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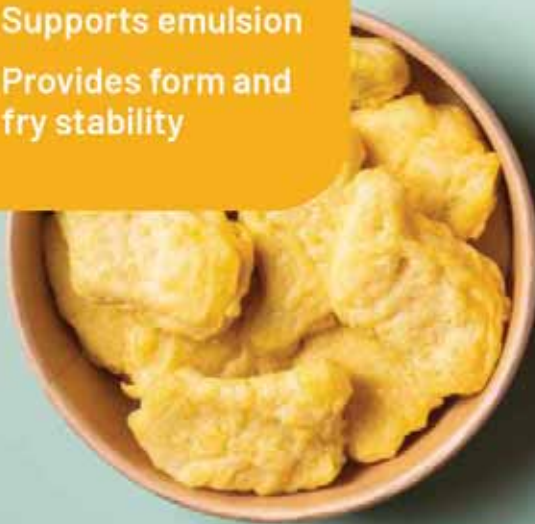


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Publisher's Note

The September Edition of Food Marketing & Technology Magazine is our FiHi and ProPak Special Edition that aims to act as a comprehensive guide on the recent innovations and advancements in the ingredients, processing, and packaging sectors.

This edition highlights the key factors for driving growth and transformation across each sector -processing technologies, functional and innovative ingredients, and the fast-evolving world of beverage packaging. From advanced machinery streamlining efficiency to ingredient solutions that address both nutrition and sustainability, our features explore how companies are rethinking processes to remain competitive in a dynamic marketplace.

A dedicated focus on beverage packaging highlights how design, functionality, and eco-consciousness are reshaping consumer perception and brand value. The future of packaging is not only about containment but about communication, experience, and responsibility. With packaging innovations taking center stage, we examine their role in strengthening trust and enhancing the product journey.

As we continue our commitment to bringing you the latest developments and trends, we hope this issue serves as both a resource and a catalyst for new opportunities. We thank our readers, contributors, and industry partners for their continued support and engagement, and we look forward to seeing how these innovations translate into the next chapter of growth for food and beverage businesses worldwide.

Overall, this edition summarizes a plethora of contemporary and relevant updates of the industry. We wish everyone a successful time at FiHi 2025.



Linda Brady Hawke



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STEER World's Lifesciences Arm Unveils Next Gen Ingredient Solutions to Drive Functional Food Innovation

STEER World, a global leader in materials transformation technology, today announced through its Lifesciences arm, STEERLife, a novel platform for advanced ingredient solutions. As a Contract Development and Manufacturing Organisation (CDMO), STEERLife's solutions are tailored for the evolving needs of the Indian Functional Food Industry, a market projected to reach approximately USD 25.38 billion by 2030 (with a 10% CAGR from 2024 to 2030), driven by increasing consumer health consciousness and demand for functional products.

With a focus on enhancing ingredient functionality, STEER World's Lifesciences arm is helping brands overcome long-standing R&D challenges like poor solubility, poor dispersibility, ingredient bitterness and stability. STEER World's technologies tackle these issues head-on to unlock new possibilities for product performance and shelf life.

In a market that's increasingly fast-paced and consumer-driven, ingredients are the backbone of new product development. "Functionalizing ingredients is no longer optional; it is essential. Through our proprietary technologies, we're enabling ingredient transformation at levels as desired by the end user to improve product performance, stability, and sensory outcomes," said Dr. Pavitra Kumar, Head – Food Business Division at STEER World's Lifesciences arm.

ABB India marks 30 Years of NSE Listing



ABB India Limited, a leading player in electrification and automation, today celebrated 30 years of its listing on the National Stock Exchange (NSE) with a ceremonial bell-ringing event at NSE Mumbai. The event was graced by Ashishkumar Chauhan, MD & CEO of NSE, and Sanjeev Sharma, Country Head and Managing Director, ABB India, alongside senior leaders from both organizations.

Listed on February 8, 1995, ABB India has evolved from a traditional electrical equipment and engineering firm into a future-ready electrification and automation technology leader. Over the past three decades, the company has consistently delivered strong financial performance and shareholder value. A lot of 100 shares purchased at listing for INR 8,883 is now worth

over INR 608,050, reflecting a 6,745% increase, excluding dividends.

ABB India has expanded its operations from manufacturing to include R&D, engineering operations, and business services. Today, it serves 23 industry segments, up from just six in the early years. Over 90% of its India-made products are consumed locally under its 'Local for Local' strategy. There are more than 10,000 people working across multiple locations, businesses, functions and entities of ABB, relentlessly serving our customers. The company works with over 750 partners across 150+ cities and 6,000+ suppliers, reinforcing its commitment to local ecosystems.

ABB India continues to be a preferred partner for industries, utilities, and infrastructure projects, supporting the nation's digital and sustainable transformation.

Smart Fuel for Real Life: Forever FastBreak Brings Snacking Convenience with Flavorful Options

In today's fast-paced world, snacking is no longer just about satisfying hunger it's about finding options that fit seamlessly into busy lifestyles. Forever Living India has introduced Forever FastBreak, a thoughtfully created snack bar range that combines convenience with indulgent flavors, making it a handy companion for people who are constantly on the move.

The FastBreak range offers a variety of taste profiles, appealing to different preferences. For those who enjoy rich and familiar combinations, Choco Almond, Choco Orange, and Choco Strawberry deliver a chocolate-infused experience. For lighter, fruit-forward choices, Almond Sea Salt Cranberry and Oaty Berry Cereal bring a refreshing, wholesome bite. Each bar is crafted to be easy to carry and can be enjoyed anytime whether during travel, at work, or as a quick snack between daily activities.

FastBreak is also part of Forever Living's larger vision of wellness and sustainability. The brand, known globally as the world's largest grower and manufacturer of aloe vera, manages over 7,500 acres of aloe fields across Texas and the Dominican Republic. Its operations follow eco-conscious practices under its "Plant to Product to You" philosophy from water conservation and solar-powered irrigation to recyclable packaging and goat-grazed land management. These initiatives have contributed to Forever earning USDA and EU organic certifications for its aloe cultivation.

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Centric PLM Serves Up New Innovations for the Food & Beverage and Grocery Industry to Drive Efficiency & Speed

Centric Software® unveils the latest evolution of its market-leading Product Lifecycle Management (PLM) platform: Centric PLM™. Centric Software delivers best-of-breed integrated enterprise solutions to design, develop, formulate, source, comply, buy, make, package, market and sell consumer goods products in food & beverage manufacturing, grocery and multi-category retail to achieve strategic and operational digital transformation goals.

The latest update of Centric PLM is a transformative release that takes advantage of AI technologies and designed to simplify workflows, boost system performance and elevate the user experience. Built



on direct input from leading food manufacturers and grocery retailers, it delivers a modern UI, intelligent supplier collaboration tools, a new mobile app and embedded AI to accelerate decisions and reduce time to market.

“Centric PLM now delivers faster performance and new capabilities designed specifically for the food & beverage and grocery industry, empowering companies to gain agility in a competitive and disrupted market,” says Ron Watson EVP Product & CSO at Centric Software. “Our innovative compliance engine simplifies the management of regulatory requirements across different countries streamlining ingredient rules and delivering precise formulation assessments. This accelerates compliance efforts, reduces the time and energy needed to build extensive rule libraries and enables faster more accurate product development—reducing compliance and claim risks and giving our customers a strategic edge in bringing products to market.

