sustainability, and global leadership. It reimagines India's dairy destiny by uniting science, technology, farmers, startups, climate resilience, and global markets.

If implemented effectively, White Revolution 2.0 will create:

- Prosperous farmers
- Sustainable production systems
- World-class dairy products
- Global export opportunities
- A healthier, stronger India

This is the dawn of a new dairy era—one that will shape the future of India's economy, nutrition, and rural prosperity.

Milk has become more than just a commodity; it is the soul of rural empowerment. By boosting daily income, creating jobs, empowering women, enhancing nutrition, and bringing technology to villages, the dairy sector is shaping a strong, self-reliant, and prosperous India.

The study shows that the potential role of dairy farming as a tool to increase households' incomes, create rural employment and increase the regional competitiveness at producing milk are still to be realized. There are much more possibilities in generation of employment and increase in income through various animals related activities performed by farm men/women and milk producers such as grazing of animals, collection, and feeding of grass and fodder and concentrates, water providing to animals, cleaning of sheds, bathing of

animals, Milking of animals and milk providing to milk societies and animal caring at all steps.

White Revolution 2.0 offers a timely and significant window for the dairy sector, especially from a technology and rural-livelihood perspective. It builds on the successful cooperative model and injection of modern technology, while addressing emerging issues of sustainability, value-addition, and small-farmer inclusion.





White Revolution in India

Operation Launched
January 13, 1970 (Operation Flood)



Verghese Kurien

Father of India's White Revolution

- Advanced farming techniques played a key role.
- Cattle crossbreeding improved milk yields.
- Cooperatives were crucial to its success.
- The revolution boosted milk production.
- It transformed India's dairy industry.

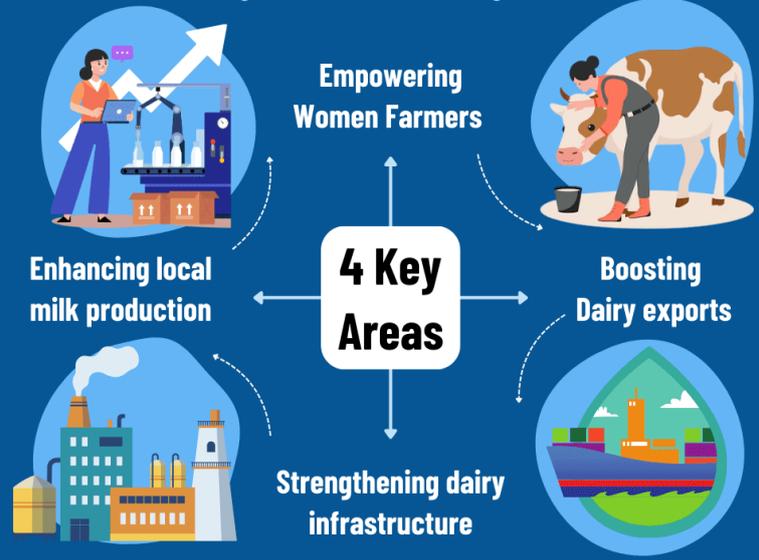
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Significance



White Revolution 2.0

White Revolution 2.0 seeks to **increase dairy cooperatives' milk procurement by 50%** over the next five years by expanding market access in underserved areas and boosting their role in the organized sector.



Objectives

Boost milk procurement by dairy cooperatives by 50% (from 660 to 1,000 lakh litres per day) in five years by expanding market access and increasing their share in the organized sector.



Funding

The National Programme for Dairy Development (NDDDB) 2.0 will support **1,000 MPACSS** with funding of **Rs. 40,000 per society**, under the Department of Animal Husbandry and Dairying.



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Milk Scenario in India

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World's largest milk producer
230.58 million tonnes (2022-23)
INDIA

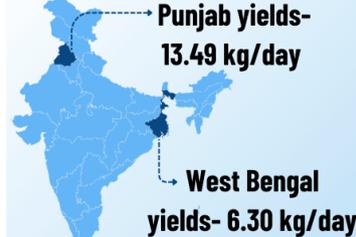


Low average yield

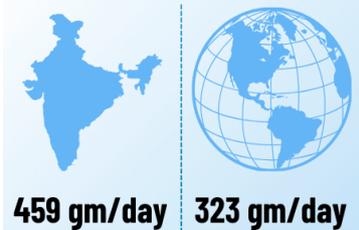
Cross breeds- 8.55 kg/day
Indigenous- 3.44 kg/day



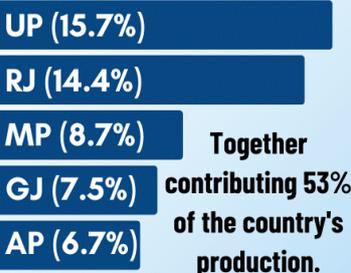
Regional disparities



Per capita Milk Availability



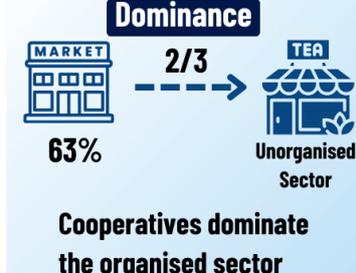
Top 5 Milk-Producing States



Decline in Growth Rate



Unorganised Sector Dominance



Employment

The dairy industry supports over 8.5 crore people, primarily women.



The Role of the Dairy Industry in Making India a Developed Country by 2047

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Abstract

The dairy sector is a strategic engine for India's inclusive development: it links millions of smallholders to urban demand, supports women's livelihoods, and provides nutrition that underpins human capital. India is already the world's largest milk producer, but its full potential to drive structural change depends on raising per-animal productivity, increasing the share of milk processed and value-added, lowering emissions intensity, and strengthening farmer institutions and finance. This paper summarizes the contemporary structure and contribution of India's dairy sector, identifies key bottlenecks (productivity, feed, cold chain, climate impacts), proposes an integrated policy and technology roadmap, and sets concrete sector targets for 2047 (the centenary of India's independence) that are realistic and measurable. Using recent government and international data as a baseline, the targets emphasize production, processing, nutrition, women's participation, and environmental intensity, and are presented with brief rationale and monitoring indicators. Achieving these targets would position dairy as a major contributor to India's transition to a developed economy by 2047.

Introduction

India's dairy sector touches rural livelihoods, nutrition, small-industry development and exports. With an estimated 239.3 million tonnes of milk produced in 2023–24 and rising per-capita availability (471 g/day in 2023–24), dairy is already central to national food systems (DAHD, 2024; NDDB, 2025). Because dairy production is widely distributed among smallholders and women, targeted investments in productivity, value addition, and climate-smart practices can generate broad-based gains in income, health and employment — all prerequisites for India's transformation into a developed country by 2047.

Table 1. Baseline indicators — India dairy (2023–24)

Indicator	Baseline (2023–24)	Source
Total milk production	239.3 million tonnes	DAHD, 2024; NDDB, 2025
Per-capita availability	471 g/day	NDDB, 2025
Milch animals (cows + buffaloes)	~125 million milch animals	BAHS / Livestock Census 2024
Households' dependent on dairy	~80 million rural households	NDDB, 2025
Share processed (organized)	~30–40%	NDDB, 2025
Annual growth (recent decade)	~5.6% CAGR	DAHD, 2024

How Dairy Contributes to Development

1. Contribution to the National Economy

The dairy industry is one of the largest contributors to India's agricultural GDP. At present, India is the world's largest milk producer, accounting for about 24% of global milk production. The sector contributes nearly 5% to the national GDP and provides a regular source of income to more than 80 million rural households. By 2047, if the growth trend continues with better policies, the dairy industry could become a global hub for milk production, processing, and export, significantly strengthening the Indian economy.

2. Employment Generation and Poverty Reduction

Dairying is not just an agricultural activity; it is a source of livelihood for millions, especially small and marginal farmers who own 1–3 animals. The sector provides direct and indirect employment across all levels—production, processing, transportation, marketing, and retail. Importantly, over 70% of the workforce in the dairy sector are women, making it one of the most inclusive industries in the country.

By 2047, the government's vision of Atmanirbhar Bharat (self-reliant India) can be realized through rural dairy entrepreneurship. Training programs in animal husbandry, dairy technology, and business management can equip rural youth to become job creators rather than job seekers. This will help reduce unemployment and migration from villages to cities, ensuring balanced regional development.

3. Nutritional and Food Security

Milk is considered a “complete food” because it contains almost all essential nutrients required by the human body. It is a major source of protein, calcium, vitamins, and energy, which are crucial for children, pregnant women, and elderly people. A developed nation must have a healthy and well-nourished population, and the dairy industry contributes directly to achieving this goal.

4. Technological Advancement and Innovation

The modernization of the dairy industry through science and technology will be one of the key pillars of India’s transformation. Artificial intelligence, biotechnology, genetic improvement, and automation in milking and processing can significantly enhance productivity and quality. Technologies like artificial insemination, embryo transfer, precision feeding, and disease diagnosis will lead to healthier animals and higher milk yield.

Furthermore, digital platforms for milk collection, quality testing, and payment systems can improve transparency and efficiency in cooperatives. With the introduction of smart dairy apps and cold chain technologies, wastage can be reduced, ensuring better income for farmers and quality products for consumers. By investing in research and innovation, India can emerge as a global leader in dairy technology by 2047.

5. Women Empowerment through Dairy Cooperatives

One of the most remarkable features of the Indian dairy industry is the participation of women. Dairy cooperatives such as Amul, Sudha, and Nandini have shown how women’s involvement in milk production, collection, and management can transform rural societies. Women not only contribute labor but also take key decisions in family economics.

By 2047, the empowerment of rural women through training, financial literacy, and leadership programs in dairy cooperatives can lead to greater gender equality. Empowered women contribute to better education, health, and nutrition in families, leading to holistic community development—a key indicator of a developed nation.

6. Environmental Sustainability

Sustainability is essential for the long-term success of the dairy sector. The future of dairying must be environment-friendly. Practices such as biogas generation from dung, organic manure production, waste recycling, and green fodder cultivation can reduce environmental pollution and promote clean energy. Encouraging climate-resilient breeds and sustainable feeding systems will help protect both livestock and the environment.

The concept of a circular dairy economy—where every output of the dairy farm (milk, dung, urine) is utilized productively—can make dairy farming both profitable and eco-friendly. A sustainable dairy sector will ensure food security and environmental safety for future generations.

7. Export Potential and Global Competitiveness

With improving quality standards, processing facilities, and brand value, India has immense potential to become a global exporter of milk products such as ghee, butter, cheese, milk powder, and traditional sweets. The global demand for dairy is rising, especially in developing countries. By focusing on quality, hygiene, and certification, India can increase its dairy exports significantly by 2047, contributing to foreign exchange earnings and global recognition.

Key Constraints and Risks

Low productivity, inadequate feed resources, fragmented cold chains, environmental pressures, and limited finance access remain the central constraints for dairy development. Addressing these requires institutional reforms and technology adoption across the value chain.

Strategic Levers and Policy Actions

1. Productivity lift: genomics, feed, breeding programs.
2. Processing & value addition: incentives for cooperatives and private processing.
3. Cold chain & digitalization: village chilling and traceability.
4. Climate-smart dairy: methane reduction and integrated systems.
5. Finance & institutions: microcredit and insurance.
6. Human capital & gender: extension, training, and women's empowerment.

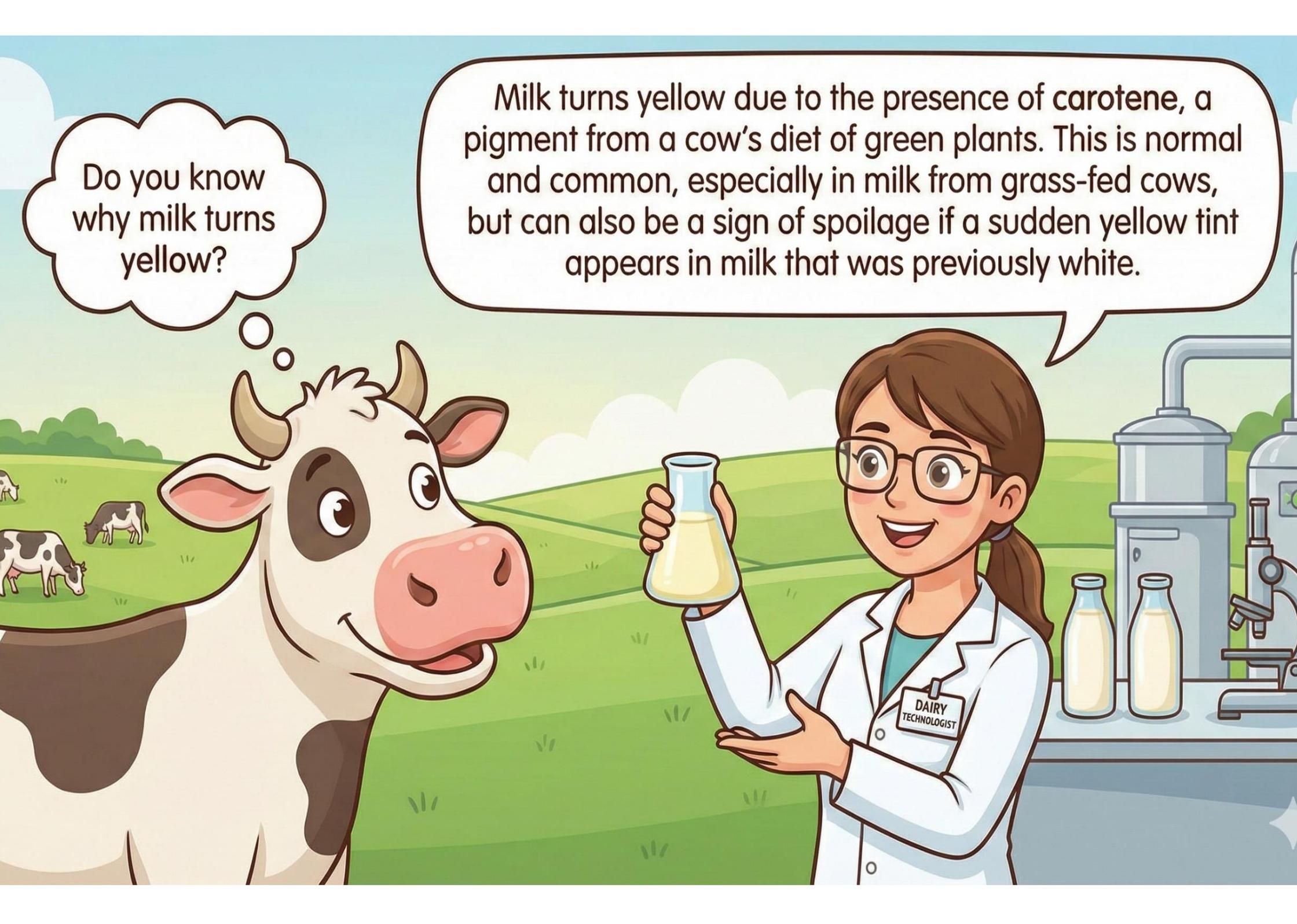
Table 2. 2047 targets for the Indian dairy sector

Indicator	Baseline (2023–24)	2047 Target
Total milk production (MT)	239.3	472.3
Per-capita availability (g/day)	471	600
Share processed (organized)	30–40%	70%
Smallholder households with access to chilling/market platforms	~40%	>90%
Women controlling dairy income (%)	Variable	≥50%
GHG intensity (kg CO ² e/litre)	Current baseline	–40%
Share of dairy in agricultural GDP	Current share	+2–3 pp increase

Conclusion

Dairy represents a cornerstone of India's inclusive development strategy. Through targeted policies in productivity, processing, climate resilience, and women's empowerment, the sector can contribute substantially to making India a developed nation by 2074. Implementing the 2047 targets will solidify dairy's role as a catalyst for rural prosperity, nutrition security, and sustainable industrial growth.





Do you know why milk turns yellow?

Milk turns yellow due to the presence of carotene, a pigment from a cow's diet of green plants. This is normal and common, especially in milk from grass-fed cows, but can also be a sign of spoilage if a sudden yellow tint appears in milk that was previously white.

श्वेत क्रांति से विज्ञान, छात्र और किसान तक

भारत का डेयरी उद्योग – आज, कल और साझा दृष्टिकोण

लेखक: अमित कुमार शुक्ला, डेयरी फील्ड ऑफिसर

आधुनिक सफलता के मायने और कुछ ठोस तथ्य

भारत लंबे समय से विश्व का सबसे बड़ा दूध उत्पादक बना हुआ है। सरकारी जानकारी के अनुसार डेयरी देश का एक बड़ा कृषि उत्पाद है, जो राष्ट्रीय अर्थव्यवस्था को मजबूत करता है और सीधे करोड़ों किसानों को रोजगार देता है। 2024 का एक आधिकारिक प्रकाशन बताता है कि डेयरी राष्ट्रीय अर्थव्यवस्था का लगभग पाँच प्रतिशत हिस्सा देता है और सीधे आठ करोड़ से अधिक किसानों को रोजगार प्रदान करता है। इससे ग्रामीण अर्थव्यवस्था और पोषण सुरक्षा पर इसका गहरा असर दिखता है।

पिछले एक दशक में दूध उत्पादन और उपलब्धता की वृद्धि उल्लेखनीय रही है। 2014–15 से 2023–24 तक उत्पादन लगभग 146.30 मिलियन टन से बढ़कर 239.30 मिलियन टन हो गया, जो लगभग 63.56% की वृद्धि दर्शाता है। इस अवधि में प्रति व्यक्ति दूध उपलब्धता भी काफी बढ़ी, जो यह दर्शाता है कि भारतीय डेयरी सेक्टर न सिर्फ मात्रा बल्कि पहुंच और पोषण दोनों में आगे है।

इस तेज़ वृद्धि के पीछे वैज्ञानिक और सेवा आधारित समर्थन, आनुवंशिक सुधार, पशु स्वास्थ्य और आधुनिक तकनीकी पहलें हैं। देशी नस्लों के संरक्षण व विकास, आनुवंशिक क्षमता बढ़ाने, पशु स्वास्थ्य सेवाओं के विस्तार से यह उद्योग केवल उत्पादन तक सीमित नहीं रहा, बल्कि गुणवत्ता, स्थायित्व और ग्रामीण समृद्धि की तरफ भी बढ़ा है।

तीन साझा दृष्टिकोण

डेयरी और फूड टेक छात्र का दृष्टिकोण

आज के युवा छात्र, जो डेयरी टेक्नोलॉजी या फूड टेक पढ़ते हैं, के लिए यह क्षेत्र एक जीवंत प्रयोगशाला जैसा है—जहाँ सिद्धांत और व्यावहारिक काम साथ-साथ चलते हैं। सहकारी नेटवर्क और सरकारी योजनाएँ उच्च गुणवत्ता का कच्चा दूध, बेहतर नस्ल, और पशु स्वास्थ्य सेवाएँ गाँव स्तर पर उपलब्ध कराती हैं। यह छात्रों को वास्तविक दुनिया का डेटा, गुणवत्ता नियंत्रण, सप्लाई चेन प्रबंधन और मूल्य वर्धित उत्पाद जैसे विषयों पर काम करने का मौका देता है।

एक प्रमुख राष्ट्रीय पहल, Rashtriya Gokul Mission, देशी नस्लों का विकास, आनुवंशिक क्षमता सुधार, और उत्पादन बढ़ाने पर केंद्रित है, और इसका लाभ खासकर छोटे व सीमांत किसान तथा महिलाएँ भी उठाती हैं। इस कार्यक्रम में उन्नत प्रौद्योगिकी, उच्च आनुवंशिक क्षमता, आर्टिफिशियल इन्सेमिनेशन और वैज्ञानिक ब्रीडिंग पर जोर रहता है, और इस योजना के तहत कुछ घटकों में सेक्स सॉर्टेड सेमेन पर 50% तक की सब्सिडी जैसी सुविधा भी उपलब्ध होती है, जिससे दूध उत्पादन बढ़ाने में मदद मिलती है। छात्रों को इन पहलों और तकनीकियों से नवाचार, मूल्य वर्धन, डिजिटल या AI आधारित समाधान अपनाने, और ठंडी चेन या स्मार्ट पैकेजिंग जैसी चुनौतियों पर काम करने के अवसर खुलते हैं। चुनौतियाँ—जैसे ग्रामीण क्षेत्रों में तकनीक अपनाने की गति, संसाधनों की कमी और प्रशिक्षण की आवश्यकता—समस्या मात्र नहीं, बल्कि नए उद्यम, पायलट प्रोजेक्ट या स्टार्ट अप के लिए अवसर भी हैं। इस दृष्टिकोण से यह उद्योग सीखने, नवाचार करने और पूरे ग्रामीण समाज में सकारात्मक बदलाव लाने का एक जीवंत मंच है।

वैज्ञानिक या अनुसंधानकर्ता का दृष्टिकोण

वैज्ञानिक, नीति निर्माता या अनुसंधानकर्ता के लिए यह सेक्टर दीर्घकालिक स्थिरता, सामाजिक आर्थिक प्रभाव, और वैश्विक प्रतिस्पर्धा के अध्ययन का केंद्र है। देशी नस्लों के विकास और तकनीकी प्रगति के साथ आनुवंशिक सुधार, स्वास्थ्य सेवाएँ, और वैज्ञानिक

ब्रीडिंग को बढ़ावा मिलता है। इससे पशु स्वास्थ्य, उत्पादन और दीर्घकालिक उत्पादकता लाभान्वित होती है। यह केवल उत्पादन वर्धन तक सीमित नहीं, बल्कि पशु कल्याण, आर्थिक स्थिरता और वैश्विक बाज़ार सामना जैसे अलग अलग विषयों को जोड़ता है।

महिला सशक्तिकरण, सहकारी मॉडल और ग्रामीण स्थिरता पर सामाजिक आर्थिक अध्ययन यह समझने में मदद करते हैं कि डेयरी कैसे शिक्षा, स्वास्थ्य और समुदाय के सशक्तिकरण से जुड़ता है। सरकारी आँकड़े, सार्वजनिक कार्यक्रम और तकनीकी विस्तार वैज्ञानिकों को ठोस जानकारी देते हैं, जिससे नीतियाँ और अभ्यास बेहतर हो सकते हैं।

जलवायु, फ़ीड, संसाधन उपयोग, ग्रीनहाउस गैस जैसे पर्यावरण संबंधी मुद्दे और वैश्विक बाज़ार की चुनौतियाँ अनुसंधान के प्रमुख विषय हैं। निर्यात, ब्रांडिंग, फूड सेफ्टी और सप्लाइ चेन सुधार से वैश्विक प्रतिस्पर्धा बढ़ सकती है। पब्लिक प्राइवेट सहयोग से बेहतर प्रणाली, स्थायी प्रबंधन और दीर्घकालिक समाधान बनाए जा सकते हैं। इस दृष्टिकोण से उद्योग केवल आंकड़ों तक सीमित नहीं, बल्कि भविष्य के मॉडल, स्थिरता और सामाजिक लाभ तक फैला है—जो वैज्ञानिक और नीति निर्माताओं के लिए प्रेरक है।

किसान या क्षेत्रीय उत्पादक का दृष्टिकोण

किसान और ग्रामीण परिवारों का अनुभव इस उद्योग की सबसे सच्ची कहानी है। उनके जीवन में डेयरी का असर प्रत्यक्ष, रोज़गार जनित और स्थायित्व प्रधान है। दूध उत्पादन मौसम या फसल पर निर्भर नहीं करता; इसके माध्यम से परिवारों को रोज़ाना की आय मिलती है। यह कृषि के अन्य स्रोतों से अलग, अधिक विश्वसनीय विकल्प बनता है, जिससे आर्थिक अस्थिरता कम होती है। परिवार में महिलाएँ दूध संग्रह, गुणवत्ता और घरेलू प्रबंधन में बड़ी भूमिका निभाती हैं। सरकारी और सहकारी पहलों से उनके सशक्तिकरण से परिवार की आर्थिक स्थिति और सामाजिक सम्मान दोनों बढ़ते हैं। सहकारी मॉडल से सीधे दूध

बेचने, उचित मूल्य निर्धारण, तथा सस्ते इनपुट तक पहुंच आसान होती है। सामूहिक प्रशिक्षण, स्वास्थ्य सुविधा, वित्तीय सलाह और निवेश छोटे किसानों को मजबूती देता है।

उच्च लागत, ऋण, जानकारी की कमी, और बाज़ार की अनिश्चितता जैसी चुनौतियाँ स्पष्ट हैं। फिर भी आधुनिक तकनीक, बेहतर फ़ीड, स्वास्थ्य मॉनिटरिंग और मूल्य वर्धित उत्पाद अपनाने से जीवन स्तर में वास्तविक सुधार और नए बाज़ार की संभावना बनती है। यह दृष्टिकोण उद्योग को केवल उत्पादन से आगे, लोक आधारित विकास तक ले जाता है।

सरकार की प्रमुख योजनाएँ और उनके प्रभाव

सरकार द्वारा केवल एक योजना पर निर्भर नहीं किया जा रहा; पशुपालन और डेयरी विभाग के तहत अनेक योजनाएँ चल रही हैं, जो पशु स्वास्थ्य, ब्रीडिंग, इन्फ्रास्ट्रक्चर, और डेयरी विकास के अलग अलग आयामों को पकड़ती हैं। विभाग के योजनाओं की सूची में Rashtriya Gokul Mission के अलावा National Livestock Mission, Livestock Health Disease Control Program, National Programme for Dairy Development, Dairy Infrastructure Development Fund, Animal Husbandry Infrastructure Development Fund और अन्य कार्यक्रम शामिल हैं। इससे साफ़ दिखता है कि नीति निर्माता कई स्तरों पर काम कर रहे हैं।

रोग नियंत्रण, टीकाकरण और पशु स्वास्थ्य

एक महत्वपूर्ण कार्यक्रम, Livestock Health and Disease Control Program के माध्यम से रोगों की रोकथाम और नियंत्रण पर जोर दिया जा रहा है। इसका उद्देश्य बड़ी पशु आबादी के स्वास्थ्य को सुरक्षित रखना है। प्रमुख बिंदुओं में टीकाकरण, मोबाइल पशु चिकित्सा सेवा, रोग सर्वेक्षण, और बेहतर चिकित्सा अवसंरचना शामिल हैं। यह योजनाएँ फूट एंड माउथ रोग, ब्रोकेलोसिस, PPR, और अन्य महत्वपूर्ण रोगों के नियंत्रण तथा मोबाइल वेटेनरी यूनिट्स के जरिए किसानों के दरवाजे पर सेवाएँ पहुँचाने पर ध्यान देती हैं। इस तरह की सेवाएँ सीधे किसानों को रोग रहित पशु, बेहतर उत्पादकता, और कम नुकसान उपलब्ध कराती हैं।

टीकाकरण, वैक्सीनेशन, रोग निगरानी, और पशु स्वास्थ्य के लिए प्रशिक्षित कर्मियों के माध्यम से दूध उत्पादन बढ़ाने के साथ साथ पशु कल्याण भी सुनिश्चित होता है।

राज्य स्तरीय सहायता, सब्सिडी और प्रशिक्षण

कई राज्यों में पशु खरीद, प्रशिक्षण, फ़ीड फडर उत्पादन, और रोग नियंत्रण के लिए सबसिडी और निःशुल्क प्रशिक्षण उपलब्ध किए जाते रहे हैं। यह छोटे व सीमांत किसानों को नया पशु खरीदने, बेहतर चारा या फ़ीड उत्पादन, तथा रोग रोकथाम उपाय सीखने में सहायता करता है।

- पशु खरीद एवं सेमेन: सब्सिडी और तकनीकी सहायता से किसान अधिक गुणवत्ता वाले पशु, बेहतर ब्रीडिंग सामग्री और सेमेन पा सकते हैं। इससे पशु परिवारों की आनुवंशिक क्षमता सुधरती है, जिससे दूध उत्पादन में सुधार आता है।
- निःशुल्क प्रशिक्षण: किसान, पशुपालक और सहकारी सदस्य को मुफ्त या अनुदानित प्रशिक्षण से बेहतर प्रबंधन सीखने का मौका मिलता है—जैसे पशु स्वास्थ्य, फ़ीड प्रबंधन, चारा उत्पादन, और ब्रीडिंग तकनीक।
- फ़ीड/फडर उत्पादन और संसाधन: राज्य स्तरीय योजनाएँ ऐसे संसाधन मुहैया कराती हैं, जिससे किसान चारा उत्पादन बढ़ा सकें या फ़ीड की लागत कम कर सकें; यह दुग्ध उत्पादन को स्थिर रखने में मदद करता है।

इन उपायों और योजनाओं के परिणामस्वरूप किसान लागत कम कर, उत्पादकता बढ़ाकर, और चारा स संसाधनों में आत्म निर्भर बनते हैं।

गुणवत्ता नियंत्रण, निर्यात और भविष्य की दिशा

सहकारी नेटवर्क, सरकारी तकनीकी हस्तक्षेप, और आधुनिक परीक्षण से दूध की गुणवत्ता नियंत्रित रही है। सीधा संग्रह, शीघ्र प्रोसेसिंग और वैज्ञानिक परीक्षण से मिलावट घटती है,

उपभोक्ता का भरोसा बढ़ता है, और उच्च मानकों वाला उत्पाद तैयार होता है—जो निर्यात के लिए बहुत आवश्यक है।

भीतरू उत्पादन और उच्च गुणवत्ता के साथ भारत वैश्विक बाज़ार में और अधिक मजबूती से प्रवेश कर सकता है। अंतरराष्ट्रीय मानकों के अनुसार खाद्य सुरक्षा, पैकेजिंग और ब्रांडिंग पर ध्यान देने से निर्यात अवसर और विश्वसनीयता दोनों बढ़ेंगी।

डिजिटल और AI समर्थित समाधान से फ़ीड, पशु स्वास्थ्य, उत्पादन और मार्केटिंग की दक्षता बढ़ेगी। ऊर्जा कुशल प्रोसेसिंग, जैव उर्वरक, संसाधन कुशल मॉडल और पर्यावरणीय प्रभाव कम करने के तरीके स्थानीय स्तर पर अपनाये जा सकते हैं। भूगोल, मौसम और परंपरा के अनुसार स्थानीय मॉडल विकसित करके उद्योग को अधिक आत्म निर्भर, पर्यावरण सतत और स्थायी बनाया जा सकता है।

इन नवाचारों से न केवल उत्पादन बढ़ेगा, बल्कि ग्रामीण अर्थव्यवस्था, पर्यावरणीय स्थिरता और राष्ट्रीय उत्पादन की गुणवत्ता भी बेहतर होगी।

दूध दिवस पर साज़ा संदेश

दूध दिवस का अर्थ केवल एक दिन का उत्सव नहीं, बल्कि उस यात्रा का सम्मान है जिसमें किसान की मेहनत, वैज्ञानिक की खोज, और छात्र की उम्मीद साथ-साथ चलती है।

आज भारतीय डेयरी उद्योग विश्व में अग्रणी है। सरकारी योजनाएँ, सहकारी और प्रौद्योगिकी पहल—नस्ल सुधार, रोग नियंत्रण, स्वास्थ्य सेवाएँ, महिला सशक्तिकरण, गुणवत्ता नियंत्रण, और नवाचार के साथ—इसे आगे ले जा रही हैं। भविष्य में निर्यात, टेक्नोलॉजी, सततता और व्यापक सामाजिक लाभ के नए अवसर खुल रहे हैं।

इस सफलता की कहानी केवल बड़े आंकड़ों से नहीं, बल्कि छोटे छोटे गाँव, किसान परिवार, महिला शक्ति, युवा छात्र और वैज्ञानिकों के सहयोग से बनी है। यही साझा कथा भारत के डेयरी उद्योग को आज मजबूत रखती है और भविष्य में नए आयाम खोलती है।

संक्षेप

यह लेख भारत के डेयरी उद्योग की आधुनिक उपलब्धि को तीन प्रमुख दृष्टिकोण—छात्र, वैज्ञानिक और किसान—से प्रस्तुत करता है। सरकारी आंकड़ों, योजनाओं और रोग नियंत्रण उपायों के माध्यम से स्पष्ट होता है कि उत्पादन, उपलब्धता और ग्रामीण आय में ठोस वृद्धि हुई है। एक प्रमुख योजना के अलावा कई अन्य योजनाओं, सब्सिडी, प्रशिक्षण, टीकाकरण और सेमेन संकुल के उपयोग से यह क्षेत्र सतत विकास और सामूहिक समृद्धि की दिशा में आगे बढ़ रहा है।

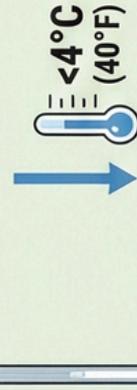


THE JOURNEY OF MILK: FROM FARM TO CONSUMER

1. FARM



Milk collected under sanitary conditions using mechanical equipment. [cite: 1]



Rapidly cooled to inhibit bacterial growth. [cite: 1]

2. CHILLING & TRANSPORT

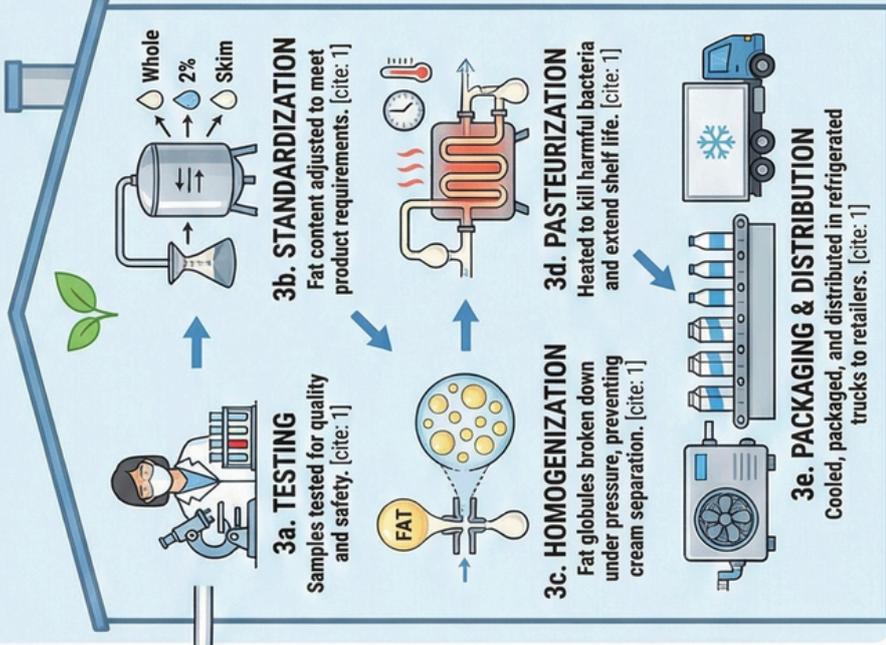


Chilled milk stored and collected by insulated tanker trucks. [cite: 1]

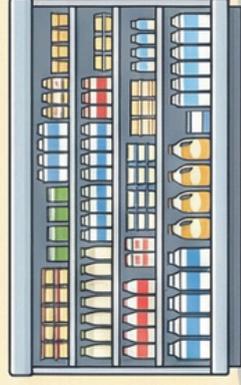


Transported at low temperature to maintain freshness and safety. [cite: 1]

3. PROCESSING



4. CONSUMER



Final step is consumer purchasing and enjoying fresh milk. [cite: 1]



Proper refrigeration ensures freshness until expiration date. [cite: 1]

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Future-Ready Dairy India



ARTIFICIAL INTELLIGENCE IN SMART DAIRY FARMING



1. WHAT IS AI IN DAIRY FARMING?



AI is the use of advanced algorithms and machine learning in agriculture & livestock

Integration with IoT devices, sensors, robotics, cloud platforms, and machine learning algorithms

2. AI-BASED TOOLS AND TECHNOLOGIES USED IN DAIRY FARMING

Sensor-based monitoring systems



Wearable collars
Rumination sensors



Pedometers
RFID



Accelerometers

Machine vision / computer vision



Cameras used for heat detection



Lameness detection
Body condition scoring



Image-based assessment of manure consistency

Robotics and automation



Bbinon milking systems (AMS)



Automated feeding systems & feed mixers



Automatic clean-robots and barn climate control

3. APPLICATIONS OF AI IN SMART DAIRY FARMING



Heat detection & reproductive management



Disease prediction & health monitoring



Milk quality analysis



Precision nutrition



Production forecasting



Animal welfare enhancement



All enalien drones



The Hidden Science Behind Perfect Curd: Why Timing Is Everything

Dairy Planet, Editorial Team

For centuries, curd (dahi) has been part of India's culinary and cultural identity. From family kitchens to modern dairy plants, it remains one of the most consumed and trusted dairy products. But while curd looks simply, its making is a delicate orchestration of biology, chemistry, and process control.