Macarons Market Size Worth USD 2,430.17 Million by 2034

Delicate, colorful, and irresistibly sweet, macarons are more than just a treat; they're a little bite of elegance. Whether stacked in pretty gift boxes or displayed in high-end patisseries, these bite-sized beauties have captured the hearts (and taste buds) of dessert lovers everywhere. With their crisp shells, soft centers, and endless flavor possibilities, macarons have gone from a Parisian indulgence to a global dessert obsession..

Macarons have gained immense popularity worldwide due to their unique combination of visual appeal, delicate texture, and wide variety



of flavors. These colorful, bite-sized confections are made with almond flour, meringue, and buttercream or ganache filling, offering a crisp outer shell with a soft, chewy center. Their elegant appearance makes them a favorite for special occasions,

Instagram-worthy dessert tables, and upscale patisseries. Additionally, their versatility in flavors, from classic vanilla and chocolate to exotic matcha or rose, appeals to a broad range of tastes, further fueling their global fascination and demand.

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Indian Poultry Alliance Poised for ₹800 Crore First-Year Topline

The Indian Poultry Alliance (IPA), a subsidiary of the Allana Group, is all set to achieve a topline of ₹800 crore in its first year of operations, marking one of the fastest scale-ups in India's organised poultry sector. This milestone comes less than a year after its launch in November 2024 at Poultry India, where Allana Group committed USD 120 million (approx. ₹1,000 crore) to create a fully integrated poultry venture with nationwide reach.

India's poultry market, valued at ₹2,304 billion in 2024, is projected to grow at a CAGR of 12.6% to ₹8,430 billion by 2033, driven in part by a rapid shift from wet-market chicken to safer, more consistent, and convenient processed formats. Despite this trend, processed poultry currently accounts for only 10% of the market. IPA aims to double this



share to 20% by 2030, while targeting a company topline of ₹2,000 crore by 2027. By year-end, it will also roll out an integrated protein retail distribution platform for chicken, seafood, and lamb, leveraging the Allana Group's nationwide network of 4,000 retail stores.

Commenting on this, Dr. Chitranjan Behl, Chairman, Indian Poultry Alliance

Fueling its ₹1,000+ crore poultry expansion blueprint, the Indian Poultry Alliance (IPA) has rapidly deepened its presence across Kishanganj, Zaheerabad, Coimbatore, and Aligarh through an integrated model spanning breeder farms, hatcheries, feed plants, broiler contract farming, value-added lines, and rendering units. This growth trajectory has been supercharged by the ₹300 crore acquisition of Kwaliti Animal Feeds Pvt. Ltd. in March 2025, with an additional ₹200 crore earmarked for scaling operations. Kwaliti's stronghold in West and South India, long-standing QSR partnerships, and advanced feed capabilities have significantly boosted IPA's production capacity and market reach.

Enhancing Efficiency with Packaging Automation

In today's fast-moving market, manufacturers are increasingly turning to automation to optimize their operations, reduce costs, and stay competitive. SupplyOne is leading the way in delivering innovative packaging automation solutions that are tailored to meet the specific needs of manufacturers in diverse industries.

Automating packaging processes can bring a wide range of benefits, including increased productivity, reduced labor costs, improved product consistency, and faster speed-to-market. These systems allow companies to scale their operations more effectively while maintaining high levels of quality and efficiency. In a business



environment where speed and precision are paramount, automation can become a critical component in maintaining a competitive edge.

SupplyOne's automation capabilities provide companies with measurable improvements. Below, we explore

how several manufacturers have harnessed automation to transform their packaging processes.

Dairy and Cheese Processor Eliminates Co-Packing and Improves Consistency

A dairy and cheese processor with two plants in different states faced significant challenges with inconsistent packaging and inefficient automation. The company relied on external co-packers, which resulted in uneven product presentation and slow production timelines. Additionally, logistical issues between the plants and a lack of in-house expertise hampered efforts to create an efficient automation strategy.

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The Rise of Spice Oleoresins: A Global Flavour Revolution

■ By Venkatesh Ganapathy

The global spice oleoresin market is experiencing significant growth, driven by a surging demand for natural ingredients in the processed food and fragrance industries. Consumers' increasing health consciousness has led to a preference for natural colouring and flavouring agents over artificial alternatives.

Spice oleoresins, which are highly concentrated liquid extracts of raw spices, offer a complete and consistent flavour profile, including both volatile and non-volatile constituents. These botanical extracts are obtained through a solvent extraction process, followed by solvent removal. Their advantages over traditional whole or ground spices are numerous: enhanced visual appeal, superior

and consistent flavour, longer shelf life, cost-effectiveness, and ease of storage and transport due to their concentrated nature. They also boast a lower microbial load and can effectively replace traditional spices in most applications where the physical appearance or bulk of the spice is not crucial.

A Legacy of Innovation and Market Dominance

The commercialisation of spice oil and oleoresin extraction began in Germany in the early 20th century. India, however, has emerged as a global leader in this sector, controlling a remarkable 60% of the 13,500-tonne global spice oleoresin market. Pioneering efforts in India, such as the establishment of oleoresin manufacturing in 1969

by Kancor Ingredients (formerly Bombay Oil Industries), followed by companies like Synthite Industries and Plant Lipids, laid the groundwork for this dominance. Notably, the Indian extraction procedure, developed by the Central Food Technological Research Institute, is a unique two-stage process that effectively separates essential oils.

Key Indian players in this market include Synthite Industries, Plant Lipids, Kancor Ingredients, Venkatramna Industries, Silverline Chemicals Ltd, Agnes Herbs, Adani Pharmachem Private Limited, and Ozone Naturals. While India maintains a strong lead, China has emerged as a significant competitor, particularly in the paprika oleoresin segment.



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Diverse Applications Across Industries

Spice oleoresins are versatile and find extensive applications across various industries, serving as base flavours or components of complex flavour profiles. They can be used directly or blended to create a wide range of seasonings, flavours, and perfumes.

- **Food and Beverage Industry:** They are widely used as colouring agents in products like butter, meat, cheese, snacks, jellies, jams, poultry feeds, and frozen foods. They are also crucial in beverages, meat canning, confectionery, sauces, and as a base for numerous seasonings.
- **Healthcare and Personal Care Industries:** Their natural properties and consistent composition make them valuable in pharmaceuticals, cosmetics, and personal care products.

Key Oleoresins

Black Pepper Oleoresin: Derived from black pepper berries, this olive-green liquid offers the characteristic pungent taste and aroma of pepper due to its piperine and volatile oil content. Beyond its use in flavouring meat products and as a preservative, it's gaining traction in traditional medicinal systems like Ayurveda for treating various ailments, including digestive issues and joint pains. The global market for black pepper oleoresin is experiencing significant growth driven by its diverse applications.

Paprika Oleoresin: Extracted from red paprika fruits, this oleoresin is a vital natural colouring and flavouring agent. Its colour comes from capsanthin and capsorubin, while capsaicin provides pungency. It's extensively used to colour



Image Source: Adobe Firefly

and flavour a wide array of food products, including meat products, confectionery, snacks, soups, sauces, and bakery items. The demand is particularly high in regions with a strong preference for clean-label natural ingredients.

Cardamom Oleoresin: Obtained from cardamom seeds, this extract is characterised by its sweet-spicy, warming fragrance. It's broadly used as a domestic spice, a fragrance component, and a flavour compound in various dishes, sweeteners, and curry products. In pharmaceuticals, it's recognised for treating digestive disorders and is also employed in personal care products and perfumes.

Market Growth and Future Outlook

The global spice oleoresin market is poised for steady growth. The market, valued at USD 1.44 billion in 2018, is projected to register a CAGR of 4.7%

over the forecast period. This growth is fuelled by increasing consumption of processed meat, confectionery, and baked goods, as well as the rising demand for food additives and the proliferation of multi-cuisine restaurants worldwide.

Oleoresins' superior properties—including uniform composition, consistent strength, absence of contaminants, ease of storage and transport, and longer shelf life—make them an increasingly attractive alternative to ground spices. Continuous research and development initiatives, particularly in introducing new varieties and improving quality for applications like aromatherapy, are expected to further augment market growth. As consumer demand for natural ingredients continues to rise, spice oleoresins are set to play an even more crucial role in shaping the flavours and colours of products across diverse industries.

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In India, spice oleoresins are extensively utilised across various industries, primarily due to their concentrated form, consistent quality, extended shelf life, and superior hygienic standards compared to traditional raw or ground spices. Their most significant application lies within the food and beverage sector. Here, they are crucial as natural flavouring agents, imparting the authentic taste and aroma of various spices to a wide array of products. This includes processed foods like soups, sauces, dressings, and ready-to-eat meals, as well as meat and seafood products, confectionery, bakery items, dairy products, and snacks. Furthermore, they form the essential base for numerous compounded seasonings and ready-made spice blends, a growing segment in the Indian culinary landscape. Beyond flavouring, oleoresins like paprika and turmeric are widely employed as natural colouring agents in products such as butter, cheese, and various processed foods, while some, like black pepper oleoresin, also offer preservative qualities.



Image Source: Freepik.com



Beyond the culinary world, spice oleoresins find significant application in the pharmaceutical and nutraceutical industries. They are incorporated into a variety of medicines and health supplements, not only to mask unpleasant tastes or provide appealing aromas but also for their inherent medicinal properties. For instance, black pepper oleoresin is a component in traditional Indian medicinal systems like Ayurveda, Siddha, and Unani, used for addressing various ailments. Similarly, cardamom oleoresin is recognised for its benefits in treating digestive issues. Their use extends to formulations designed to address specific illnesses, and as active ingredients in carminative, stomachic, and stimulant preparations.

Moreover, the cosmetics and personal care industry in India increasingly utilises spice oleoresins. They are valued for their natural fragrances and potential skin benefits, finding their way into products like creams, soaps, shampoos, and perfumes. This trend is driven by a growing consumer preference for natural and herbal ingredients in their personal

care routines. The fragrance industry also leverages oleoresins for their rich and true-to-origin scent profiles in products such as air fresheners and specialised perfumes. Finally, the animal feed sector indirectly benefits from oleoresin extraction, as the residual spice powder, rich in nutrients, can be used in animal feed formulations, contributing to improved animal performance and productivity. While the direct use of oleoresins in Indian household cooking is still evolving, their integral role in the organised food processing sector means they are a substantial, albeit often unseen, presence in the modern Indian kitchen through processed foods and ready-to-use products.



About the author:

* (Venkatesh Ganapathy teaches marketing and strategy at IBS, Bangalore)



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India's Dairy Powerhouse: A Legacy of Innovation and Opportunity

■ By Ashutosh Jaiswal* and Ayushi Shukla**

India is not just a milk-producing nation—it's a dairy superpower. With over **230 million tons of milk** produced annually, India contributes **more than 25% of the world's milk**. Yet, this story is not merely about quantity; it's about people, traditions, and transformative innovation.

Let's take a journey through India's incredible rise in dairy, its global influence, and where the white wave is headed next.

The White Revolution: India's Creamy Uprising

Rewind to the 1960s. India was facing a major dairy crisis. Milk was scarce. Imports were costly. Malnutrition was widespread.

Enter Dr. Verghese Kurien, the man who would change the game. He didn't just revolutionize milk production—he created a movement. The White Revolution, or Operation Flood, began in 1970 and transformed India's dairy landscape.

Operation Flood was implemented in three phases:

- **Phase I (1970–1980):** Focused on establishing dairy cooperatives in major cities and connecting rural milk producers with urban consumers. This phase laid the foundation for a nationwide milk grid.
- **Phase II (1981–1985):** Expanded the network of dairy cooperatives and introduced modern dairy farming techniques and



infrastructure, such as chilling centers and pasteurization plants.

- **Phase III (1985–1996):** Strengthened the infrastructure required to procure and market increasing volumes of milk, and emphasized research and development in animal health and nutrition.
- Key pillars of the White Revolution:
 - Establishment of **Amul** as a cooperative model.
 - National Dairy Development Board (NDDB) initiatives.
 - Focus on empowering rural farmers, especially women.
 - Village-level milk collection and chilling infrastructure.

This revolution was not merely about quantity but equity. It empowered over **75 million dairy farmers**, the majority being smallholders owning **1–2 cattle**, contributing to both household nutrition and rural incomes.

By the 1990s, India had dethroned the U.S. as the world's largest milk producer.

India's Dairy Production: A Global Perspective

- **Global Leader in Milk Production:** India stands as the world's largest milk producer, contributing over **25%** of the global milk supply. In the fiscal year 2023–2024, India produced approximately **230.58 million metric tons** of milk, nearly three

times more than China, the next largest producer.

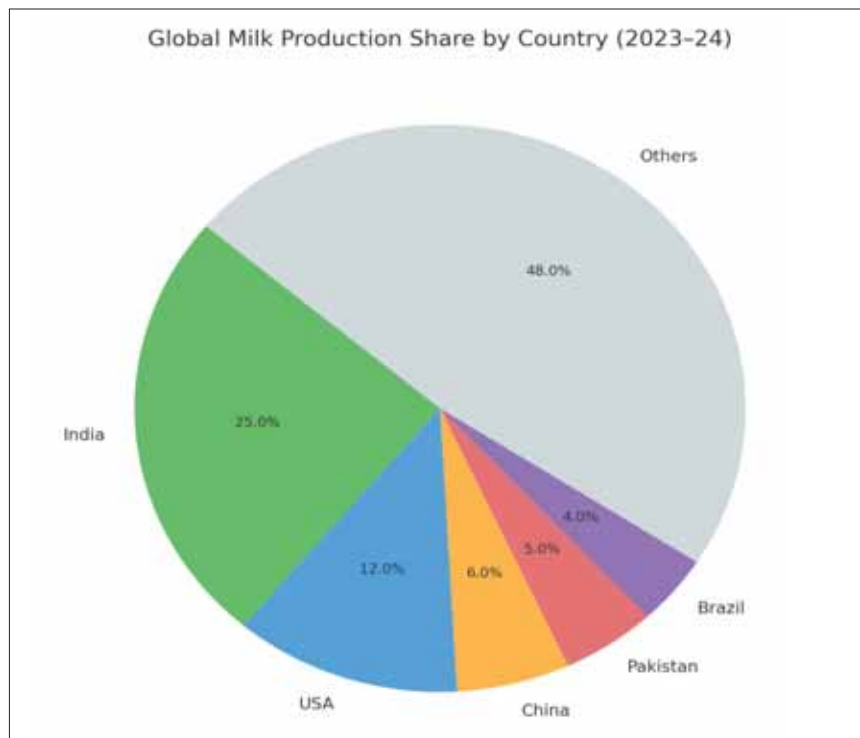
- Domestic Consumption Dominates:** Despite its massive production, India's dairy exports are relatively modest. In 2023–2024, India exported **63,738.47 metric tons** of dairy products, valued at **\$272.64 million**, representing only **0.25%** of the global dairy product exports.
- Emerging Opportunities:** There is potential for India to increase its presence in international markets by addressing quality and infrastructure issues. Enhancing value-added dairy product offerings and meeting global standards can pave the way for expanded exports.