At the heart of this orchestration lies one critical factor: incubation timing.

The Clock of Fermentation

Once starter cultures—primarily *Lactococcus* and *Lactobacillus* species—are added to milk, the transformation begins. These bacteria feed on lactose and steadily convert it into lactic acid, reducing the milk's pH. As acidity rises, casein proteins destabilize and form a coagulum, giving curd its characteristic body and flavor.

Here's why timing matters:

- Too fast fermentation → Excess acidity, sour taste, brittle curd
- Too slow fermentation → Weak or incomplete setting, poor body, reduced shelf life

The sweet spot for most dairy operations is 4–6 hours at 40–45°C. But this “ideal” is influenced by:

- Milk quality (fat and SNF levels)
- Strength and dose of starter culture
- Ambient conditions in the incubation room

Even a half-hour deviation can change the final product's acidity, texture, and consumer acceptance.

Why One Batch Feels Silky, Another Grainy

If you've noticed that some curd feels luxuriously smooth while others break into a grainy mass, the answer lies in process precision:

- Temperature fluctuations → Weak, grainy coagulum
- Over-acidification → Syneresis (whey separation) and sour taste
- Uneven incubation → Patchy or inconsistent set

In short: curd is a mirror of how well incubation is controlled.

The Incubation Rooms

In modern dairies, the incubation room is the silent guardian of curd quality. Its functions go beyond simply keeping milk warm:

- Ensuring uniform temperature distribution across vats and batches
- Maintaining stable heat without fluctuation
- Minimising vibration or disturbance during gel formation
- Enabling predictable, repeatable fermentation cycles

Without these controls, even the best culture and milk cannot guarantee consistent results.

The 10 Common Pitfalls in Curd Incubation

Despite technological progress, many plants still struggle with:

1. Temperature instability during incubation
2. Weak or contaminated starter culture
3. Incorrect dosage of inoculum
4. Over- or under-incubation
5. Delayed cooling after coagulation
6. Batch-to-batch inconsistency
7. Syneresis (whey separation) issues
8. Hygiene lapses leading to contamination
9. Power failures or equipment breakdowns
10. Premature packaging before proper cooling

Each misstep reduces yield, shelf life, and consumer satisfaction.

Towards Consistent, High-Quality Curd

For processors, curd-making success lies in one mantra:

“Perfect curd is not chance—it’s controlled fermentation.”

That means:

- Investing in automated incubation systems with precision temperature control
- Using well-characterized, high-quality starter cultures
- Enforcing strict hygiene and handling protocols
- Training staff to recognise and respond to critical control points
- Implementing timely cooling and packaging procedures

The result? A product that is not only consistent in texture and taste, but also trusted by consumers for safety and quality.

Conclusion

Curd-making may have ancient roots, but in modern dairy plants it is a fine-tuned bioprocess. Timing is not just about the clock—it’s about the chemistry of acid development, the physics of gel setting, and the engineering of process control.

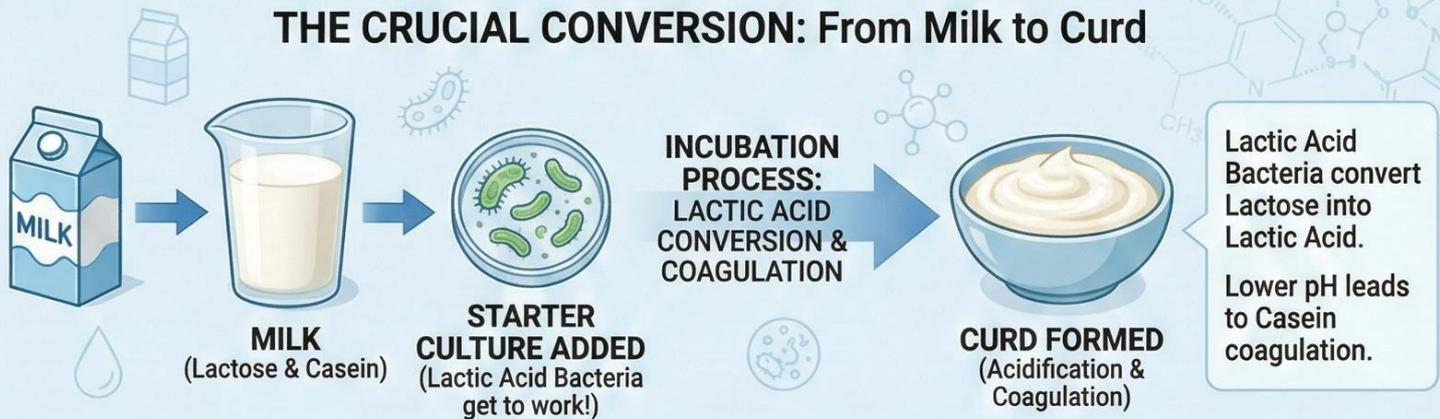
Get it right, and you deliver:

- Higher yields
- Consistent product quality
- Longer shelf life
- Stronger consumer loyalty

So, the next time you taste that silky-smooth spoon of dahi, remember—it is more than tradition in a cup. It’s science, precision, and expertise working in perfect harmony.

WHY DOES TIMING MATTER IN CURD INCUBATION?

THE CRUCIAL CONVERSION: From Milk to Curd



THE CATCH: EVERY MINUTE COUNTS! (INFLUENCING ACIDITY, TEXTURE, & TASTE)

1-2 hours TOO FAST (Excess Acid)

- Sour, brittle curd.
- Rapid acidification.
- Over-fermentation.



10+ hours TOO SLOW (Weak Setting)

- Weak setting, poor body, reduced shelf life.
- Incomplete fermentation.
- Loose structure.



4-6 hours THE SWEET SPOT (Ideal Balance)

- Perfect texture, balanced acidity, optimal taste & shelf life.
- Controlled fermentation. Smooth & creamy.

OPTIMAL RANGE:
4-6 HOURS
at **40-45°C**
(Ideal for most dairies)



VARIABLES INFLUENCING THE SWEET SPOT



MILK COMPOSITION (SNF and Fat Levels)

Higher solids lead to firmer curd. Fat content affects richness and setting.



STARTER CULTURE QUALITY & DOSAGE

Activity of culture and precise amount are critical for correct rate.



AMBIENT ROOM CONDITIONS & CONSISTENCY

Temperature fluctuations affect incubation speed and uniform quality.



QUESTION TO READERS: If you are working in dairy processing, what's the single biggest challenge you face during curd incubation—temperature stability, starter culture, or shelf-life consistency?



TEMPERATURE STABILITY



STARTER CULTURE



SHELF-LIFE CONSISTENCY

Artificial Intelligence In Dairy: The Future of Smart Farming & milk Production

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Introduction: Beyond the Red Barn

Picture a farm. You probably imagine a classic, idyllic scene: a farmer in overalls, a cow grazing peacefully in a green field. But what if that cow was wearing a fitness tracker? What if the farm's most valuable tool wasn't a tractor, but a tablet streaming real-time data on animal health and behavior?

This isn't science fiction. It's the reality of a high-tech revolution transforming agriculture from the ground up. On modern farms, AI-powered tools are becoming as essential as harvesting equipment, creating a world where every animal can have a digital twin and interventions are driven by data, not guesswork. This shift is turning farmers into data analysts and system managers.

This article explores the most surprising and impactful ways artificial intelligence is reshaping the world of farming. We'll look beyond simple automation to uncover how AI is creating a more precise, humane, and sustainable future for agriculture—one that will eventually find its way to your dinner plate.

1. Cows Have Fitness Trackers (And Digital Passports)

On today's connected farms, animal health management is proactive, not reactive. Cows are being fitted with smart collars that function like fitness trackers, monitoring everything from activity levels and rumination patterns to core body temperature. By analyzing this data, AI systems can predict health issues like mastitis or other diseases before serious symptoms appear, allowing for immediate, targeted intervention. This early detection keeps animals healthier and improves the farm's overall productivity.

This data collection goes even further, creating a unique digital identity for each animal through concepts like "personalized cow NFTs." Pioneering work at institutions like the Indian Institute of Information Technology, Allahabad, demonstrates the power of this

approach. Their system uses AI to detect diseases just from video feeds by observing a cow's movement and posture, with the resulting health data forming part of a cow's permanent digital record on a secure blockchain.

These aren't just digital collectibles; they are verifiable digital twins that record an animal's entire lifecycle. This digital passport contains everything from genetics and health records to milk production history, creating a secure, transparent, and easily accessible record for every single animal on the farm.

2. Counter-Intuitively, AI Means More Freedom for Cows

While it may seem counter-intuitive, the introduction of high-tech automation and AI monitoring can actually lead to more autonomy for animals. The goal of the technology is not constant intervention, but "smarter intervention," which allows animals to follow their natural behaviors with greater freedom.

A prime example is the robotic milking system. Instead of being herded for milking at set times, a cow can decide for itself when it wants to be milked. The AI recognizes the individual cow, guides the robotic arm, and ensures a stress-free process. This principle extends to other activities as well, with technology enabling cows to choose when they want to eat and when they want to sleep. By providing this freedom, farmers are seeing tangible benefits in animal welfare and longevity.

"The values I measure are their longevity cows are living longer cows are having more productive life and they're having less health events and that to me is a happier cow so a happier cow is a healthier cow in my world and today we have healthier cows than we've ever had"

3. The Rise of the 'Cow Comfort Index'

One of the most powerful applications of AI in farming is the ability to measure and manage animal welfare with unprecedented precision. Using 24/7 camera monitoring and sophisticated computer vision models, AI systems watch entire herds, identifying each cow and tracking its behavior every minute of the day.

This has allowed for the practical application of metrics like the "cow comfort index." What was once a tool used mostly in academic research settings—requiring someone to manually

count and observe animals—is now measured automatically, every single day. The AI tracks key performance indicators, such as the difference between "standing time," which is generally unproductive, and "lying time." Lying time is a positive indicator, as this is when cows are resting and efficiently turning the feed they eat into milk.

This constant monitoring represents a significant shift in focus from pure production metrics to data-driven animal welfare. It's built on the understanding that a comfortable, healthier cow is ultimately a more productive one, creating a system where well-being and profitability go hand-in-hand.

4. AI's Impact Goes from the Acre Down to the Plant

Beyond animal welfare, AI is making a massive impact on resource management and environmental sustainability. By leveraging data from sensors, cameras, and real-time analysis, AI enables hyper-precise resource allocation that minimizes waste and boosts efficiency.

This technology has helped farmers achieve remarkable savings. On a vineyard in India, a service built by the startup Fasal Agri Tech—based in Bangalore, India's "Silicon Valley"—has helped save "around 50% of the water" previously used for irrigation. In another application, an AI-powered robot equipped with precision cameras that scan the ground in real time is revolutionizing how farmers handle pests and weeds. Instead of spraying an entire field—what's known as "acre level" treatment—the robot identifies and targets individual plants. This "plant level" decision-making has resulted in a "56% savings" in spraying materials.

These efficiencies not only make farming more profitable by reducing input costs but also make it more environmentally sustainable by conserving water and reducing the use of chemical sprays.

4. Conclusion: The Future on Your Plate

From digital passports for cows to plant-by-plant crop care, artificial intelligence is quietly transforming farming into a more precise, humane, and transparent industry. This is more than a technological upgrade; it's a fundamental rethinking of how we produce food, balancing tradition with data-driven innovation.

These advancements on the farm will ultimately connect directly to the consumer. A "personalized cow NFT," for instance, is more than just a clever use of technology; it's a "verifiable, on-the-blockchain promise of traceability." Soon, you might be able to scan a code on a carton of milk and see the health and production history of the very cows that produced it.

As our food becomes a product of data as much as soil, what does this new level of transparency mean for the choices we make at the grocery store ?



Chocolates with Millet Infusion

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Abstract

Background

Millets such as finger, pearl, foxtail, Kodo, proso, little, and barnyard varieties are nutrient-rich grains that contain high levels of fibre, slowly digestible starches, well-balanced proteins, essential minerals, and bioactive phenolics. Adding millets to chocolate products presents an opportunity to boost their nutritional value, lower glycemic response, and support sustainability due to millets' resilience to climate change and minimal water requirements.

This review consolidates existing knowledge regarding the compositional and functional characteristics of millets that are pertinent to chocolate manufacturing. It explores methods for including millets in dark, milk, and compound chocolates while assessing their impacts on rheological behaviour, microstructural properties, polymorphic forms, shelf-life stability, sensory qualities, nutritional benefits, and regulatory factors.

Research suggests that incorporating millet enhances the nutritional and functional characteristics of chocolates. However, notable formulation challenges remain, especially concerning particle size distribution, controlling water activity, and preserving a continuous fat phase. There are still research gaps in understanding long-term fat bloom behaviour, clinical validation of glycemic effects, and the flavour impacts of roasted millets in cocoa matrices.

Millets hold significant promise as a functional ingredient for creating innovative chocolate products, delivering health and sustainability advantages. Future studies should concentrate on refining formulations and processing methods at both laboratory and pilot stages, while also addressing critical knowledge gaps to facilitate their effective commercial use

Keywords: Millets, Cocoa, Flow properties, Phenolic compounds, Grain size, Fat bloom phenomenon, Taste evaluation, Blood sugar index, Environmental impact, Entire grain.

Introduction

Chocolate is commonly understood to be a complex fat-based dispersion system where sugar crystals and cocoa or cocoa-milk solids are finely suspended in a continuous fat phase mainly made up of cocoa butter, often with added milk fat. The unique texture, shine, and characteristic "snap" of high-quality chocolate result from the crystallization behaviour of cocoa butter, which must be tempered with precision to achieve the desired $\beta(V)$ polymorphic form. This careful management of fat crystallization is crucial for maintaining the stability, mouthfeel, and attractiveness of chocolate products. In recent years, there has been an increasing focus on enhancing chocolate with whole grains to boost its nutritional content and attract health-conscious consumers. Traditionally, such enhancement approaches have utilized cereals like rice, wheat, or oats, typically introduced as inclusions (for example, puffed or crisped grains), flours, or particulate dispersions within the chocolate mix. These additions offer a variety of textures, nutritional benefits, and opportunities for product differentiation. Nevertheless, beyond conventional cereals, millets present a highly attractive option for enriching chocolate. Millets are small-seeded, drought-resistant grains that have historically been consumed in many regions of Africa and Asia, and they are currently receiving renewed global interest for their superior nutritional profile and environmental sustainability. Compared to refined cereals, millets are abundant in dietary fibre, micronutrients such as iron, calcium, and magnesium, as well as bioactive compounds that may offer health benefits. Their cultivation aids climate resilience and biodiversity, owing to their low input needs and adaptability to poor soils and semi-arid conditions. Consumer interest in "ancient grains" has surged recently, mirroring broader trends towards natural, minimally processed, and nutrient-rich foods. Despite this rising interest, systematically incorporating millets into chocolate has not been thoroughly investigated. Unlike straightforward inclusions, the integration of millet-based ingredients into chocolate requires careful attention, as factors such as particle size distribution, water-binding capacity, and fat interaction can significantly affect essential quality characteristics like tempering, gloss, viscosity, and melt-in-mouth performance. Striking a delicate balance between nutritional enhancement and maintaining the sensory and physicochemical qualities of chocolate poses a technical challenge that necessitates both scientific insight and innovative processing techniques. This paper, therefore, aims to assess the current understanding of formulation, processing, and quality considerations

linked to the creation of millet-enriched chocolates. By exploring the science of fat crystallization, ingredient compatibility, and textural refinement, the paper seeks to provide systematic guidance for incorporating millet flours, crisps, or other derivatives into chocolate without compromising the industry quality standards characteristic of premium products. The review underscores opportunities, challenges, and prospects for advancing millet chocolates as a new category of functional, sustainable, and consumer-attractive confectionery items.

1.1 Millets: Classification and Nutritional Content

The main types of millets include pearl (*Pennisetum glaucum*), finger (*Eleusine coracana*), foxtail (*Setaria italica*), proso (*Panicum millicum*), Kodo (*Paspalum Scrobiculatum*), little (*Panicum Sumatrense*), and barnyard (*Echinochloa* spp.). Common characteristics consist of total dietary fibre ranging from 7% to 15% (which is higher in whole meal), resistant starch components, slowly digestible starch, and protein content of 7% to 14%, with a relatively higher level of lysine compared to other grains. They are also rich in minerals, particularly calcium in finger millet, and contain phenolic compounds like ferulic and caffeic acids, along with tannins found in certain varieties. The endogenous lipids, comprising 2% to 6%, are predominantly unsaturated, and the presence of lipase activity can affect the flavour during the roasting process.

1.2 What Makes Millets Great in Chocolate?

Millet-based ingredients offer distinct benefits in terms of nutrition, functionality, and sustainability, positioning them as an appealing choice for innovation in product development. From a nutritional standpoint, millet flours and extracts boast higher concentrations of dietary fibre and minerals when compared to refined sugars. When incorporated as a partial substitute for sucrose, millet has the potential to lower postprandial glycaemic responses, providing consumers with a healthier carbohydrate alternative. The combination of both soluble and insoluble fibres promotes satiety and supports digestive health, while the richness of micronutrients adds benefits beyond mere energy supply.

In terms of functionality, millet adds unique roasted Flavors, often referred to as nutty and malty, which complement cocoa-based products like chocolates, beverages, and baked goods. These flavour pairings can improve sensory appeal while minimizing the need for

artificial additives. Moreover, the insoluble fibre content in millet affects particle arrangement within complex food structures, thereby altering rheological characteristics such as viscosity and yield stress. These properties can be utilized to enhance texture, mouthfeel, and stability in formulations without relying on synthetic stabilizers.

From an ecological perspective, millet presents considerable sustainability benefits. Its ability to withstand drought, shorter growth cycle, and lower resource requirements (such as fertilizers, pesticides, and water) render it more adaptable to shifting climate conditions than traditional cereals like rice and wheat. Additionally, encouraging the cultivation of millet helps diversify farming systems and offers farmers new income opportunities, thereby promoting agricultural sustainability and supporting rural economies. Ultimately, the incorporation of millet into food systems responds to consumer preferences for nutritious, functional, and environmentally conscious products.

2. Formats and strategies for incorporation

2.1 Formats

Millet can be processed into various ingredient types, each providing distinct functional and sensory attributes to food products. Finely milled whole-grain flours, ground to $\leq 20\text{--}25\ \mu\text{m}$ (D90), can be blended with sugar and cocoa to create a smooth mouthfeel in chocolate or confectionery applications while preserving fibre and micronutrients. Puffed or crisped pieces (0.5–3 mm) act as crunchy additions in enrobed or moulded bars, enhancing textural variation and consumer attraction. Sprouted millet malts, extracts, or syrups offer natural sweetness, complex flavors, and serve as partial sugar substitutes, imparting nutty or malty notes that complement cocoa. Pre-gelatinized flakes or microgranules aid in providing satiety and improving texture, making them suitable for use in bars, cereals, and beverages. Lastly, protein concentrates or fractions derived from millet play essential roles in aeration, especially in whipped or filled products, enhancing structure and mouthfeel. Collectively, these ingredient formats broaden the potential for nutritional, functional, and sensory advancements in millet-based product development.

2.2 Strategies for Incorporation

Millet can be integrated into chocolate formulations through various processing methods, each resulting in unique functional and sensory characteristics.

Route A (co-grinding) involves combining sugar, cocoa liquor, and millet flour, and then refining it to achieve a desired particle size distribution (PSD). The resulting mixture is then conched, after which fats and emulsifiers are incorporated before tempering and Molding. This method guarantees an even distribution of millet flour, which adds fibre and minerals while keeping a smooth mouthfeel. However, care must be taken to manage starch damage during refining to prevent viscosity problems.

Route B (post-refining addition) involves adding pre-milled millet flour ($D_{90} \leq 20 \mu\text{m}$) during the later stages of conching. By avoiding thorough refining, this method reduces starch damage and better retains functional properties while still ensuring appropriate integration within the chocolate mixture. It may be necessary to adjust the emulsifier levels to uphold flow and stability.

Route C (inclusion) utilizes puffed or crisped millet particles, typically added at a rate of 5–15% to the tempered chocolate. To maintain their crunchiness, inclusions should have low water activity ($a_w \leq 0.30$) and might need oil barrier coatings to prevent fat migration or sogginess throughout their shelf life. This method enhances textural variety and visual appeal, catering to consumer preferences for multisensory experiences in chocolate.

2.3 Parameters for processing

To process chocolate containing millet, it is essential to carefully manage unit operations to maintain both quality and functionality.

Roasting millet grains or flours generally occurs at temperatures of 120–150 °C for 5–15 minutes. This process enhances nutty and malty Flavors through Maillard reactions, while also decreasing antinutritional components and inactivating lipase to prevent spoilage. Optimizing this step is important: overly prolonged roasting can lead to increased redness (a^*) and bitterness, which negatively impacts flavour.

The refining stage subsequently lowers particle size, aiming for a distribution where D_{90} is at or below 25 μm , D_{50} is around 15–18 μm , and D_{10} is no less than 1–3 μm .

Meeting these specifications helps avoid a gritty texture while maintaining enough body for an appealing mouthfeel. Effective refining also guarantees that millet flour is uniformly integrated into the cocoa matrix.

Conching, performed at temperatures between 60–80 °C for 6–12 hours depending on the size of the batch, requires that residual moisture be kept below 0.6% while also minimizing volatile acidity. This process creates a smoother texture, rounds out flavour, and improves overall viscosity management.

The fat phase, along with emulsifiers, significantly influences flow properties. In dark chocolate, cocoa butter generally comprises 28–34%, or 26–32% when cocoa butter equivalents (CBEs) are utilized. Sunflower lecithin (300–500 ppm) or polyglycerol polyricinoleate (PGPR, 100–300 ppm) can be used to adjust the Casson plastic viscosity (η_C) and yield stress (τ_0), facilitating efficient Molding and coating.

Lastly, tempering organizes fat crystals into the stable $\beta(V)$ polymorph, which provides chocolate with its characteristic snap, shine, and resistance to bloom. Both seed point and continuous tempering methods are effective, with temper index values ideally ranging from 2.5 to 5.5. To verify the crystalline structure, measurements can be taken using thermometers, differential scanning calorimetry (DSC), or X-ray diffraction (XRD).

3. Design of formulations and limitations

3.1 Core formulations (standards)

Chocolate recipes can be modified to include millet while preserving appealing sensory and processing qualities.

dark chocolate containing (comprising 70% cocoa solids), a standard formulation consists of 40% cocoa liquor, 30% sugar, 30% cocoa butter, and 0.3% lecithin. In variations that incorporate millet, 5–15% of the sugar can be substituted with fine whole-grain millet flour. To maintain optimal flow properties, cocoa butter may need to be increased by 0.5–1.5%, and lecithin can be adjusted up to 0.5% to compensate for changes in viscosity. This replacement improves fibre and mineral levels while maintaining the texture.

In the formulation of milk chocolate, the typical recipe includes 12% cocoa liquor, 18% milk powder, 50% sugar, 20% cocoa butter, and 0.3% lecithin. Millet flour or sprouted-malt powder can replace 5–12% of sugar and/or milk solids, enhancing nutritional value while adding malty flavour nuances. However, this may increase yield stress (τ_0), requiring the addition of polyglycerol polyricinoleate (PGPR) to ensure suitable flow and processing efficiency.

For compound coatings, where cocoa butter is partially substituted with cocoa butter equivalents (CBEs), special attention must be given when adding millet flour. The flour needs to be ground to a very fine particle size to prevent a gritty or waxy mouthfeel. When processed correctly, millet can enhance flavour, increase nutrition, and expand the variety of chocolate products available.

3.2 Water resource management

Millet provides bound water through their fibre and starch components, which can affect the processing of chocolate. To maintain texture and flow, it's crucial to keep the total moisture content below 0.6% following conching. Excess moisture can lead to sugar bloom, increased viscosity, and inadequate tempering. If conventional conching fails to lower moisture sufficiently, vacuum conching can be utilized to speed up drying and the removal of volatiles. Although hygroscopic syrups serve as effective sweeteners, they should generally be avoided as they raise water activity and affect shelf stability—unless polyols are also used to mitigate a_w . Thus, careful management of water is vital for ensuring stable millet-enriched chocolate.

3.3 Rheology objectives

Controlling rheology is essential when creating chocolate enhanced with millet. Based on the Casson model, optimal flow characteristics for Molding and tableting require a plastic viscosity ranging from 2.5 to 4.0 Pa·s and a yield stress (τ_0) between 5 and 20 Pa. In enrobing scenarios, lower τ_0 values (1–5 Pa) are favoured to facilitate uniform and efficient coating. The addition of millet flour brings in fibrous and irregularly shaped particles, which can increase τ_0 by interfering with flow and particle arrangement. To mitigate this effect, formulators can modify the fat phase by slightly raising cocoa butter content, fine-tune emulsifier systems (such as lecithin and PGPR) to reduce interparticle friction, and carefully refine the particle size distribution (PSD) for a smoother texture and reliable processing performance.

3.4 Consistency and Growth

Fat bloom, a significant stability issue in chocolate, is caused by fat movement and transitions between different crystal forms. Various methods can be utilized to address this challenge in millet-enriched products. The most important method is proper tempering,

which ensures the creation of the stable $\beta(V)$ polymorph that imparts gloss, snap, and helps resist recrystallization. Furthermore, ensuring adequate fat coverage on particle surfaces prevents the formation of clusters of hydrophilic fines (like millet fibre or starch), which can draw in moisture and disturb the cocoa butter matrix, leading to potential bloom initiation.

The conditions under which chocolate is stored are also crucial. It should be maintained at a temperature of 16–18 °C with a relative humidity below 50% to prevent temperature variations and condensation, both of which can accelerate the blooming process. For products that include elements like puffed or crisped millet, applying barrier coatings (either fat- or sugar-based) can help reduce moisture absorption and limit fat migration from the chocolate into the inclusions.

Additional techniques to combat blooming include the addition of small amounts of milk fat, which interferes with the recrystallization of cocoa butter, or choosing compatible cocoa butter alternatives (CBEs) that have triglyceride compositions rich in POP (1,3-dipalmitoyl-2-oleoylglycerol) and Post (1-palmitoyl-3-stearoyl-2-oleoylglycerol) to align with cocoa butter behaviour. Small crystallization modifiers may also be utilized to enhance stability.

3.5 Balance and flourish

Fat bloom in chocolate is a frequent quality issue resulting from the movement of fat and unstable crystallization. It manifests as a white film on the surface, diminishing both the visual appeal and texture. To mitigate fat bloom caused by migration, several strategies are vital. First, ensuring proper tempering is essential to form the stable $\beta(V)$ polymorph of cocoa butter, as this structure is less likely to convert into the unstable $\beta(VI)$ polymorph that encourages bloom. Additionally, applying fat to the surfaces of particles during the refining and conching processes helps prevent the formation of clusters of hydrophilic fines, which otherwise serve as pathways for migrating fats. The conditions under which chocolate is stored are also critical: it should be kept at a temperature of 16–18 °C with a relative humidity of less than 50% to minimize condensation, recrystallization, and fat migration. For products that include add-ins like nuts or wafers, employing barrier layers—such as sugar or fat coatings—can help stop the migration of oils into the chocolate. Finally, methods to prevent bloom include adding small quantities of milk fat, which disrupts the

crystal network of cocoa butter; using cocoa butter equivalents (CBEs) that have triacylglycerol profiles high in POP and Post for better compatibility with cocoa butter; or introducing minor crystallization modifiers to slow down fat diffusion. Collectively, these approaches can prolong shelf life and maintain the sensory quality of chocolate.

4. Characterization through analysis

4.1 Particle size distribution

Laser diffraction techniques, such as the Malvern Mesmerizer, are utilized to analyse particle size distribution in a medium that does not contain solvents and is compatible with cocoa butter, ensuring proper dispersion of cocoa solids. This approach yields important percentile values—D10, D50, and D90—that represent the fine, median, and coarse particle fractions, respectively. Of these values, D90 is particularly significant because it signifies the upper end of the distribution, which is directly associated with mouthfeel. Sensory evaluations reveal that chocolate starts to feel gritty when particles are larger than approximately 25–30 μm . Therefore, managing D90 to remain under this limit is essential for achieving a smooth texture, while D10 and D50 are instrumental in refining processing methods and ensuring quality consistency.

4.2 Rheology properties

Apparent viscosity can be assessed at 40 °C using a rotational rheometer fitted with either concentric cylinder or parallel plate configurations, which ensures that the shear conditions for chocolate or fat-based mixtures are representative. Flow curves are produced over a range of shear rates and are modelled with rheological equations such as Casson or Herschel–Bulkley to characterize shear-thinning behaviour. Yield stress, a vital factor that affects flow and mouthfeel, can be evaluated through a stress ramp or by determining the point where tangents intersect on the flow curve. These measurements offer valuable information on processing efficiency, pumpability, and sensory experience, aiding in the optimization of formulations and consistency in manufacturing.

4.3 Thermal properties and polymorphic forms

Differential Scanning Calorimetry (DSC) evaluates the thermal characteristics of cocoa butter and chocolate, including the temperatures at which melting begins and peaks. For well-tempered dark chocolate, the ideal $\beta(V)$ polymorph exhibits a distinct peak in the

range of 33–34 °C, which guarantees an appropriate snap, shine, and melting behaviour. Additionally, X-ray diffraction (XRD) complements this by confirming the crystalline structure and validating the presence of $\beta(V)$ patterns. In storage studies, XRD can monitor the gradual transition from $\beta(V)$ to the more stable $\beta(VI)$ form, which is linked to fat bloom and degradation in quality. By using both DSC and XRD, a comprehensive method is established for assessing tempering quality, polymorphic stability, and the longevity of the product.

4.4 Microstructure

Confocal laser scanning microscopy or scanning electron microscopy (SEM) can be utilized to observe interactions between particles and fat, showcasing wetting performance and agglomeration behaviour within chocolate compositions. The evaluation of fat coverage can be accomplished through a blend of solvent extraction and image analysis, offering insights into the surface visibility of particles. Such measurements are essential for comprehending dispersion quality, refining processing parameters, and guaranteeing favourable texture, stability, and sensory qualities in final chocolate products.

4.5 Colour and shine

The CIELAB system (L^* , a^* , b^*) can be used to assess colors and appearance under standard D65 lighting, yielding objective measurements of lightness, redness, and yellowness. A glossmeter calibrated to 60° measures surface sheen, which reflects the quality of tempering and visual attractiveness. Tracking changes in ΔL^* over time allows for the observation of oxidative darkening or fat/sugar bloom, both of which can diminish consumer appeal. In combination, colorimetry and gloss evaluation offer complementary insights into the visual quality, storage longevity, and overall shelf-life performance of chocolate.

4.6 Moisture and Water Activity

Moisture content can be determined through oven drying or Karl Fischer titration for accurate measurements, whereas water activity (a_w) is evaluated using an a_w meter. The desired values are ≤ 0.30 for dry inclusions to avoid microbial growth and texture deterioration, and ≤ 0.40 for fillings to maintain stability and prolong shelf-life.

4.7 Nutritional components and bioactive substances

Proximate analysis reveals the fundamental composition of chocolate and its inclusions, including moisture, protein, fat, ash, and carbohydrates. The quantification of dietary fibre is carried out using official AOAC methods (991.43 or 2009.01) to evaluate its nutritional value. Mineral analysis is conducted with ICP-MS, allowing for accurate identification of essential elements such as calcium, iron, zinc, and magnesium. The content of polyphenols is assessed through the Folin–Ciocalteu assay, while antioxidant capacity is measured using DPPH, ABTS, or ORAC methodologies. In-vitro starch digestibility assessments are performed according to established static digestion protocols, permitting the calculation of both rapidly and slowly digestible fractions. Based on this information, the predicted glycaemic index is calculated, offering important insights into the metabolic effects, functionality, and potential health advantages of chocolate-based products.

4.8 Shelf-life

Accelerated storage experiments are carried out at 25 °C/50% RH and 30 °C/65% RH for periods of 6 to 12 weeks to evaluate the stability of chocolate. The development of bloom is tracked by assessing ΔL^* color variations, which are further verified through microscopy. The levels of oxidative rancidity are measured using peroxide value (PV) and p-anisidine tests. Changes in texture are analyzed through a three-point bend test to determine hardness and brittleness. Additional sensory evaluations offer insights into how consumers perceive alterations in flavour, texture, and appearance, aiding in the prediction of shelf-life and overall product quality.

Sensory Evaluation

A two-phase sensory evaluation method is suggested to encompass both expert analysis and consumer feedback. In the initial phase, trained panellists perform a descriptive analysis, identifying critical sensory traits related to flavour (cocoa richness, roasted millet, malt, bitterness, astringency), texture (smoothness, grittiness, snap, melt rate), and appearance (gloss, bloom). This creates a comprehensive sensory profile for each product. In the second phase, consumer acceptance testing is conducted with a minimum of 100 participants, utilizing a 9-point hedonic scale to assess overall liking and Just-About-Right (JAR) scales to evaluate sweetness and crunchiness, which are especially significant for products containing inclusions. Additionally, purchase intent is recorded to connect sensory perceptions with market significance. The samples are presented using a Williams design

to reduce order and carryover effects. Statistical evaluations include mixed-effects ANOVA, where product is treated as a fixed factor and subject as a random factor, followed by Tukey's HSD for pairwise comparisons. Penalty analysis is used on the JAR data to pinpoint sensory factors that are either too low or too high, adversely impacting overall liking. Ultimately, descriptive attributes are correlated with consumer liking scores through partial least squares (PLS) regression, helping to identify essential drivers of preference. This comprehensive methodology offers practical insights for optimizing formulations, ensuring quality control, and developing consumer-focused products.

Safety and compliance factors

When creating chocolate products that include millet, it is crucial to consider various regulatory and nutritional factors to ensure compliance and maintain consumer trust.

Most types of millet are naturally gluten-free, making them ideal for those with gluten sensitivities and individuals with celiac disease. Nevertheless, it is vital to prevent cross-contamination in facilities that also handle wheat, barley, or rye. For items labelled as "gluten-free," testing must confirm gluten levels are below 20 ppm, following Codex guidelines and local regulations.

Ingredients must be clearly disclosed, using phrases like "whole-grain millet flour" or naming the specific type of millet to facilitate effective communication. In India, products should adhere to the Food Safety and Standards Authority of India (FSSAI) regulations regarding chocolate identity, which includes requirements for minimum cocoa solids. In other regions, such as the EU or US, it is important to differentiate between products that can officially be termed "chocolate" and those that are required to be labelled as "compound chocolate" or "chocolatey" if they include cocoa butter substitutes (CBEs) or other vegetable fats.

Millet contains antinutrients like phytates and tannins, which can hinder mineral absorption. This issue may be alleviated through processing methods such as malting, sprouting, fermentation, or using enzymatic treatments with phytase.

Nutritional claims such as "source of fiber," "source of iron," or "source of calcium" need to be validated with analytical evidence and must comply with local regulatory standards.

Adhering to both compositional guidelines and allowable nutrient content claims enhances product credibility and reinforces its image as a functional, health-focused indulgence.