The Dairy Shelf Is Evolving—Fast

If you think the Indian dairy story is all about raw milk and traditional dahi, think again.

India's dairy is not industrial—it's emotional. Milk is deeply woven into every region's culinary and cultural identity:

- North India:** Paneer, lassi, ghee
- East India:** Mishti doi, rasgulla, chhena
- South India:** Curd rice, filter coffee with milk, buttermilk
- West India:** Shrikhand, basundi, kharwas



India's model is uniquely decentralized, inclusive, and resilient. Welcome to India's dairy 2.0, where innovation meets palate.

Brands like Amul, Mother Dairy, and even startups like Epigamia and White Cub are introducing vegan, lactose-free, and gourmet options. The cold chain is improving. Packaging is smarter. And e-commerce is making doorstep delivery of dairy a daily norm.

Fortification: Powering Up India's Milk

Milk fortification involves adding essential micronutrients—mainly Vitamin A and Vitamin D—to fluid

milk. This boosts its nutritional value without changing taste, color, or texture.

In a country where Vitamin A deficiency affects over 50% of preschool children and Vitamin D deficiency is widespread, fortification is a silent lifesaver.

India's Push for Fortified Milk

In 2016, the Food Safety and Standards Authority of India (FSSAI) launched the "Food Fortification Resource Centre". Soon after, the "+F" logo began appearing on milk packets across the country.

Comparative Analysis: India vs. Global Dairy Markets		
Metric	India (2023–2024)	Global Context
Milk Production	230.58 million metric tons	Largest globally
Share of Global Milk Production	Over 25%	Leading producer
Dairy Exports	\$272.64 million	0.25% of global dairy exports
Major Export Destinations	UAE, Saudi Arabia, USA	Focused on select markets
Domestic Consumption	Predominantly domestic	High internal demand limits exports

As part of Eat Right India, this move ensures that everyday dairy consumption contributes directly to better immunity, bone health, and child development.

Fortification and the Global Edge

Fortified dairy also gives India a competitive edge in international markets, especially in:

- Health-conscious countries where enriched foods are in demand.
- Regions battling nutritional deficiencies in Africa and Southeast Asia.
- Custom formulation for export-specific needs (e.g., fortified milk powder for infant food in the Middle East).

Tech Meets Tradition: Cows Go Digital

It might surprise you, but technology is now grazing in Indian pastures.

- Farmers use mobile apps to track cow health.
- IoT sensors monitor milk yield and quality in real-time.
- Drones survey fodder availability.
- Block chain ensures milk traceability from udder to fridge.

In states like Karnataka and Punjab, cooperative dairies are digitizing procurement systems. A farmer can now get paid for his milk through UPI within 24 hours of delivery.

This fusion of tradition with technology is improving productivity, ensuring hygiene, and building trust with consumers.

But Wait—It's Not All Cream and Butter

Every big success story has its shadows.

India's dairy industry, despite its size, faces persistent challenges:

- **Infrastructure gaps:** Chilling centers and cold logistics are still patchy in remote areas.
- **Quality inconsistencies:** Adulteration and hygiene issues persist, especially in the unorganized sector.
- **Export hurdles:** Indian dairy, rich in quantity, still struggles to match the stringent quality norms for global exports.

Still, the country is making strides. India exported over \$270 million worth of dairy products in 2023–24, with ghee, butter, and milk powder leading the charge.

Government support under schemes like Rashtriya Gokul Mission is encouraging indigenous breed development and scientific cattle rearing.

The 2023–24 Slowdown: A Temporary Setback?

India saw a **30% drop in dairy exports** in 2023–24—from \$391M to \$273M. Why?

- **Raw milk supply crunch:** Rising input costs, post-COVID herd issues

- **High domestic prices:** Made Indian SMP uncompetitive globally
- **Global surplus:** EU and NZ flooded markets, pushing down prices
- **Weak international demand:** Especially from China and the Middle East

Competitive Advantage: India's Unique Dairy Proposition

Core Strengths:

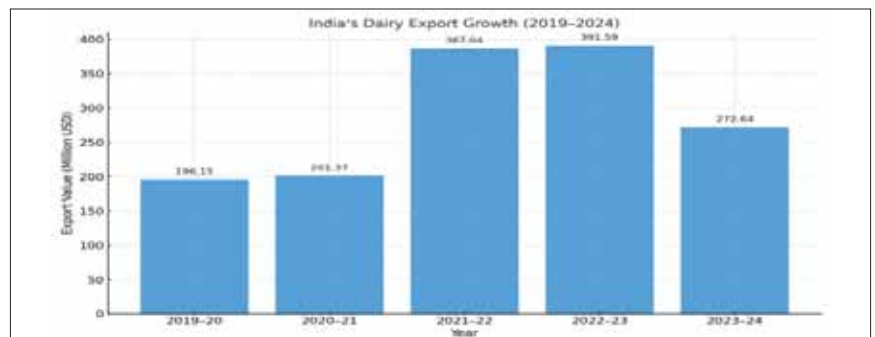
- Low production cost per litre (with better scale)
- Diverse product portfolio beyond just SMP and cheese
- Trust and traceability through dairy cooperatives
- Built-in domestic demand ensures market safety

Expansion Frontiers:

- Custom dairy for export markets (e.g., lactose-free, fortified)
- Organic milk and A2 cow milk
- Indian sweets and ethnic dairy in global ethnic food aisles

The Way Forward: What Needs to Be Done

India's dairy story isn't just about



However, this is likely a **cyclical correction**, not a long-term trend. With stabilization, India is expected to regain growth momentum.

volume anymore—it's about value. To take next leap, India must work on-

- **More innovation:** Probiotic dahi, protein shakes, oat milk—diversity is growing.
- **More startups:** Young entrepreneurs are shaking up traditional models with ethical sourcing, transparent labeling, and niche offerings.
- **More global presence:** With the right infrastructure and branding, Indian dairy can become a premium player globally.

International collaborations are in the works. There's growing interest in Indian milk-based health foods and functional beverages.

Green Is the New White: Sustainability in Focus

With climate concerns rising, the dairy sector is embracing green practices:

- **Biogas** plants powered by cow dung.
- **Feed optimization** using crop residues to reduce methane emissions.
- **Water reuse** in dairy processing units.
- **Solar chilling units** for off-grid milk collection centers.

Sustainable dairy isn't just a trend—it's fast becoming a necessity. And India, with its massive herd and cooperative model, could lead a green dairy revolution.

Final Sip

India's journey in the dairy world is more than just an economic achievement—it's a social revolution. Today, India boasts not only **the world's highest milk production** but also one of the most **inclusive and**

culturally rooted dairy ecosystems. From household staples like ghee and curd to innovations in flavored milk, digital dairy solutions, and fortified products, India is merging tradition with technology at every level.

Challenges remain—productivity gaps, infrastructure lags, and limited exports. But with targeted reforms, investment in breed improvement, sustainable practices, and smart supply chains, the country is poised to make a larger dent in the global market.

As we look ahead, the synergy of women-led rural enterprises, scientific innovation, government support, and global demand will

shape India's dairy destiny.

The white wave isn't fading-it's only getting stronger.



About the authors:

* Ashutosh Jaiswal
Food Safety Professional
Email: ashuthewall@gmail.com
www.foodsafetywithashutosh.com

**Ayushi Shukla
Food Safety Professional
Email: ayushishukla2223@gmail.com

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Evaluating the Critical Role of Air Filters in the Food Industry

■ By Mrigank Bothra*

In this era where consumers are noticeably more aware of food safety and hygiene, ensuring that food production environments are provided with clean air is no longer optional, but essential. Air, while often invisible, plays a major part in the possible contamination of food products. Air pollution in the form of dust, allergens, and microbes poses persistent risks, from processing areas through to packaging sections. This is the moment where advanced air filtration systems step in, discreetly protecting the food we consume long before it comes to our plates.

Filtering the Invisible Elements

In food and beverage processing, every element that comes in contact with the product must comply with the highest hygiene standards, including the air. The new filtering systems are mainly dust collector filter bags and panel filters, which are among the cleverest in technology to catch dust particles efficiently during prime operations like seed cleaning, grinding, and packaging. These filters minimize airborne contamination, promoting a safer, more controlled production environment.

Designed for Hygiene-Critical Zones

Facilities dealing with high-sensitivity food products require far more than standard filtration. In such areas, the use of high-performance filter bags and cartridge filters is a must-have. Filters of this kind are made with special materials to capture even the smallest airborne particles. As a result, these filters ensure that no invisible substances can enter the food chain, thus helping the company observe the exacting hygiene standards required by the sector.



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Purifying What We Consume

Filtration is not only about air, it is also about clarity in the liquids that we consume daily. In fruit juice clarification, edible oil purification, and other beverage processing stages, filter press cloths play a vital role. These fabrics help remove unwanted sediments and particles, ensuring that every bottle poured is as pure as designed. The application of such filters transforms the production process from merely efficient to uncompromisingly clean and healthy to consume.

Standards That Speak Across Industries

Interestingly, many of the most effective filtration technologies used in food plants today draw from innovations in heavy industries like steel and cement. What makes them different, afterward, is that they are founded on food-grade hygiene standards. Food-grade filter products comply with cross-industry

standards which include ISO, DIN, and EN endorsements, ensuring they meet both the requirements of operational efficiency and cleanliness.

Protection at the Source and Safety Beyond the Product

What makes modern filtration so critical is its preventive nature. Rather than treating contamination after the fact, today's air filters work at the source, capturing pollutants before they even have a chance to settle on surfaces or ingredients. This proactive defense minimizes the overall risk of cross-contamination and ensures that both product quality and consumer trust remain intact. Clean air is not just about the end product; it's also about the people. In clean room environments within food factories, filters maintain sterile air that protects both the food and the workers who handle it. This dual role of product and personnel safety makes filtration systems one of the unsung heroes of the food industry.

As the food industry continues to evolve with consumer expectations and regulatory standards, the role of air filtration systems becomes an increasingly crucial and important aspect. From maintaining air purity to supporting uninterrupted production, these systems operate silently in the background, while their impact is loud and clear in the process. Clean air isn't just a health requirement; it's the foundation of safe food and a safe environment.



About the author:
* Mrigank Bothra, Director, ClipOn.io

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Driving Efficiency & Sustainability Through Advanced Power Transmission Systems

In today's industrial landscape, efficiency and sustainability are no longer optional; they're essential. Power Build, with its decades of engineering excellence, is at the forefront of this transformation. Through its advanced range of power transmission products, the company is actively helping industries minimize energy consumption, extend machine lifespans, and transition toward greener manufacturing practices.

Power Build's entire gearbox and geared motor portfolio is engineered with energy optimization at its core. Whether it's the **Series M Helical Inline Geared Motors**, known for their compact design and high efficiency, or the **Series K Helical Bevel Geared Motors**, offering torque up to 50,000 Nm with minimal energy loss, each product is built to maximize output while reducing unnecessary power draw. These solutions are precision-designed to minimize friction, vibration, and wear three major contributors to energy inefficiency and mechanical failure.

One of the most effective ways Radicon supports sustainability is through its gear systems' **high mechanical efficiency**, which directly contributes to lower electricity consumption in



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Series_C



Series_F



Series_J



Series_K



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continuous operations. For example, the **Series C Heli-Worm and Series F Parallel Shaft Geared Motors** are designed to deliver optimal performance even under varying load conditions, reducing the stress on motors and associated systems. This not only conserves energy but also lowers the carbon footprint of plants over time.

Moreover, Power Build's **planetary (Series PL) and worm gear (PBWR)** series contribute significantly to space-saving, heat reduction, and maintenance-free operations all of which are key to sustainable plant design. Many of these gearboxes are pre-filled with high-grade lubricants and designed for long maintenance cycles, ensuring reduced downtime and lower waste generation over the life of the equipment.

To complement its mechanical excellence, Radicon also offers the **PBL VFD Series (Variable Frequency Drives)** a modern, electronic solution that brings intelligent speed and torque control to the table. These

drives allow motors to operate at optimal speeds, cutting down on excess energy use during startup, operation, and load variations. The result is a finely tuned drive system that aligns with green manufacturing goals.

Lastly, through extended equipment life cycles, Radicon products inherently reduce the need for frequent replacements and resource consumption. Gear units like the **Series J Shaft Mounted Reducers** and **Roloid Gear Pumps** are crafted with durability and long-term efficiency in mind, further reinforcing the company's commitment to sustainable industry practices.

Power Build isn't just powering machines, it's enabling a future where industrial growth and environmental responsibility go hand in hand.





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Innovations in Packaging: Enhancing Shelf Life and Quality

■ By Komal¹ and Ruchi Verma²

ABSTRACT

Innovations in food product development and packaging are driven by the need for safe, nutritious foods with minimal environmental impact. Traditional preservation methods are being replaced by non-thermal technologies such as high hydrostatic pressure, pulsed electric fields, cold plasma, and ohmic heating. These techniques inactivate microorganisms, extend shelf life, and maintain product quality. Combined with advanced packaging systems, they offer tailored solutions for safety, preservation, and reduced wastage.

1. INTRODUCTION

Packaging is one the essential elements required for protection

and to extend the shelf life of food products. However, it is required not only for food preservation and protection but also for safe transportation of products during storage and handling. Increasing exports and developing export market needs have also affected the packaging trend. Packaging requires containing food, protecting food from environmental factors, convenience in handling, storage, marketing, and communicating information to consumers about the food inside the package. Therefore, it has an active role in retaining the safety and quality of foods throughout the supply chain. The use of properly designed containers for transporting and marketing of horticultural produce can significantly reduce their losses and maintain their freshness and quality for longer

periods. Although traditional packaging covers the basic needs of food containment, innovations in food packaging are both anticipated and expected. Innovative packaging is the result of consumers demand for packaging that is more advanced and creative than what is currently available. Traditional food packages are passive barriers designed to delay the adverse effect of the environment on the food product. These new innovative packages allow the package to interact with food and environment and play a dynamic role in preservation of food product. All the new packaging technologies have great commercial potential to ensure the quality and safety of food with fewer or no additives and preservatives, thus reducing food wastage and maintaining the quality of the produce.



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2. CONTROLLED AND MODIFIED ATMOSPHERIC PACKAGING

In controlled atmosphere packaging (CAP), the composition of gas inside the package is altered and continuously monitored/maintained at a preset level with the use of scrubbers or other means. Whereas, in modified atmosphere packaging (MAP), the gas composition within the package is not monitored or adjusted and a predetermined gas mixture is used to flush packages before closing, which depends on the oxygen sensitivity and rate of the metabolic activity of the product. It involves changes or modification in atmosphere inside the package with respect to the normal composition of air and ultimately reduces the physiological and microbial decay of perishable produce.