Sustainability and the supply chain

Millets are identified as grains that can withstand climate fluctuations due to their minimal water needs, brief growth cycle, and adaptability to less fertile and drought-affected areas. Incorporating them into food systems not only promotes climate-smart agricultural practices but also enhances the resilience of livelihoods when sourced through networks of smallholder farmers, especially in semi-arid zones. The addition of millet to chocolate recipes presents an opportunity to diversify supply chains while bolstering the sustainability profile of the product. To maximize effectiveness, it is essential to pair millet integration with certified sources of cocoa, such as those recognized by Rainforest Alliance or Fairtrade, ensuring ethical lab or practices, protection of biodiversity, and adherence to sustainability standards at the farm level. Clear mapping of supply chains improves traceability, enabling consumers and stakeholders to confirm responsible sourcing practices. Furthermore, performing a life cycle assessment (LCA) is vital for measuring the environmental advantages. Specifically, substituting refined sugar with whole-grain millet components can help decrease greenhouse gas (GHG) emissions and reduce water usage while also enhancing nutritional quality. In combination, these approaches align sustainable ingredient selections with tangible environmental results, positioning millet-based chocolate as both eco-friendly and socially responsible.

Suggested experimental strategy (laboratory–pilot scale)

8.1 Purpose

This research seeks to assess how the integration of millet affects the quality and functionality of chocolate. Initially, the study will explore the effects of different levels of millet flour (0, 5, 10, 15%) in both dark and milk chocolates, concentrating on their rheological properties, tempering behaviour, and sensory characteristics. Next, a comparison will be made between two different forms of inclusion—flour and puffed millet crisps—to evaluate their impact on texture, microstructure, and bloom formation during storage. Lastly, the nutritional benefits will be measured through compositional analysis,

and in-vitro starch digestibility tests will be conducted to estimate the glycemic response, offering insights into the health advantages of millet-infused chocolate formulations.

8.2 Research methodology

The research will assess the incorporation of millet into chocolate by examining four primary factors: the percentage of millet (0, 5, 10, 15%), the variety of millet (finger, pearl, foxtail), the type of chocolate (dark 60%, milk 35%), and the format (flour versus crisp). A fractional factorial design will first analyze these variables, followed by response surface methodology (RSM) utilizing a central composite design to fine-tune the significant factors. Important responses include Casson viscosity (η_C), yield stress (τ_0), particle size (D90), $\beta(V)$ polymorph index, and color change (ΔE^*). Other outcomes will include sensory preference, dietary fiber content, mineral enrichment (Fe, Ca), and estimated glycemic index, aiding in the optimization of the formulation.

8.3 Method

Millet processing starts with roasting at 135 °C for 10 minutes, followed by milling with a pin mill and classification to achieve a particle size distribution with $D_{90} \leq 25 \mu\text{m}$. The flour is ground together with sugar and cocoa liquor to obtain the desired chocolate particle size. Conching is conducted at 70 °C for 8 hours, with lecithin (0.4%) and polyglycerol polyricinoleate (PGPR) added as necessary to enhance flow properties. The chocolate is tempered using the seed method, then shaped into 5 g thins and 100 g bars. Samples are stored at 18 °C for 7 days before undergoing analytical, structural, and sensory assessments.

8.4 Data analysis

The data analysis will utilize ANOVA with batch blocking to address production variability, followed by Tukey's HSD for subsequent pairwise comparisons. The rheological data will be modelled using the Casson and Herschel–Bulkley equations, and multi-response optimization will adopt a desirability method: minimizing viscosity, aiming to keep yield stress within acceptable limits, and enhancing sensory preference. A power analysis ($\alpha = 0.05$, power = 0.8) suggests that around 30–50 consumers per product will suffice for initial screening studies, whereas confirmatory validation should include at least 100 consumers to guarantee strong statistical confidence and the generalizability of sensory acceptance results.

Expected outcomes and analysis

We expect that replacing up to approximately 10% of the flour with millet flour can result in acceptable viscosity and mouthfeel when the D90 is less than or equal to 25 μm and the fat content is modified by about 1%. Exceeding this replacement may lead to a significant increase in τ_0 due to fiber-driven bridging flocculation, which may require the addition of PGPR or extra cocoa butter. Roasting is likely to enhance nutty and malty flavors that complement cocoa; however, varieties high in tannins might increase astringency, which could necessitate partial decortication or the use of milk chocolate bases. The addition of puffed millets can provide a pleasant crunch and enhance perceived health benefits, but also raises the risk of bloom without the use of oil barriers. From a nutritional standpoint, these formulations can increase dietary fiber content by 2–4 g per 100 g and provide minerals (especially calcium from finger millet) with a minimal effect on energy density. The anticipated glycemic index is projected to be lower than that of sucrose-matched controls due to the presence of slowly digestible starch and fiber, though this requires clinical testing for confirmation.

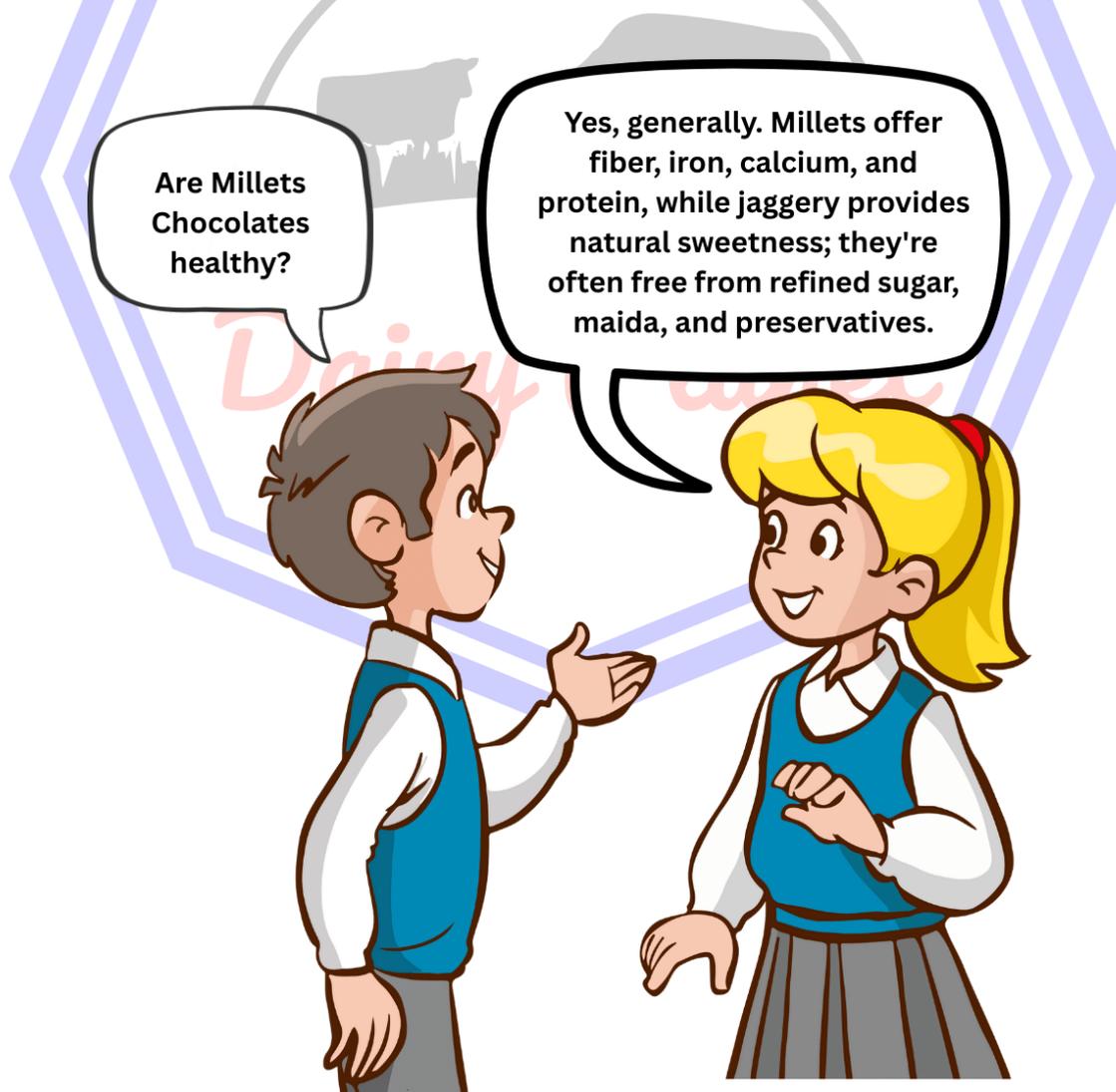
Constraints and areas needing further investigation

Future investigations should focus on the long-term kinetics of bloom formation in chocolate matrices enriched with millet, considering realistic storage and distribution scenarios to more accurately assess shelf-life stability. Another critical area of research involves exploring the interactions between phenolics derived from millet and cocoa polyphenols, particularly in terms of their possible synergistic effects on antioxidant properties and their impact on flavour perception. Research involving human subjects is necessary to confirm in vitro results, especially concerning the glycemic response and satiety advantages linked to the inclusion of millet. Lastly, trials aimed at scaling up the processes of continuous conching and tempering should be conducted, emphasizing how increased fiber content affects rheology, processability, and the quality of the finished product in industrial production settings.

Conclusion

Millet represents a valuable avenue for creating chocolate products that blend greater nutrition with enhanced sustainability, while maintaining the essential qualities that

consumers associate with chocolate. Their inherent gluten-free nature, significant fiber content, and wealth of minerals render them effective functional ingredients. Nevertheless, their successful incorporation relies on meticulous particle size manipulation to eliminate grittiness, strict moisture management to mitigate microbial risks, and careful control of rheological properties to ensure processability and a desirable mouthfeel. It is essential to optimize roasting parameters to reveal attractive cereal and nut-like flavor characteristics while reducing any bitterness and astringency. The outlined methodological framework—which includes particle size assessment, rheological evaluation, thermal and structural analysis, nutritional assessment, and sensory testing—offers a thorough guide for research and development. Collectively, these strategies arm product developers, academic researchers, and industry collaborators with the resources needed to create millet-based chocolates that meet consumer desires for indulgence, health, and sustainability, ultimately expanding the horizons for innovation in functional confectionery.



Yogurt : How Friendly Bacteria Turn Milk into a Probiotic Powerhouse

Dairy Planet Editorial Team

“Milk becomes yogurt not by magic—but by millions of tiny workers called bacteria doing chemistry on your behalf.”

Yogurt—A Living Food You Never Knew Was Alive

Have you ever wondered how liquid milk transforms into a thick, tangy, spoonable dairy food?

Milk doesn't thicken because of freezing or heating—it transforms because billions of friendly bacteria wake up, eat lactose, and reshape the milk structure from the inside out.

Yogurt is alive, active, and scientific.

Let's decode this transformation.

What Really Happens When Milk Turns into Yogurt?

Milk contains sugar (lactose).

LAB (Lactic Acid Bacteria) eat this lactose → produce lactic acid → which lowers pH. This acidification causes casein proteins in milk to reorganize into a gel network.

Result: Milk becomes yogurt. Smooth, thick, tangy, and probiotic-rich.

Meet the Two Friendly Bacteria Behind Yogurt

Bacterium	Role in Fermentation
 Streptococcus thermophilus	Fast acid producer → kickstarts fermentation
 Lactobacillus delbrueckii subsp. bulgaricus	Strong acid producer → develops flavor & structure

They work in symbiosis:

- Streptococcus grows first, producing acid & CO₂ → supports Lactobacillus.
- Lactobacillus grows later, producing more acid & aroma compounds.

Together, they give yogurt its texture, tanginess, and aroma.

The Science Behind Fermentation

Step-by-Step:

Milk heated to 85–90°C

- Denatures whey proteins → improves yogurt body
- Kills unwanted microbes

Cooled to ~42–45°C

- Optimal growth zone for starter cultures

Starter added

- Bacteria start eating lactose

pH drops from 6.6 → 4.6

- Casein network forms → milk thickens

Set yogurt

- Gel holds water, fat, and nutrients

How Milk Thickens Into Yogurt Gel

Casein micelles (protein clusters) stay suspended in milk. But when acidity rises →

- Their charges neutralize
- They move closer
- They bond into a 3D protein gel

This traps:

- Water
- Fat globules
- Minerals
- Bacterial cells

Giving yogurt its smooth, firm texture.

Milk vs Yogurt: Quick Comparison

Feature	Fresh Milk	Yogurt
pH	6.6–6.8	4.5–4.6
Texture	Liquid	Semi-solid gel
Bacteria	low	high (LAB)
Lactose	Higher	Lower (partly fermented)
Digestibility	Moderate	Improved
Shelf Life	Short	Longer (acid inhibits spoilage)

Active Recall Zone

1. Why is yogurt thicker than milk?

Because acidification causes casein micelles to form a gel network.

2. Which two cultures are essential for yogurt?

Streptococcus thermophilus & *Lactobacillus bulgaricus*.

3. Why does yogurt taste sour?

Lactic acid produced during fermentation lowers pH.

Why Yogurt Is a Probiotic Powerhouse

- Live bacteria support gut health
- Improves lactose digestion (LAB break down lactose)
- Enhances immune function
- Produces bioactive compounds like peptides & B-vitamins
- Helps maintain microbial balance in the intestine

Not all yogurt is probiotic—only those containing live, active cultures.

Dairy Reinvented: How Value-Added Milk Can Power a Protein Rich India

Hetal Anand

B. Tech Dairy Technology, MPUAT, Udaipur

Imagine sipping your morning milk that not only nourishes you but also strengthens immunity, supports gut health, and even helps manage stress. Sounds futuristic right? But not anymore. India's dairy industry is stepping into a new era — where milk is more than just a daily drink. From probiotic curds to protein-fortified beverages, value-added milk products are redefining how consumers perceive nutrition, convenience, and innovation.

The Turning Point for Traditional Milk

India is the world's largest milk producer — yet millions of its citizens still don't meet their daily protein requirements. Despite being rich in nutrients, traditional milk often fails to provide the protein density that modern, health-conscious consumers seek. As eating habits shift towards convenience and fitness-focused foods, plain milk has struggled to stay relevant on the breakfast table. At the same time, urban lifestyles, inconsistent cold chains, and adulteration concerns have reduced consumer trust. For a nation striving to fight hidden hunger and build a stronger, healthier population, this gap between milk abundance and protein adequacy poses a serious challenge. The question isn't whether India produces enough milk — its whether that milk meets the nutritional needs of today's India.

India's Dairy Revolution: From White Waves to Wellness Drinks

India's dairy story has always been one of scale and pride — we're the world's largest milk producer, churning out over 239 million tonnes in 2023-24, and supporting more than 80 million rural households. But the story doesn't end at the milk can anymore. The dairy shelves in cities today tell a new tale — one of change, innovation, and wellness.

The Indian dairy market, valued at nearly ₹19 trillion, is rapidly shifting from plain milk to value-added and health-focused products. Consumers are no longer just buying milk; they're buying nutrition, immunity, and convenience. Flavoured milks, probiotic drinks, and protein-fortified milk are emerging as everyday choices, especially among young professionals and fitness-conscious families.

What's fueling this trend is a growing awareness of protein deficiency in Indian diets. Brands like Amul, Mother Dairy, and Nestlé are responding with high-protein milk variants that promise to make nutrition both accessible and enjoyable. In many ways, fortified and protein-rich milk isn't just another product — It's India's next step towards a stronger, healthier future.

What is Protein-Added Milk?

Protein-added milk is regular cow or buffalo milk that's been enriched with extra protein, usually through milk protein concentrates, whey isolates, or ultrafiltration technology that increases natural protein levels without changing taste.

Nutritionally, it packs nearly 1.5 to 2 times more protein than regular milk — helping meet India's rising need for muscle repair, immunity support, and balanced diets, especially among youth and fitness enthusiasts.

Commercially, It's a game changer. With growing demand for functional and wellness foods, dairy brands are tapping into a high-value market segment that promises better margins and brand differentiation. Protein-added milk bridges the gap between traditional nutrition and modern convenience, making it one of the most promising innovations in India's dairy evolution.

How Protein-Enriched Milk Makes a Real Difference?

Protein-enriched milk helps bridge a critical gap in India's nutrition landscape. It provides a steady, easily digestible source of high-quality protein, essential for muscle repair, bone strength, and overall immunity. For growing children, athletes, and working adults with rushed meals, it offers the nutrition of a wholesome diet in just one glass — simple, familiar, and effective.

Let's dive deep how it's actually made?

Step 1: Choosing the Right Raw Milk

High-quality, fresh milk is the base. Lower-fat or skim milk is often preferred because it's easier to concentrate proteins without excessive cream interfering in the process.

Step 2: Filtration — Where the Magic Begins

This is the heart of protein enrichment. Using advanced membrane technologies like ultrafiltration or microfiltration, milk is gently passed through filters that separate components based on size.

- Proteins (casein and whey) are large molecules, so they're retained.
- Water and smaller nutrients like lactose and minerals pass through.

The result? A protein-rich retentate—the concentrated part that holds more protein per drop.

Step 3: Fine Balancing for Taste and Texture

The concentrated milk can be too thick or intense, so processors carefully adjust it by adding back some of the natural lactose-rich part to balance taste, texture, and mouthfeel. The goal is to make it smooth and creamy, not chalky or heavy.

Step 4: Standardization and Fortification

To meet nutrition claims (like “two times more protein”), the protein concentration is standardized. Some producers also blend in whey protein isolates or casein concentrates to further boost the protein level while keeping the product natural.

Step 5: Pasteurization and Packaging

Finally, the enriched milk is pasteurized to ensure safety and long shelf life. It's then packaged—often in sleek cartons that highlight its nutritional edge—and sent off to stores, gyms, and breakfast tables.

The End Result

When you pour that glass, you're not just drinking milk—you're sipping a blend of cutting-edge dairy technology and pure nutrition. Every protein-packed gulp is designed to fuel your muscles, power your mornings, and keep you fuller for longer

Is it easily accessible and affordable?

“Protein Milk Goes Mainstream”

Protein-enriched milk is gaining momentum across India as consumers prioritize fitness and balanced diets. The segment has seen nearly 20-25% annual growth in urban markets, fueled by rising awareness and the entry of brands like Amul,

Mother Dairy, and Country Delight. Prices typically range between ₹60-₹90 per liter, making it slightly premium but still accessible compared to imported protein drinks. Availability has expanded through supermarkets, dairy outlets, and e-commerce platforms, reaching tier-2 and tier-3 cities. With local dairies adopting advanced filtration technology, protein-rich milk is fast becoming an affordable everyday choice for health-conscious Indians.

Let's put our eyes onto a Practical Case Study!!