3. METHODS FOR CREATING MODIFIED ATMOSPHERES

- **Passive Modified Atmosphere:** In this method, fresh produce is sealed in a packaging film

with selective or non-selective permeability to gases. The product's natural respiration consumes oxygen (O_2) and releases carbon dioxide (CO_2), gradually creating the desired internal atmosphere. This process is self-regulating but slower, and the equilibrium gas composition depends on the respiration rate of the product, storage temperature, and film permeability. It is widely used for fresh fruits and vegetables.

- **Active Modified Atmosphere:** Active MA is achieved by mechanically altering the gas composition before sealing the package. This is typically done by creating a partial vacuum and flushing the package with a predetermined gas mixture (e.g., nitrogen, carbon dioxide, or a blend) to quickly establish the desired atmosphere. Active MA ensures faster preservation benefits and allows precise control over gas ratios, making it suitable for high-value, perishable, or oxygen-sensitive foods such as meat, seafood, and bakery products.

4. FOOD SAFETY ISSUES

The present food legislation, taking into consideration the consumer desire for natural, minimally processed, and convenient food products, in addition to the never-ending changes at industrial, retail, and distribution levels, considers food safety as a global concern. This concern provides a stimulus to the packaging industry to present numerous innovative techniques to address the legal and regulatory requirements along with the changing needs of the food industry and consumers.

CONCLUSION

Trends in the emergence of biodegradable packaging technology with improved quality and safety have resulted in innovations in packaging techniques. Research and development, in response to consumer preferences, have given rise to active, intelligent, and bioactive food packaging techniques that are purely innovative. These innovative packaging technologies have contributed toward the

enhancement of food quality, safety, feasibility, and the bioactivity of functional components. The applicability of novel and innovative packaging techniques is growing widely because of their health impact and has resulted in reduced consumer complaints. In the near future, traditional packaging will be completely replaced by innovative food packaging techniques, as these techniques are rapidly making their way into the global market.

About the authors:

¹M.Sc Student

^{2*}Assistant Professor

^{1,2}Department of Food Processing and Technology, Gautam Buddha University, Greater Noida (U.P)

* Corresponding author email: ruchiverma0715@gmail.com

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Mayonnaise is an emulsion of oil in water phase, manufacturing process need precise context of dosing of various ingredients and right kind of homogenisation.

Silver Touch: Chitin-Based Packaging That Thinks Ahead

■ By Riya Salunke, Dr Ramya V

1. Introduction

Increased need for safe, sustainable, and long-lasting food packaging is diverting attention from conventional synthetics to sustainable alternatives. Active packaging based on natural polymers with antimicrobial compounds is a promising candidate. Chitin and chitosan with silver nanoparticles (AgNPs) provide improved food preservation by antimicrobial activity, increased strength, and sustainability.

Chitin, an abundant marine polysaccharide found in crustaceans and certain fish, is a repeating unit of N-acetyl-D-glucosamine. It's non-toxic, biodegradable, and biocompatible. Chitosan, prepared from chitin through alkaline

deacetylation, dissolves in acidic solutions and is capable of forming films. Chitin and chitosan with silver nanoparticles (AgNPs) have antimicrobial activity, especially against fungi and Gram-positive bacteria. Both tend to lack sufficient strength and barrier properties, which usually must be enhanced often by combining with nanoparticles or other polymers. This is what makes chitin perfect for bioactive packaging films that prolong shelf life and maintain food safety.

2. Synthesis and Chitin-Silver Nanoparticles (Chitin-AgNPs) Processing

2.1 Extraction of Chitin:

Deproteinization employs sodium hydroxide (NaOH) to extract proteins

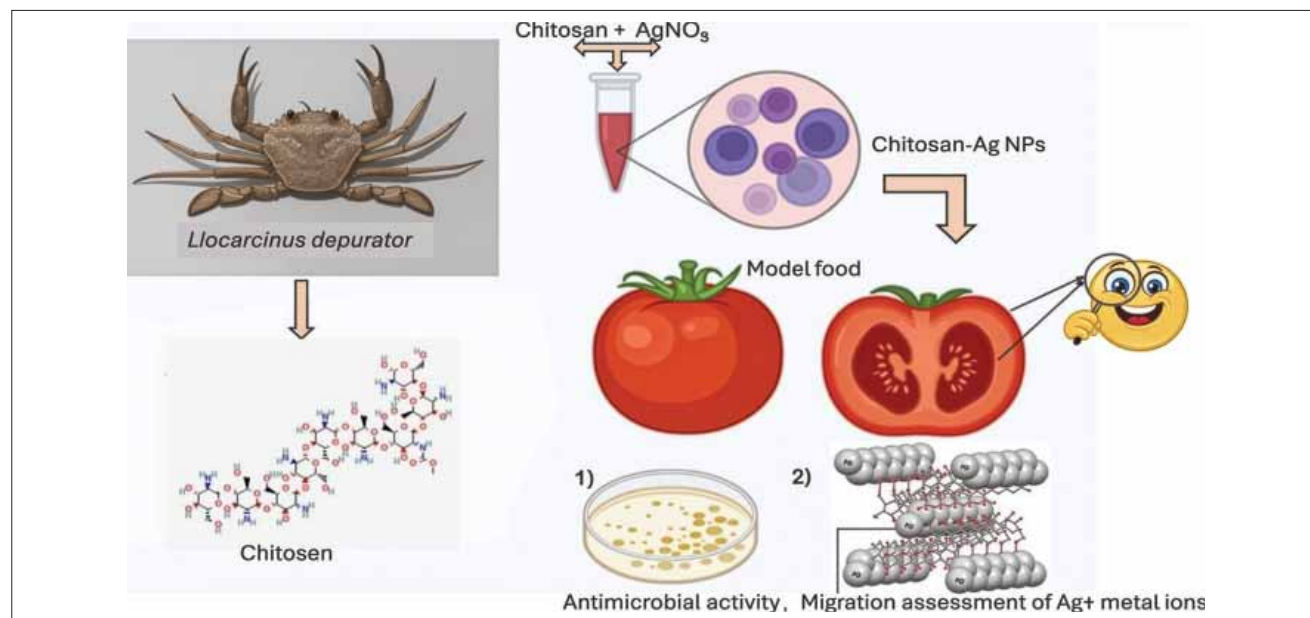
from crustacean shells or fish scales; demineralization utilizes hydrochloric acid (HCl) for the removal of calcium carbonate and other minerals; and decolorization utilizes solvents such as acetone to extract pigments, leaving purified chitin for the synthesis of nanoparticles. Silver nanoparticles are prepared by in-situ or ex-situ methods:

In-situ synthesis can be achieved by directly adding silver nitrate (AgNO₃) to a chitin or chitosan solution, reducing and stabilizing under controlled heat and stirring, with chitin playing both reducing and stabilizing roles.

Ex-situ synthesis involves incorporating pre-synthesized silver nanoparticles (AgNPs) into

Fig 1: Synthesis and Chitin-Silver Films

(Sourced from: Demirbas, A., & Karsli, B. (2025). Innovative chitosan-silver nanoparticles: Green synthesis, antimicrobial properties, and migration assessment for food packaging. *Food Chemistry*, 467, 142363)



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the chitin matrix and stabilizing them by interacting with functional groups such as amino and hydroxyl. Vijayaraj et al. (2023) reported a green synthesis process employing fish-scale-derived chitin for reducing AgNO₃ under mild heat; a brownish color indicates successful nanoparticle formation.