“Nutrition is not just about eating, It’s about learning to live – Patricia Compton For years, India has battled a silent issue — protein deficiency, affecting nearly 70% of the population, according to national nutrition surveys. Regular milk, though nutritious, provides only about 3.2 grams of protein per 100 ml, which often falls short for growing, active, or fitness-conscious consumers. Recognizing this gap, dairy companies like Amul introduced protein-enriched milk, using advanced ultrafiltration to naturally concentrate milk proteins without additives. The result is milk that offers twice the protein with the same creamy taste. A case in point: Amul’s Pro Protein Milk has seen rapid adoption among young professionals and gym-goers, reflecting how fortified dairy is quietly transforming India’s daily nutrition story.

Benefits of Protein-Enriched Milk Beyond Nutrition

- Supports muscle growth and repair, making it ideal for athletes and fitness lovers.
- Helps you feel full longer, which can aid in healthy weight management.
- Contributes to stronger bones by working with calcium and other minerals.
- Boosts energy and metabolism, keeping you active throughout the day.
- Enhances immune function for better overall health.
- Convenient and versatile: can be enjoyed on its own, in shakes, or used in cooking.

Challenges and Barriers in the Market

While protein-enriched milk is gaining popularity, the industry faces several challenges on its growth path. Producing high-protein milk requires advanced filtration equipment and energy-intensive processes, which increase production costs. This directly impacts pricing, making it costlier than regular milk and limiting its reach among price-sensitive consumers. Many buyers still view it as a “premium” product rather than a daily essential. Another

major challenge is consumer trust—instances of mislabeling and adulteration in the dairy market have made people cautious about claims related to protein content and purity. Building stronger quality checks, transparent labeling, and consumer awareness is essential. Additionally, limited cold chain infrastructure and short shelf life increase handling costs for producers.

Solutions for Every Stakeholder

For farmers and co-operatives

- Adopt whey valorization—using leftover whey for products like paneer or beverages—boosting farm income and reducing waste.

For dairy technologists and startups

- Launch pilot tests with consumers to tweak flavor, packaging, and pricing for wider acceptance.

For policymakers and NGOs

- Run awareness campaigns to counter protein deficiency—especially as about 73% of Indians don't meet recommended protein intake (the number goes up to 91% for vegetarians).

For consumers

- Learn to check packaging for actual protein content and quality certifications (FSSAI, ISO, etc).
- Compare price and value: natural protein milk packs (like 450ml with 2X protein, priced around ₹41) are becoming more accessible.

India's milk protein market is valued at over \$241 million and is expected to grow above 5% annually, driven by health awareness and innovation. These solutions, when adopted together, help make protein-rich milk safer, more affordable, and accessible for every family.

“Access to protein-rich milk isn't just about nutrition—it's about empowering every Indian to grow stronger, dream bigger, and live healthier every single day”

Conclusion

Protein-rich milk is more than just a nutritious drink—It's a step towards a healthier, stronger, and more vibrant India. By supporting innovation, making informed choices, and demanding transparency, every reader can play a role in this nutritional revolution. Future dairy technologists have a unique opportunity to bridge health gaps and touch millions of lives through smart, ethical innovation.

Let's work together—farmers, scientists, policymakers, and consumers—to ensure that the power of protein is within everyone's reach. Your choices today can create a ripple of health, trust, and opportunity for generations to come.





Smart Farms: The AI Revolution in Dairy

Automated Animal Care



Autonomous Milking Robots

Cows can choose when to be milked by AI-guided robots, reducing herd stress.



Activity Monitor
Temperature

Wearable Health Trackers

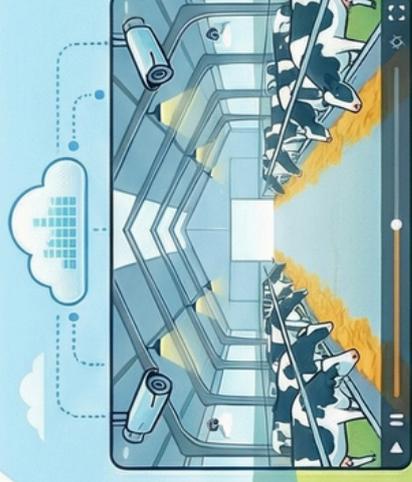
Smart collars monitor activity and temperature, predicting illness before symptoms become visible.

Facial Recognition for Cows

AI identifies individual cows to automatically track their personal health records over time.



Data-Driven Farm Intelligence



24/7 Behaviour Monitoring

Computer vision analyses video feeds to ensure herd comfort, welfare, and productivity.



Water Savings



Up to 50% Water Savings

AI provides precise irrigation data, drastically reducing water consumption on farms.



The Farmer's New Role: Data Analyst

The modern farmer's role is shifting to managing systems and interpreting data.

POLICY, MARKET & ECONOMICS SECTION



Insights for a Dynamic World

WOMEN IN DAIRY — IMPACT MAP: A CONCEPTUAL FRAMEWORK FOR ANALYSIS

1. FARM LABOR AND MANAGEMENT

- Perform majority of daily tasks: feeding, cleaning sheds/utensils, calf management, milking animals.
[cite: Women in Dairy — Impact Map is not a single, specific, publicly available map or database. Instead, it refers to a conceptual framework used by organizations like the International Dairy Federation (IDF) and the National Dairy Development Board (NDDB) to analyze the significant impact of women across the dairy value chain. This framework highlights the substantial social and economic contributions of women in various areas.]
- Key Areas of Women's Impact in Dairy Farm Labor and Management:
Women perform the majority of daily dairy farming tasks, including feeding livestock, cleaning sheds and utensils, managing calves, and milking animals.}]

4. TECHNOLOGICAL ADOPTION AND SUSTAINABILITY

- Increasingly involved in adopting modern, climate-smart farming practices (e.g., improved fodder quality, efficient manure management).
[cite: Technological Adoption and Sustainability: Women are increasingly involved in adopting modern, climate-smart farming practices, such as improved fodder quality (e.g., the Shaktifarms Cooperative in India) and efficient manure manurey.]
- Contributes to long-term social, economic, and environmental sustainability.
[cite: Technological Adoption and Sustainability: Women are increasingly involved in adopting modern, climate-smart farming practices, such as improved fodder quality (e.g., the Shaktifarms Cooperative in India) and efficient manure management, which contributes to long-term social, economic, and environmental sustainability.]

IDF KNOWLEDGE HUB & TASK FORCE: FILLS GAPS IN FACTS/STORIES ON WOMEN IN GLOBAL DAIRY VALUE CHAIN; CONTRIBUTES TO UN SDG 5.

[cite: IDF Women in Dairy Report: The International Dairy Federation has a dedicated Knowledge Hub and a task force to fill gaps in facts and stories regarding the place of women in the global dairy value chain and their contribution to UN Sustainable Development Goal 5 (Gender Equality).]

FAO GENDER ASSESSMENT: DETAILED ANALYSES OF MEN'S AND WOMEN'S ROLES AND BENEFITS WITHIN SPECIFIC DAIRY VALUE CHAINS GLOBALLY.

[cite: FAO Gender Assessment of Dairy Value Chains: The Food and Agriculture Organization provides detailed analyses of men's and women's roles and benefits within specific dairy value chains globally.]

2. ECONOMIC EMPOWERMENT

- Through women-only dairy cooperatives, gain financial independence, control over income, and decision-making power in households.
[cite: Economic Empowerment: Through participation in women-only dairy cooperatives, women gain financial independence, control over income, and decision-making power in their households.]
- Membership in women-led cooperatives leads to increased milk productivity, lower production costs, and higher net returns.
[cite: For example, studies in India have shown that membership in women-led cooperatives leads to increased milk productivity, lower production costs, and higher net returns.]

3. LEADERSHIP AND GOVERNANCE

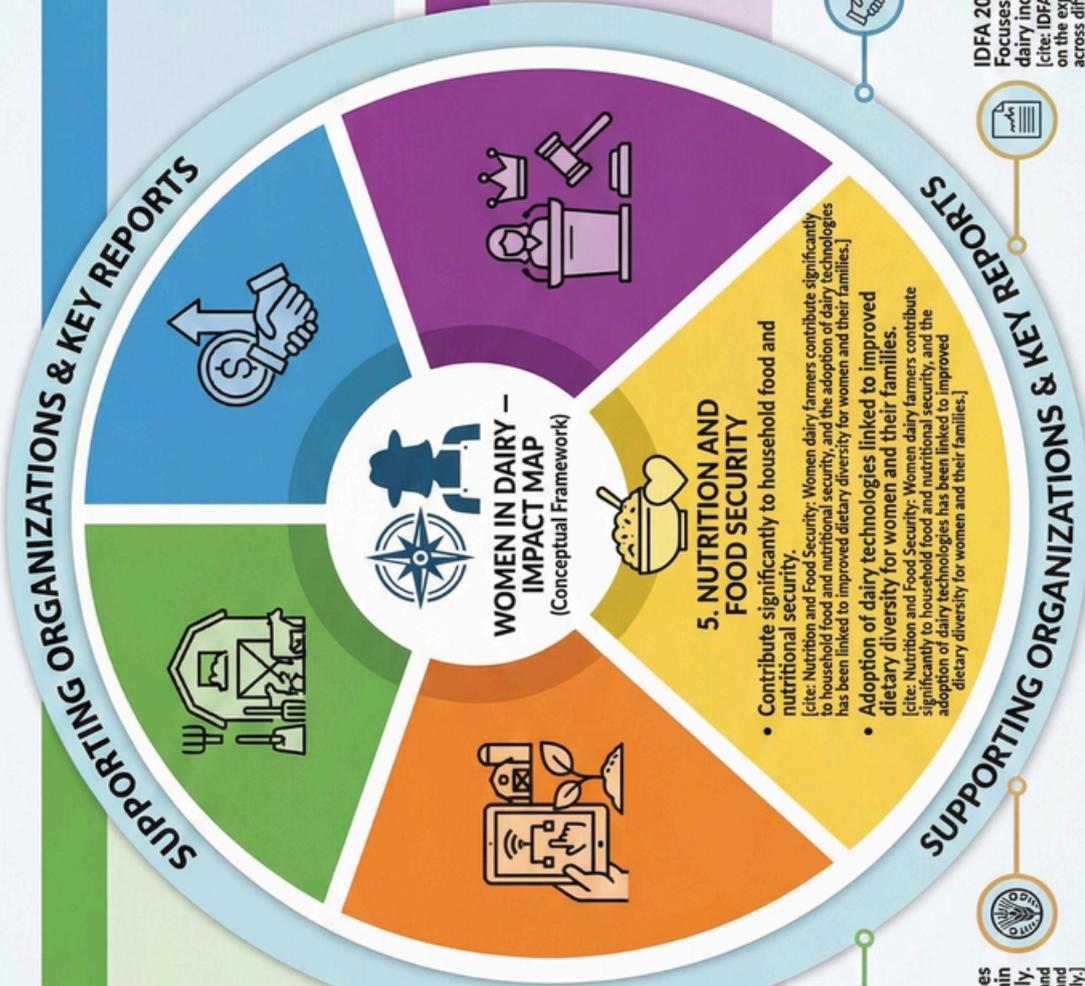
- Initiatives (e.g., by NDDB) aim to enhance women's participation in governance and management of cooperatives.
[cite: Leadership and Governance: Initiatives by organizations like NDDB aim to enhance the participation of women in the governance and management of dairy cooperatives, with some all-women producer organizations receiving awards for innovation.]
- Some all-women producer organizations receive awards for innovation.
[cite: Leadership and Governance: Initiatives by organizations like NDDB aim to enhance the participation of women in the governance and management of dairy cooperatives, with some all-women producer organizations receiving awards for innovation.]

NDDB INITIATIVES: FOCUS ON ENHANCING WOMEN'S PARTICIPATION IN COOPERATIVE GOVERNANCE AND MANAGEMENT.

[cite: Leadership and Governance: Initiatives by organizations like NDDB aim to enhance the participation of women in the governance and management of dairy cooperatives, with some all-women producer organizations receiving awards for innovation.]

IDFA 2025 STATE OF WOMEN IN DAIRY REPORT: FOCUSES ON EXPERIENCES AND OUTLOOK FOR WOMEN IN THE U.S. DAIRY INDUSTRY ACROSS GENERATIONS AND WORK ENVIRONMENTS.

[cite: IDFA 2025 State of Women in Dairy Report: This report focuses on the experiences and outlook for women in the U.S. dairy industry across different generations and work environments.]



WOMEN IN DAIRY — IMPACT MAP (Conceptual Framework)

5. NUTRITION AND FOOD SECURITY

- Contribute significantly to household food and nutritional security.
[cite: Nutrition and Food Security: Women dairy farmers contribute significantly to household food and nutritional security, and the adoption of dairy technologies has been linked to improved dietary diversity for women and their families.]
- Adoption of dairy technologies linked to improved dietary diversity for women and their families.
[cite: Nutrition and Food Security: Women dairy farmers contribute significantly to household food and nutritional security, and the adoption of dairy technologies has been linked to improved dietary diversity for women and their families.]

Foreign Direct Investment (FDI) in India's Dairy Sector: Policy, Progress & Prospects

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Introduction

India's dairy industry stands as one of the country's greatest success stories. With an annual output contributing over **24% of global milk production**, India today leads the world in milk supply - a remarkable transformation from the days of scarcity before Operation Flood. More than **80 million rural households**, a majority of them smallholders, depend on dairying for their livelihood. This sector is not only an engine of nutrition and rural employment but also a symbol of self-reliant growth.

Yet, as India's dairy sector matures, new questions arise: How can it scale up quality, technology, and global competitiveness? Can foreign capital play a role in modernizing infrastructure without undermining the cooperative spirit that defines India's dairy revolution? This is where **Foreign Direct Investment (FDI)** enters the frame - as both an opportunity and a challenge.

FDI: A Double-Edged Opportunity

FDI brings with it the promise of **global capital infusion, technological innovation, advanced processing systems, and enhanced export potential**. However, it must be carefully balanced with India's **unique socio-economic ecosystem** - one built on cooperatives, cultural sensitivities, and rural livelihoods. The challenge lies not in attracting investment, but in ensuring that foreign players align their business models with the grassroots structure of India's dairy economy.

The Government of India's stance has been welcoming yet cautious - seeking to invite global participation without disturbing the socio-economic equilibrium that sustains millions of farmers.

Policy Framework and Evolution

India's FDI policy in the dairy sector has evolved gradually, striking a fine balance between **market liberalization** and **agricultural sensitivities**. Key policy provisions include:

- **100% FDI under the automatic route** for dairy processing - covering chilling, pasteurization, packaging, and production of value-added products.
- **100% FDI through the government approval route** for food retail (including e-commerce), provided goods are manufactured in India.
- **Restrictions** on FDI in animal husbandry, dairy farming, and cattle rearing - a reflection of India's socio-religious ethos and livelihood concerns.

These provisions gained momentum post-2016 under flagship initiatives like '**Make in India**', the **National Dairy Plan**, and the vision for '**Doubling Farmers' Income**'. The aim: to attract foreign investment into value addition, logistics, and export-oriented agribusiness infrastructure.

Despite the liberalization, FDI inflows have remained modest. Between 2010 and 2016, total FDI in the dairy sector stood at barely **₹114 crore**, far short of the aspirational **₹1 lakh crore** target. Yet, international interest is evident.

Notable examples include:

- **Acquisitions:** French dairy major *Lactalis* acquiring *Tirumala* and *Prabhat Dairy*.
- **Joint Ventures:** Partnerships between Indian and foreign companies to share technology and market access.
- **Strategic Alliances:** New Zealand's *Fonterra* collaborating with *Future Consumer Ltd* to explore high-end dairy products for Indian consumers.

This pattern shows that while policy is enabling, commercial success depends on understanding and integrating into India's **cooperative-driven milk economy**.

Growth Drivers and Investment Opportunities

1. Infrastructure Expansion

India's dairy value chain, though vast, remains fragmented. There is immense potential for FDI in developing:

- Modern milk collection and testing centers

- Bulk milk cooling units and UHT processing
- Energy-efficient logistics and cold chains
- Automated large-scale processing plants

These investments could drastically reduce wastage, improve quality standards, and enhance shelf life of dairy products.

2. Premium and Value-Added Products

Urbanization and rising incomes are changing consumer preferences. A new class of health-conscious consumers is driving demand for:

- Probiotic and functional dairy beverages
- Whey proteins and nutrition supplements
- Lactose-free and fortified milk
- Artisanal and international cheese varieties

Such products remain underdeveloped domestically but align well with the expertise of multinational dairy companies.

3. Technological Advancements

FDI can serve as a channel for technological transfer - integrating innovations such as:

- Automated milking and herd management systems
- AI-based farm-to-fork traceability
- Smart packaging and food safety technologies
- Digital procurement platforms linking farmers directly to processors

These tools can transform smallholder efficiency, reduce intermediaries, and ensure transparent pricing.

4. Export Potential

India's dairy exports - **63,700 metric tonnes valued at \$273 million (FY 2023–24)** - represent only a small fraction of global trade. However, the potential is vast. Opportunities lie in **niche markets** such as:

- Ghee, paneer, and traditional Indian sweets
- Value-added milk powders and dairy desserts
- Region-specific markets in **South Asia, Africa, and the Middle East**

Challenges and Constraints

Despite the policy push, several bottlenecks deter large-scale foreign participation:

1. **Livestock Regulation:** India's legal restrictions on cattle slaughter create challenges in managing unproductive animals, raising costs for intensive dairy operations.
2. **Dominance of Cooperatives:** Giants like *Amul (GCMMF)* and state federations dominate milk procurement, leaving limited room for new entrants to secure supply at competitive margins.
3. **Socio-Political Sensitivities:** Policymakers must safeguard farmer interests. Any perception of foreign dominance could trigger political and social backlash, threatening the cooperative model that ensures equitable income distribution.
4. **FDI from Border Nations:** Geopolitical considerations, especially concerning investments from neighboring countries, necessitate prior government approval.