2.2 Film Formation: Chitin-AgNP films are prepared by casting a uniform solution of chitin (or chitosan), silver nanoparticles (AgNPs), plasticizers (such as glycerol), and occasional bacterial cellulose nanofibers (BCNF) into molds or petri dishes. Films are air dried and condition at 50% relative humidity for a few days to stabilize them.

2.3 Structural and Morphological Analysis: Methods such as Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), and X-ray Diffraction (XRD) verify dispersion of AgNP in the chitin matrix and reveal chemical interactions. FTIR normally indicates peaks indicating AgNP bonding to amino groups of chitosan.

2.4 Mechanical and Thermal Properties: AgNP addition increases chitin film tensile strength, elongation, and thermal resistance. Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA) indicate increased thermal stability, important for various storage and transport conditions.

2.6 Barrier Properties: Resistance to moisture and oxygen is crucial in packaging. Chitin-AgNP films exhibit a significant reduction in Water Vapor Permeability (WVP). For instance, In the study conducted by Yazdi et al. (2024) the WVP reduced with AgNPs and BCNF, significantly enhanced food preservation.

3. Food Packaging Applications

Sl. No.	Author Name	Study Conducted	Inference
1	Yazdi et al. (2024)	Packaging of bread using chitosan film reinforced with BCNF and AgNPs	Packaging of bread using chitosan film reinforced with BCNF and AgNPs
2	Vijayaraj et al. (2023)	Chitin-Derived Silver Nanoparticles for Enhanced Food Preservation: Synthesis, Characterization, and Antimicrobial Potential	Coating of tomatoes and chillies with chitin-AgNP resulted in better shelf life of the product.
3	Karolina et al.(2020)	Biopolymers-Based Materials Containing Silver Nanoparticles as Active Packaging for Food Applications—A Review	Packaging of meat and seafood with chitin-AgNP films was a success.

2.7 Antimicrobial Activity and Mechanism: Antimicrobial activity of chitin-AgNP films is one of their most desirable characteristics. Silver ions (Ag⁺) emitted from AgNPs interfere with microbial cells by:

Injuring cell membranes.

Binding to thiol groups in proteins and enzymes.

Producing reactive oxygen species (ROS).

These activities lead to the inhibition of bacteria, yeasts, and molds. The films have been reported to prevent pathogens such as *E. coli*, *S. aureus*, *L. monocytogenes*, and *Vibrio spp.* from growing.

4. Conclusion and Future Directions

Chitin-silver nanoparticle composites offer a renewable, efficient and multifunctional solution for active food packaging. The composites provide antimicrobial protection, improve mechanical

and barrier function, and mitigate environmental issues related to plastic wastes.

Future lin of work:

Long-term safety experiments on nanoparticle migration.

Scalability and economical production.

Incorporation of natural antioxidants or essential oils to achieve additional functionality.

As consumers become increasingly concerned and regulatory food safety mandates become more stringent, chitin-AgNP packaging will be at the forefront of the next generation of intelligent and eco-conscious food preservation systems.

About the author:

* Email id: riyasalunke559@gmail.com
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“Why Aluminum is the Go-to Material for Beverage Packaging”

■ By Dr Ruchi Lamba*



Aluminum (Al) is one of the most abundant elements in the Earth's crust. It is a light weight, silvery-white metal with low density and excellent corrosive resistance. Al is a popular choice for food packaging due to its benefits over other materials like plastic, paper and glass. Al packaging helps reduce plastic waste pollution, conserve resources, and consumption and lower carbon emissions, making it a preferred material for flexible food packaging.

1. **Availability-** Al is third most common element found in earth's crust. India is among the top aluminium-producing countries globally, with companies like Hindalco, NALCO, and Vedanta contributing significantly to the country's production. "India's Odisha state is a significant producer of aluminium".

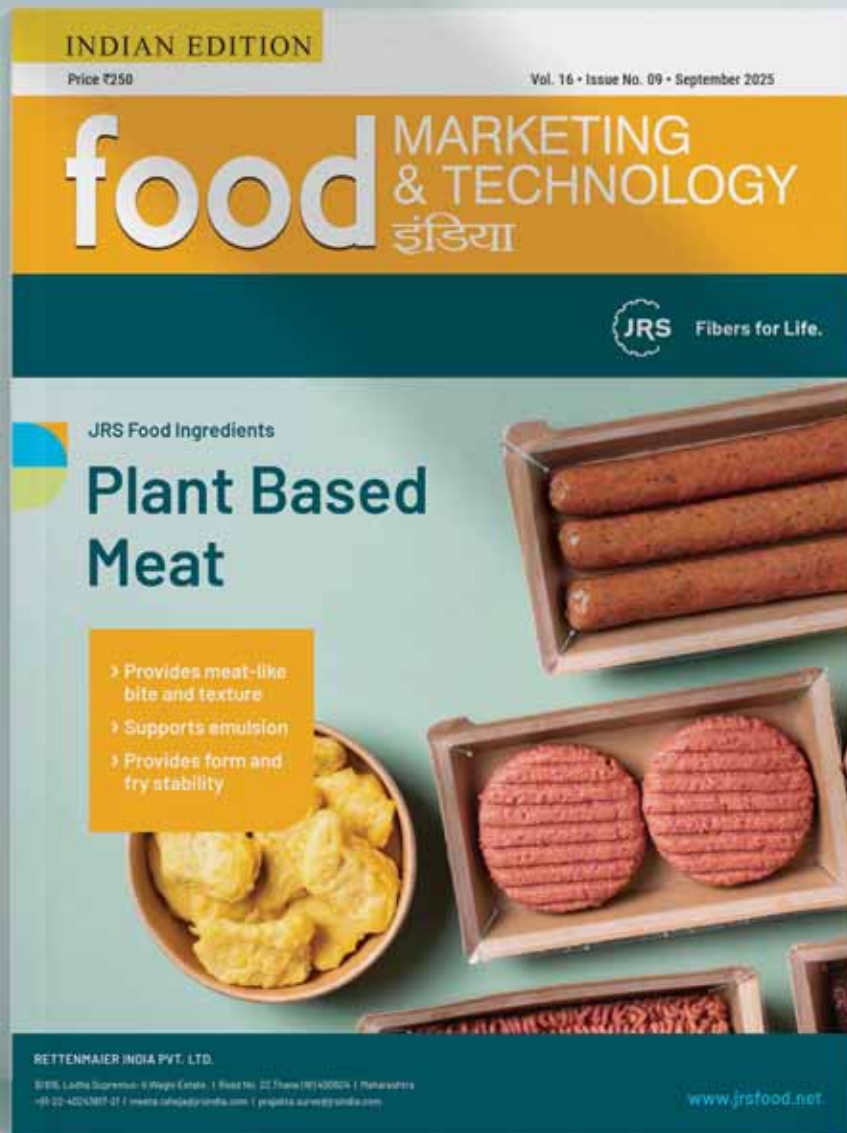
2. **Longevity-** Al metal is corrosive resistant, easy to shape, stable with resistant to light organic acid. These properties contribute to its longevity and ability to protect products without degrading. However, Highly concentrated acid and basic substance should be avoided in aluminium container to prevent potential reaction.

3. **Environmental sustainability-** Al is cost effective and environmental friendly choice for food packaging material. Al packaging can be recycled and reused, making it an ideal green packaging material.

4. **Versatility-** Al packaging offers a significant advantage from a marketing perspective. Al metal can be easily molded into various creative shapes, and its surface is ideal for embossing and printing enabling effective brand identification and consumer appeal.