Government Initiatives and Support Mechanisms

Recognizing these realities, the Government of India has adopted a calibrated and farmer-centric approach to FDI:

- **FDI Action Plan (2016 onwards):** Targeting ₹1 lakh crore in investments focused on farmer-linked processing.
- **Collaborations with International Agencies:** The **World Bank, JICA,** and **NDDB** are promoting rural entrepreneurship, training, and infrastructure.
- **Financial Schemes:**
 - **Animal Husbandry Infrastructure Development Fund (AHIDF)** – ₹15,000 crore for modern plants, chilling units, and logistics.
 - **Dairy Processing and Infrastructure Development Fund (DIDF)** – ₹10,881 crore to modernize cooperative dairies.

- **Tax Incentives:** Up to 150% deduction for capital investments in dairy processing.
- **Mega Food Parks:** Offering plug-and-play infrastructure — cold chains, packaging units, and testing labs — to attract both domestic and foreign players.

These initiatives collectively aim to build a **robust ecosystem** where FDI can complement, not compete with, the cooperative and private sectors.

Outlook: Balancing Global Capital and Rural Prosperity

Over the past three decades, the private dairy sector has grown steadily, now matching the processing capacity of cooperatives. This diversification signals a maturing market, capable of accommodating responsible foreign participation.

The **future growth trajectory** for FDI lies in four key areas:

1. Premium and functional dairy products
2. Cold-chain and logistics infrastructure
3. Technology transfer and automation
4. Export-oriented dairy clusters

However, the success of FDI will depend on its alignment with inclusive growth goals - ensuring that investment strengthens, not supplants, India's rural producers. FDI must enhance value chains, empower farmers, and uphold the cooperative spirit that has sustained India's dairy success for decades.

Conclusion

Foreign Direct Investment in India's dairy sector represents more than the movement of capital - it embodies a **partnership** between global expertise and local empowerment. If guided by thoughtful policy and grounded in rural realities, FDI can transform India from the world's largest milk producer into a global hub for high-quality, value-added, and sustainable dairy products. The path ahead lies in synergizing foreign innovation with India's grassroots milk economy - a collaboration that can redefine rural prosperity, enhance global competitiveness, and sustain the white revolution for generations to come.



GLOBAL DAIRY TRADE EVENT 393:



BUTTER COLLAPSE & MARKET CONTRACTION WARNING

PROFESSIONAL A4 SIZE DESIGN

OVERALL GDT INDEX DECLINE: 4.3%



1 BUTTER COLLAPSE & GLOBAL CONTRACTION

FAO DAIRY PRICE INDEX (OCTOBER 2025)



GDT 393 Major Warning: Confirms Period of Global Market Contraction.



HIGH INVENTORIES



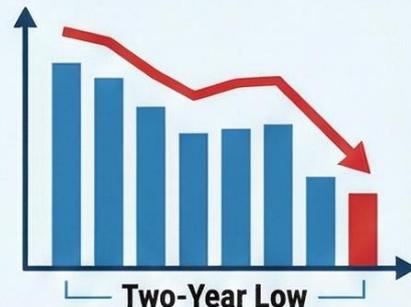
SLUGGISH DEMAND

OVERWHELMING THE MARKET

FORCING EXPORTERS TO CUT FARMGATE PRICES



DECREASED
3.4%



Contributing to **1.6% DROP** in Overall **FAO FOOD PRICE INDEX**. Lowest in over **TWO YEARS**.

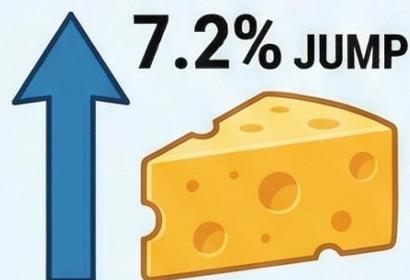


ROBUST MILK PRODUCTION



OUTPACING GLOBAL DEMAND

3 GDT CHEDDAR SURPRISE RISE



US\$4,639/MT

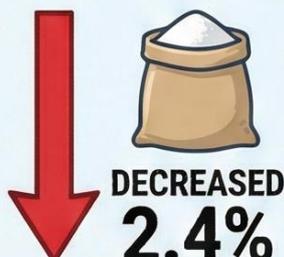
LARGEST PRICE RISE amid Overall Decline.



Increased Demand from **FOOD SERVICE INDUSTRY** ahead of New Year Holidays.

4 WMP & SMP SYNCHRONIZED WEAKNESS

WHOLE MILK POWDER (WMP)



US\$3,364/tonne

SKIM MILK POWDER (SMP)



US\$2,498/tonne

Confirms **SYNCHRONIZED WEAKNESS** in Commodity Powder Categories.

Where Do SMP & WMP Stand in GST 2.0?

Dairy Planet Editorial

In the GST Council's latest notification (Sept 2025), Skimmed Milk Powder (SMP) and Whole Milk Powder (WMP) were not given any new exemptions or reduced slabs. They remain in the 5% GST bracket (for milk powder and condensed milk under HS code 0402).

This means:

- Condensed milk = Reduced from 12% → 5%
- Milk powders (SMP/WMP) = Already at 5% earlier, no further cut → Continue at 5%

Why Does This Matter?

When raw milk is processed:

- Butter/ghee = Fat fraction
- SMP/WMP = Solids-not-fat (SNF) fraction
- Together they form the basis of recombined milk, whitener, and many dairy formulations.

So, in terms of processing economics:

- Butter/ghee now enjoys a 7% tax relief (12% → 5%).
- SMP/WMP stay at 5% (no change).
- UHT milk & paneer = Nil GST (zero-rated).

This creates a differential tax structure within the same processing cycle.

Industry Implications

1. Recombined products (Whitener, reconstituted milk)

Since SMP/WMP still carry 5% GST, recombination cost doesn't fully benefit from tax cuts. If companies blend butter oil/ghee (now 5%) with SMP (5%) → recombined milk/whitener still carries input cost with tax burden.

2. Export competitiveness

SMP/WMP are crucial for exports (e.g., to Bangladesh, Middle East, African markets). Keeping them at 5% instead of Nil means India's powders aren't as tax-advantaged as paneer/UHT.

3. Price transmission to farmers

As processors balance ghee/paneer gains with SMP's unchanged status, milk price passthrough may be slightly muted, especially during flush seasons when excess milk gets converted into SMP.

4. Stock market note

This is why you see Parag, Dodla, Hatsun rallying more on ghee/paneer/cheese optimism rather than on SMP outlook. SMP is bulk, industrial, and export-linked → less impacted by consumer-facing GST cuts.

In summary:

- SMP & WMP remain at 5% GST under GST 2.0.
- The big beneficiaries are ghee, butter, paneer, UHT milk, cheese, and ice cream.
- Since SMP/WMP are backbone ingredients, their unchanged tax means input cost relief is partial, especially for whitener, recombined milk, and bulk B2B formulations.



Do you know India buys over 550 million tonnes of green and dry fodder annually – yet still faces a fodder deficit?

Yes, A 12% green fodder deficit and 23% dry fodder deficit directly inflate milk prices.

India's Milk Prices Are Entering a New Era — Rising Costs, Global Signals & the Battle for Farmgate Stability

Dairy Planet Editorial

Why 2025 may redefine India's dairy economics

India's milk prices are no longer driven only by domestic demand—they're being shaped by a powerful combination of rising feed costs, tightening procurement margins, and global dairy market cues. What we're witnessing is not a seasonal fluctuation, but a structural realignment in farm economics.

What's Driving the Upward Pressure on Milk Prices?

1. Feed Costs Are Climbing — The Core Trigger

Feed represents 55–65% of the total cost of milk production for Indian farmers.

Recent increases in:

- Maize & soybean meal prices
- Green fodder scarcity due to erratic monsoons
- Higher fertiliser & energy costs

...have pushed production costs up sharply, forcing cooperatives and private processors to rethink procurement pricing.

2. Procurement Prices Are Rising Across India

Official channels—DAHD, PIB, and state cooperatives—are clearly signalling a push for better farmgate realisation.

- Several dairy unions have initiated procurement hikes of ₹2–3 per litre in the past quarter.
- Private companies like Heritage Foods have already reported margin compression due to elevated procurement costs, as disclosed in their latest earnings commentary.

This means processors are walking a tightrope: protecting farmers while managing their own profit pressures.

3. Global Market Cues Are Adding Complexity

Milk may be local, but prices aren't.

Global dairy major **Fonterra's trimmed farmgate price forecasts** suggest a weak international environment—meaning India cannot rely on cheaper imports or global relief to ease domestic procurement tension. With international SMP/WMP prices lacklustre, processors face fewer hedging opportunities. Domestic markets must self-correct.

India's Dairy Leadership Is Pivoting Toward Stability

1. Government Messaging → Producer Welfare

This year's National Milk Day announcements emphasised:

- Cooperative resilience
- Better milk realisation for farmers
- Strengthening of procurement networks

2. NDDB → Strategic Expansion & Brand Support

NDDB continues to push:

- State-level plant upgrades
- Chilling infrastructure
- Breed improvement programmes
- Digital milk testing & transparency systems

Their goal: protect farmer incomes while stabilising retail prices.

Short-Term Outlook: Pressure Upstream, Tight Margins Downstream

Farmers

- ✓ Better procurement prices
- ✗ But higher feed costs erode net gain

Processors

- ✓ Value-added dairy helps maintain margins
- ✗ Raw-milk-driven product lines remain under stress

Consumers

- ✓ No immediate steep price shocks
- ✗ Retail price cuts are unlikely in the near term

What Needs to Happen Next?

Feed-Cost Efficiency Must Become Priority

- Fodder banks
- Hydroponic systems
- Precision feeding
- Silage adoption

Cold Chain Investment Is Non-Negotiable

- Reducing losses from 4–6% to <2% can directly improve profitability without raising consumer prices.

Shift Toward Value-Added Dairy

- Cheese, paneer, ghee, UHT milk, flavoured milk—these offer margin stability when raw milk becomes volatile.

Policy Support for Fodder & Productivity

- State schemes must focus on:
- Green-fodder acreage
- AI & breed improvement
- Farmer extension services

The Big Picture: India's Milk Price Is Becoming the Sector's Most Important Signal

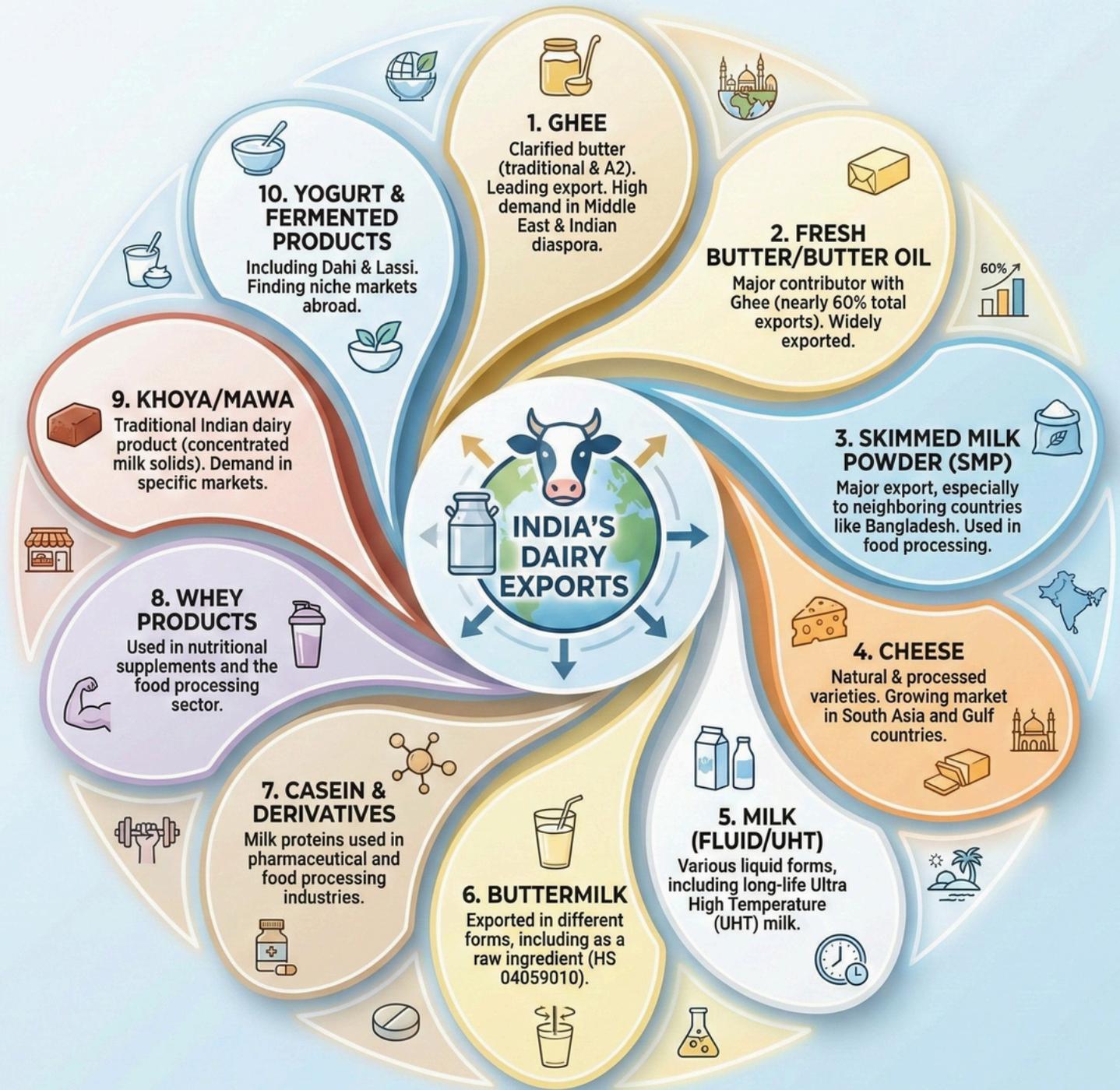
For farmers, processors, retailers, and investors alike, “milk price India” is now the single most critical metric reflecting stress, opportunity, and sector health.

India's dairy industry is resilient—built on cooperatives, smallholder strength, and daily micro-transactions across 80 million households. But navigating 2025 will require smart feed strategies, better infrastructure, and innovation-driven value chains.

The next 12 months will determine whether India can maintain affordable consumer prices while strengthening farmer incomes in a volatile global environment.



INDIA'S TOP 10 DAIRY EXPORTS



YOUTH & SPOTLIGHT SECTION

Empowering the Future,
Celebrating Talent

Empowering the Future, Celebrating Talent



Milk: The Gold of the Dairy Industry and a Path to Rural Empowerment

— Mohit Singh

B. Tech Dairy Technology, WBUAFS

Milk has long been considered the *liquid gold of India*—not only for its rich nutrition but because it forms the backbone of countless dairy products. Among all its components, milk fat holds the highest commercial value. Whether converted into ghee, cream, or butter, it offers remarkable shelf life, premium pricing, and excellent market demand—making it a practical avenue for rural entrepreneurship.

During my first year of B.Tech in Dairy Technology, I spent 15 days conducting a field survey across villages in West Bengal. What I witnessed was eye-opening. Milk was plentiful, but opportunities were scarce.

Local villagers produced good volumes of milk, yet limited household demand meant that a large portion was sold to local vendors—often at unfairly low prices. Some of these vendors diluted or adulterated the milk before selling it in nearby towns, compromising both producer income and consumer safety.

This situation revealed a powerful truth: ***Villages don't lack milk. They lack value addition.***

The Untapped Potential of Rural Dairy: Start with Ghee

One of the simplest and most effective ways to increase income is through home-based ghee production. Converting surplus milk into ghee drastically improves value, requires minimal equipment, and opens doors to direct-to-consumer sales, including online markets.

But the opportunity doesn't stop there.

Small-Scale Dairy Units: The Game Changer

With support from government schemes, NGOs, or community cooperatives, villages can set up mini dairy processing units to separate cream from milk and produce:

- ✓ Ghee
- ✓ Paneer
- ✓ Cream
- ✓ Flavoured ghee or artisanal dairy products

Skimmed milk left after fat separation can still be used for tea stalls, curd preparation, school supply programs, or household consumption.

These units can be:

- Manual or semi-automatic
- Low-cost and energy-efficient
- Operated by families or self-help groups (SHGs)

This creates multiple income streams while ensuring no milk goes to waste.

Training: The Key to Dairy Entrepreneurship

Along with machinery, what rural India needs is knowledge.

Workshops on:

- Hygienic processing
- Packaging techniques
- Shelf-life management
- Branding and storytelling
- Online sales and logistics

can empower villagers to launch their own micro-dairy brands.

Imagine a village selling “Dinka Gold Ghee” or “Mandya Pure Cream” on ecommerce platforms or to urban restaurants!

The Road to Rural Prosperity

When villagers shift from merely selling milk to processing and branding their own dairy products, everything changes:

- Household incomes rise
- Employment is generated locally
- Middlemen exploitation decreases
- Food adulteration reduces
- Village economies become self-sustaining

India’s villages are rich in milk—but even richer in potential. With the right blend of traditional dairy knowledge and modern entrepreneurship, rural communities can transform dairy from a livelihood into a thriving enterprise.

National Milk Day with a Twist: My Experiment with Vegan Oat–Coconut Milk at BHU

— Ayushmann Jaiswal, BHU

This National Milk Day, I wanted to celebrate differently — not by drinking milk, but by reimagining it.

As a food technology student who believes innovation begins in the kitchen, I created a refreshing, dairy-free alternative using humble ingredients: oats and coconut.

Step 1: The Oat Milk

I soaked oats for an hour, blended them with water, and strained the mixture to obtain a smooth, naturally creamy oat milk. Mild, neutral, and nutrient-rich — a perfect base.

Step 2: The Coconut Milk

Fresh coconut gratings were churned with water and filtered to extract rich coconut milk. This gave body, aroma, and a beautiful mouthfeel.

Step 3: The Perfect Blend

I combined the two in a 40:60 oat-to-coconut ratio, achieving the ideal balance of creaminess and lightness.

Step 4: Natural Sweetness

Instead of refined sugar, I added:

- ✓ Dates
- ✓ Banana
- ✓ A tiny bit of sugar (optional)

The result? A naturally sweet, energizing plant-based beverage.

Showcasing It at BHU

I presented this vegan milk at Banaras Hindu University (BHU), and the response was heartwarming. Students and faculty were surprised by how delightful and refreshing a plant-based milk could be. Many appreciated the concept, the taste, and the sustainability angle.

Their feedback made this National Milk Day truly special — a reminder that:

Milk doesn't have to come only from animals. It can come from plants too — nourishing, ethical, and innovative.

Success Story: How Two Women Redefined Dairy Farming in South India

From One Gunta Land to Lakhs in Revenue — The Inspiring Journeys of Mangalamma & Vidhu Rajeev

In the heart of Mandya district, Karnataka, stands a story that has become a symbol of resilience, innovation, and quiet revolution. Mangalamma, a 47-year-old dairy farmer from Dinka village, transformed her one-gunta farmland into a thriving dairy enterprise — earning ₹30 lakh in a single year. Her remarkable journey earned her the title “Best Dairy Farmer of Karnataka” at the Southern Dairy Summit-2025, hosted by the Indian Dairy Association (South Zone).

But she wasn't the only one lighting up the summit stage. Alongside her stood Vidhu Rajeev from Kottayam, Kerala, who produced over 1 lakh litres of milk, earning ₹50 lakh in 2024–25, proving that scientific dairy farming is not just profitable — it's transformational.

Mangalamma: The Woman Who Built a Dairy Empire from Scratch

Twenty years ago, Mangalamma and her husband stood at a crossroads. With no capital, no modern equipment, and just a handful of cows, they chose courage over comfort.

- Instead of guessing, they studied.
- Instead of waiting, they experimented.
- Instead of complaining, they learned.

They attended seminars, met experts, and embraced scientific dairy practices. Slowly but steadily, their tiny operation grew.

Today, her farm houses:

- 30 cows & 2 buffaloes
- Daily milk production: ~300 litres
- Annual revenue: ₹30 lakh

Her success lies in precision feeding and scientific herd management. Each cow receives a carefully balanced diet of maize, oil cakes, groundnuts, and sorghum fodder, ensuring optimal health and consistent yields. Machines — from automated milking to planned feeding systems — replaced manual guesswork.

What began on one-gunta land now supports:

- Three additional families in the village
- A mini rural economy
- A model farm that inspires new dairy entrepreneurs

Her message for India's youth is simple yet powerful:

"If my journey inspires even one more farmer, our entire village grows."

Vidhu Rajeev: Kerala's Dairy Innovator Leading with Sustainability

From the lush fields of Kottayam comes another shining example — Vidhu Rajeev, who built a dairy system that blends technology + sustainability beautifully.

Her achievements last year:

- 1,00,000+ litres of milk produced
- ₹50 lakh annual income
- 50 milking animals under her care

What sets Vidhu apart is her commitment to future-ready dairy farming. Her farm features:

- Automatic drinking systems
- Ventilation-controlled sheds
- Temperature regulation to reduce heat stress
- Biogas plant powered by cattle dung
- Organic manure sold at ₹40/kg
- Slurry recycled into paddy fields

Her farm is not just a business; it is a sustainable ecosystem — cleaner, profitable, and community-driven.

Why Their Stories Matter

At a time when dairy farming faces rising input costs, climate challenges, and technological gaps, women like Mangalamma and Vidhu are redefining what rural entrepreneurship looks like.

Their stories prove that:

- Scientific management can multiply income
- Small farms can become sustainable enterprises
- Women are emerging as powerful leaders in India's dairy economy
- Dairy farming is not just a livelihood — it's a path to rural prosperity

Southern Dairy Summit-2025: Celebrating the True Heroes of Dairy

By honouring these women, the Indian Dairy Association sent a resounding message: Future of Indian dairy is female. Future of dairy is scientific.

From Karnataka to Kerala, their journeys mark a new beginning — where knowledge replaces guesswork, sustainability replaces waste, and dairy becomes a platform for empowerment.

A New Generation of Dairy Leaders Is Rising

If one-gunta land and a handful of cows can turn into lakhs, imagine what India's 80 million dairy farmers can achieve with the right knowledge and support.

This is not just their success story.

This is a blueprint for India's dairy future.

Quiz Result
ANNOUNCEMENT

We're thrilled to announce the top 3 performers of National Milk Day 2025 Quiz Competition

 Ashmita Paul West Bengal University of Animal and Fishery Sciences	 Rudra Makwana Sheth M.C. College Of Dairy Science Anand	 Sneha Sureshkumar Jain University School of Allied Healthcare and Sciences
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Your hard work and quick thinking earned you a well-deserved spot among the top achievers.
Great job and keep shining! 🌟🌟

www.dairyplanets.com +91 8987717995 [dairy_planet_](https://www.instagram.com/dairy_planet_)

From Homemaker to Dairy Entrepreneur: The Inspiring Journey of Goa's "Adishri Dairy" Founder, Amita Naik

Women's empowerment isn't defined by slogans — it lives in the stories of women who dare to reinvent themselves.

One such story rises from Ibrampur, Pernem, where 47-year-old Amita Naik transformed from a homemaker into one of Goa's most promising dairy entrepreneurs.

Today, Amita is known for crafting high-quality, homemade dairy products — lassi, curd, paneer, ghee, and even the nostalgic childhood favourite: Pepsi ice candy. But her rise was anything but planned.

From Gerbera Farming to Dairy — A Journey No One Saw Coming

For years, Amita and her husband experimented with gerbera farming inside a polyhouse. Despite hard work, success eluded them. Something felt incomplete.

In 2017, they took a leap of faith: They bought their first cows.

Feeding them wasn't a challenge — they already had good farmland. They joined local dairy farmers supplying to Goa Dairy, just like farmers in Ibrampur, Chandel, Hasapur, Nagzar, and Casarvannem. But soon reality hit.

"Selling milk at ₹30 per litre didn't justify our effort. We knew we had to do something more." — Amita

For two years, they continued supplying milk at low margins. But the dream of better income refused to fade.

When the Pandemic Became a Turning Point

2020 changed everything.

As lockdowns increased milk demand, Amita wondered, "What after the pandemic?"

That question sparked a transformation.

They realized that Goa had a huge gap in locally made, good-quality dairy products. Instead of selling raw milk, they could create value-added products — curd, paneer, and lassi — that fetch double the income.

Amita enrolled in training programs through Lupin Foundation, learning the science of dairy processing, hygiene, testing, and packaging. She explored government schemes from RDA and Lupin Foundation to purchase equipment like:

- ✓ Lassi stirrer
- ✓ Paneer-making machine
- ✓ Sealing machine
- ✓ Dairy testing kits

“This was not an overnight success. Between 2020 and 2022, we learned, failed, improved — and prepared.” — Amita

After two years of planning, the Naiks received approvals from the FDA and local panchayat.

In 2023, their dairy brand Adishri was born.

A Full-Fledged Dairy Unit — Built From 10 Cows to 25

Today, Adishri Dairy:

- Houses 25 cows
- Produces 150 litres of milk a day
- Converts milk into lassi, curd, paneer, ghee, and ice candy
- Sells 1,000 litres of products regularly, especially across Bardez

Their income has doubled, thanks to value addition:

- Selling raw milk: ₹30 per litre
- Selling processed dairy: ₹70 per litre

Sustainability as a Side Hustle

Amita didn't stop there.

She started making vermicompost from cow dung, earning another ₹15,000 every month with almost no investment — a brilliant example of circular economy at the village level.

A Message for Goa: Support Local, Build Local

Despite her success, Amita acknowledges Goa's tough retail reality:

"Goans still hesitate to support local brands. But I believe one day they will value home-grown quality."

Her dream is to make Adishri a leading Goan dairy brand — strong, trusted, and proudly local.

What Makes Amita's Story So Powerful?

It is not just about dairy.

It is about:

- Reinvention
- Knowledge empowerment
- Smart use of government schemes
- Value addition
- Persistence through obstacles

From a homemaker to a thriving entrepreneur, Amita Naik stands as proof that rural dairy can become a powerful engine of women-led growth.

"We built this from scratch. And now, there's no looking back." — Amita

How can Milk Production be Increased Under White Revolution 2.0?

Milk production can be increased by Genetic Improvement, Embryo Transfer (ET) Technology, In Vitro Fertilisation (IVF) Technology, Nutrition and Feed Intervention at Low Cost, and Improved Diet Quality

White Revolution 2.0

Dairy Planet



WHITE REVOLUTION 1.0 VS 2.0: A COMPARATIVE OVERVIEW

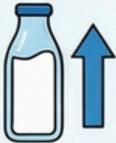
WHITE REVOLUTION 1.0 (Operation Flood) [cite: 1]

Launch Year: 1970 [cite: 3]

WHITE REVOLUTION 2.0 (2024) [cite: 1]

Launch Year: 2024 [cite: 3]

PRIMARY AIM



To make India self-sufficient in milk production and create a national milk grid. [cite: 3]



To increase milk procurement by cooperatives by 50% over five years (to 1,007 lakh kg/day by 2028-29) and address modern challenges. [cite: 3]

FOCUS



Augmenting milk supply, building processing capabilities, and establishing a robust distribution network. [cite: 3]



Expanding cooperative coverage to unserved areas, improving animal productivity and nutrition, leveraging technology, and promoting sustainability and exports. [cite: 3]

KEY PERSON



Dr. Verghese Kurien, known as the 'Father of the White Revolution in India'. [cite: 3]



Led by the Ministry of Cooperation and NDDB, with a focus on collective effort through expanded cooperatives. [cite: 3]

FUNDING SOURCE

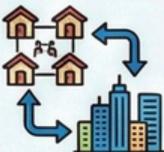


Financed by the sale of skimmed milk powder and butter oil donated by the European Union through the World Food Program. [cite: 3]



Funded through existing schemes like the National Programme for Dairy Development (NPDD) 2.0 and NDDB's own resources initially. [cite: 3]

INFRASTRUCTURE



Established thousands of village cooperatives and linked urban markets to rural milk sheds. [cite: 3]



Plans to form 75,000 new Dairy Cooperative Societies (DCS) and strengthen 46,422 existing ones, using advanced technology like Automatic Milk Collection Units (AMCU) and bulk milk coolers. [cite: 3]

TECHNOLOGY



Introduced basic machinery, artificial insemination, and improved breeding practices. [cite: 3]



Focuses on advanced breeding technologies (sex-sorted semen, IVF), ration balancing, and the use of IT for data management. [cite: 3]

OUTCOME



India became the world's largest milk producer and achieved self-sufficiency. [cite: 3]



Aims for higher efficiency, quality control, value addition, women empowerment, and increased global market share in exports. [cite: 3]

ENVIRONMENTAL ASPECT



1.0: Minimal initial focus on environmental impact. [cite: 3]

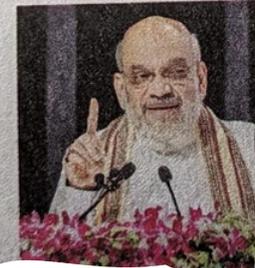


2.0: Promotes sustainable waste utilization, organic manure production, and a circular economy through cow dung and agricultural waste conversion. [cite: 3]

White Revolution empower women malnutrition: An

The Hindu Bureau NEW DELHI

Union Home and Cooperation Minister Amit Shah on Thursday launched the standard operating procedure for 'White Revolution 2.0' stating that milk dai-



Madhya Pradesh Dairy Federation and NDDB join hands to improve milk producers' earnings

Co-operative movement had remained in shambles as laws not tweaked, says Shah at co-operative meet

SATYAPRAKASH SHARMA

BHOPAL: In a significant move, the Madhya Pradesh State Co-operative Dairy Federation (SCDF) and the state's six other federations signed an agreement with the National Dairy Development Board (NDDB) to enhance the income of the state's dairy farmers.

The pact took place in the presence of Union Home and Co-operative minister Amit Shah and Chief Minister Mohan Yadav during a state-level cooperative conference held in Bhopal on Sunday.

Addressing the meet, Shah said the co-operative movement had remained in shambles in the country as laws were earlier not tweaked accordingly. "But after 75 years of independence, the co-operative movement was formed by Prime



Key Points

- Yadav said that the agreements will open new avenues of opportunities in the state
- Efforts are being made to promote cattle rearing and milk production
- Shah said no thought was given by the previous governments to bolster the co-operative sector

Minister said.

Shah said 100 per cent computerisation of PACS (primary Agriculture Cooperative Societies) in Madhya Pradesh was a remarkable achievement and a reflection of the state's efficient governance. He lauded MP for becoming the top-per-

9 per cent to the national output, and called for the expansion of cooperative and dairy villages to at least 50 per cent of villages. "This is a golden opportunity to revitalise the cooperative movement. The Centre is committed to standing firmly with the farmers of Madhya Pradesh," he said.

Shah emphasised the Centre's push for modernisation, citing the Rs 2,500 crore fund allocated for PACS computerisation and integration with district and state cooperative

will open new avenues of opportunities in the state. The state government is promoting cooperative activities through multipurpose societies and has made several decisions for the welfare of the weaker sections, he said. "Soon, petrol pumps, medical stores, and other enterprises will be run by cooperative societies," the CM said.

"Dairy farming is a proven source of income enhancement in households. Efforts are being made to promote cattle rearing and milk production. Subsidies have been arranged for cattle farming," Yadav said. The government will procure milk from farmers to improve their livelihoods, he further said.

MP currently ranks third in milk production in the country, after Uttar Pradesh and Rajasthan.

The MoUs are aligned with "White Revolution 2.0" and will promote women's empowerment and higher

It is time for India to launch its White Revolution 2.0

VIDYA MAHAMBARE & VIVEK JADHAV



National Milk Day is celebrated in India every year on 26 November. The day marks the birth anniversary of Verghese Kurien, the leader of India's White Revolution of the 1960s and 1970s that helped the country overcome milk shortages. Milk and milk products are essential for a nutritious diet, especially for children. A persistent low-quality diet has serious consequences for children's

of scale and discounts on bulk buying. In such cases, lower per-person expenditure in larger families may not be a good indicator of the quantity of food consumed per person. However, for milk, there are rarely significant discounts on larger packets.

There is little research on how family size matters in India in terms of per-person expenditure on food items. Here, we consider the case of spending on milk and milk products (henceforth called milk) in rural and urban India for two types of families: three-member households with one child and four-member households with two children. Our estimates are based on India's National Household Consumption Survey 2022-23 data. There are 18,179 three-member, single-child families and 28,070 four-

While the per-person milk expenditure in two-child families is lower, the share of spending on milk in total monthly expenditure is marginally higher for two-child families. This suggests that parents face trade-offs caused by an insufficient increase in family income as its size rises and they must prioritize other critical expenditures, such as on education, healthcare and other food items, which may limit the available budget for milk.

When we divide households based on total household

within rural and urban areas, rather than between rural and urban. This is because prices can differ significantly between cities and villages. Note that in rural areas, the reported milk spending includes the value of home-produced milk.

Both in rural and urban India, per capita milk expenditure in all quartiles based on total monthly expenditure is lower among two-child families than single-child families, with per-person milk spending around 30-32% lower in larger families in each quartile. This is especially concerning in the

Although public policy cannot roll out interventions based on family size, efforts should be made to increase milk consumption through various schemes to address nutritional gaps and improve children's health outcomes. The Gift Milk programme of the National Dairy Development Board expansion, for example, offers 200ml of flavoured milk fortified with vitamins A and D. Some states, such as Tamil Nadu and Karnataka, include milk distribution in their school mid-day meal programme for government schools.

It would help families even more if we could arrest the increase in milk prices. While milk production in the country has been growing at an annual rate of 5% over the years, milk has steadily

India can become a flagbearer of White Revolution, say experts

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ACKNOWLEDGE: Uttar Pradesh can become a flagbearer of the White Revolution (milk production) not only in the country but also globally with a modern production technique for cattle, dairy sector experts have said. Aimed at maximising the state's potential in milk production, the 'Mission Million Sexed Artificial Insemination' relies on a technique wherein offspring from artificial insemination will predominantly be female calves, with a probability of up to 90%.

"By using this technique, it will be possible to increase the number of female calves and double the milk production in 10 years," explained the

The current value of dairy sector is roughly \$124.93 bn, and it is estimated to reach \$227.53 bn by 2030. The dairy sector is a vast field with possibilities in employment and economic contributions

DR RAKESH KUMAR SHUKLA, **Union Minister**

Operation Flood in India



Union Ministers Amit Shah and Rajiv Ranjan Singh, Thursday.

of milk.

White Revolution or Operation Flood History

The White Revolution in India was supervised by Indira Gandhi, who was the country's prime minister at the time. Its main objectives are to raise people's living standards and make India a self-sufficient producer of milk. On October 2, 1970, Mrs. Gandhi started the White Revolution in Motihari, Bihar. 100 cows were imported from New Zealand to help low-income households improve their nutritional status and give them with a consistent supply of milk at a reasonable price.

Father of White Revolution in India

people aware

"The calves the desirable parents, leadership of employment and development, said Dr. Shukla, the Union Minister.

Approximately 10 million families in India with this sector at 8.9% of the dairy sector's \$124.93 billion

domestic milk powder output increased as a result of the co-operative direct milk sales from 22,000 tonnes in 1980 to 140,000 tonnes in 1989, and the sale of milk also increased by several million litres per day. The only reason for all output increases was the dairies that Operation Flood implemented.

Phase III: It lasted roughly ten years, from 1985 to 1996. The program's finishing touches were applied during this phase, which also allowed the dairy cooperatives to expand. In addition, it strengthened the system required to gather and market increasing milk volumes. By the time White Revolution or Operation Flood

of them were inspired to start a dairy as a side business.

India is currently the world's top milk producer. In 2009-2010, more than 112 million tonnes of milk were produced, compared to roughly 17 million tonnes in 1950-1951. Milk production has increased more than six times from the time before independence. Currently, each person has access to about 263 grammes of milk daily, up from 125 grammes before the White Revolution.

Significance of operation flood

The white revolution brought about significant changes in Indian society and economy.

Operation Flood led to India becoming independent in dairy

cal milk production, strengthening dairy infrastructure and boosting dairy exports.

Shah said in the first 100 days of Prime Minister Narendra Modi's third term, the Ministry of Cooperation has taken "10 important initiatives out of which three are being launched today". These initiatives will help make the co-operative sector self-reliant and

broad-based, he said.

Shah said: "Many people are apprehensive about whether budget support will be available for this programme (White Revolution 2.0) or not. I assure the Animal Husbandry Department that this is the highest priority area of the government and this programme will get full budgetary support."

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