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- 5. High degree of barrier protection-** Al metal preserve the food against moisture, light and oxygen and also preserve the quality, safety and aroma of food product.
- 6. Light weight-** Al packaging is lightweight, which reduces transportation costs since more products can be loaded onto a vehicle. Additionally, Al packaging is durable, eliminating the risk of breakage and is easy to handle and carry.

Aluminum (Al) as a packaging material uses Al plate, Al blocks, Al foils, metalized film, Al disc, Al sheet, Al coils, Al strips etc. There are different application forms of Al packaging

Foil food packaging- Aluminum foil is used for food packaging. It

is typically made from a type of 1 series, 3 series and 8 series Al alloy. Common tempers for Al alloy include H14, H16 and H18. In the pharmaceutical industry, Al foil is used for capsule packaging and blister packs, providing a high barrier that protect drug quality. Al foil is also suitable for dairy product and beverage allowing for long time preservation.

Aluminium containers are used for carbonated drinks to maintain the pressure of CO₂ in soda drink and ensuring a better taste. Aluminium is a safe packaging option for food and beverages because it does not react with or release chemicals into contents. Aluminium containers are made from 5052, 3104 and 3004 aluminium plate, which are also used for packaging various products,

including drug, cosmetic packaging, personal care product, industrial product, tea and drink etc.

Conclusion: Aluminium containers are becoming a leading option for beverages due to their ability to chill quickly, retain carbonation, and block light and oxygen. These properties make aluminium superior to other packaging materials.

About the author:

* Dr Ruchi Lamba
Assistant Professor
Gautam Buddha University
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Technological Developments in the Beverage Sector: An Innovation Approach Focused on People

■ By Mulla Sai Teju*

Introduction

Once mainly reliant on conventional production methods, the beverage industry is currently undergoing a technological revolution. The production, packaging, and distribution of beverages are being completely transformed by cutting-edge technologies including automation, artificial intelligence (AI), the Internet of Things (IoT), and sustainable processing. These developments meet the needs of current consumers for sustainability, customization, and safety in addition to increasing productivity and product quality. The most recent cutting-edge innovations in the beverage business are examined in this article along with their effects on both the industry and customers.



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1. Automation and Robotics: Enhancing Efficiency and Safety

A key element of contemporary beverage production is automation. Robotic systems now carry out repetitive tasks with unparalleled speed and accuracy, from bottling to labeling. Robotic arms, for example, can handle up to 120,000 bottles per hour in high-speed bottling lines, greatly lowering workplace accidents and human mistake (Kumar & Nayak, 2021).

2. Internet of Things (IoT): Intelligent Monitoring and Traceability

Real-time decision-making and transparency are being improved by the beverage industry's implementation of IoT. To improve processes, IoT-enabled devices receive data from production lines while keeping an eye on temperature, pressure, humidity, and other crucial variables. To guarantee the best possible taste

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and quality, for instance, smart fermentation tanks in breweries can modify internal conditions depending on real-time data (Sahoo & Pattnaik, 2022).

IoT also makes the supply chain's traceability better. Manufacturers are able to track each product's journey from the factory to the customer by using RFID tags and smart packaging. For product recalls, shelf-life monitoring, and guaranteeing adherence to food safety laws, this is particularly important.

3. Artificial Intelligence and Machine Learning: Predictive and Adaptive Systems

These days, product development, inventory optimization, and demand forecasting are all done with AI and machine learning algorithms. As an example, Coca-

Cola has employed artificial intelligence (AI) to assess consumer preferences and design novel beverage varieties, including Cherry Sprite (Mehta, 2023).

Machine learning models are used in quality control to forecast equipment failure before it occurs by analyzing massive datasets from production sensors. While maintaining product consistency, predictive maintenance helps minimize downtime and prevent expensive repairs.

AI is being applied to customer service as well. Beverage firms may establish a closer connection with their clients through personalized marketing campaigns powered by AI-based consumer behavior research, which provides customized product recommendations and targeted discounts.

4. Sustainable and Green Technologies

Nowadays, the core of beverage innovation is sustainability. Eco-friendly packaging, energy efficiency, and water reuse technologies are becoming increasingly popular. Advanced membrane filtering methods, for example, minimize effluent formation and recycle rinse water, hence reducing water waste in beverage processing (Pereira et al., 2021).

Packaging technologies such as edible films and biodegradable bottles manufactured from plant-based polymers are becoming more popular. Investing in biodegradable packaging has helped PepsiCo and Nestlé cut down on plastic pollution. The carbon footprint can also be considerably decreased by using lightweighting techniques, which use less material per bottle or can.

5. Digital Twins and Simulation Models

Utilizing digital twins, which are virtual copies of real assets like fermentation tanks or bottling lines, is a state-of-the-art technology in the beverage sector. Without interfering with real-time operations, manufacturers can use these digital models to



Image Source: Freepik.com

model and optimize production scenarios. According to Ghosh et al. (2023), they aid in locating bottlenecks, testing novel recipes, and cutting down on development time.

Planning and scaling operations are two areas where digital twins are very useful. They enable more economical and efficient operations by offering insights into process dynamics, equipment wear, and energy consumption.

6. Advanced Beverage Formulation and Nutraceutical Integration

To create functional and nutraceutical drinks, beverage businesses are using biotechnological methods as customer preferences shift toward healthier options. For instance, encapsulation technologies make it possible to add vitamins, probiotics, and plant extracts to drinks without sacrificing flavor or shelf life.

Health-conscious beverages are using nanoemulsion technology to increase the bioavailability of their active ingredients. This is particularly prevalent in non-alcoholic tonics, wellness shots, and sports beverages that are meant to increase mental clarity and immunity (Singh & Thakur, 2022).

Conclusion

Modern technologies are changing the beverage business to become a more intelligent, flexible, and sustainable one. Automation, artificial intelligence, green packaging, digital twins, and other innovations are tackling today's problems while opening doors for efficiency, personalization, and environmental responsibility.

Food scientists, engineers, and technologists will need to work together as these technologies develop further. Consumer

preferences, health requirements, and environmental concerns are still the most important human factors driving innovation in the beverage sector. The industry is not only changing, but also developing into a responsible force for the welfare of the world by concentrating on technology that benefits both people and the environment.



About the author:

* Mulla Sai Teju
M.sc Food Science and Nutrition Student
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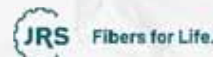


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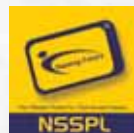


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Contact Person: **Srikanth Robbi /**
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5.		13-15 November 2025	Bombay Exhibition Centre (BEC), Mumbai
6.		13-15 November 2025	Bombay Exhibition Centre (BEC), Mumbai
7.		13-15 November 2025	Bombay Exhibition Centre (BEC), Mumbai
8.		10-13 December 2025	India Expo Centre, Greater Noida, Delhi-NCR
9.		19-21 December 2025	Yashobhoomi, Dwarka Delhi

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Linda Brady Hawke

Binoy Sahee

Marketing & Events

info@lbassociates.com

Neenu Choudhary

Marketing Manager

foodmarketing5050@gmail.com

contact@lbassociates.com

+91-8744069171

Abhishek Tiwari

Business Development Manager

sales@lbassociates.com

+91-7827892179

Kanchi Batra

Managing Editor

kbatra@lbassociates.com

fmteditorial@lbassociates.com

Priyasha Mohanty

Jt. Editor

editorial@lbassociates.com

Sr. Designer / Video Editor

Atul Kumar

Sr. Layout & Design

Arjun Sarkar

Ads & Subscription

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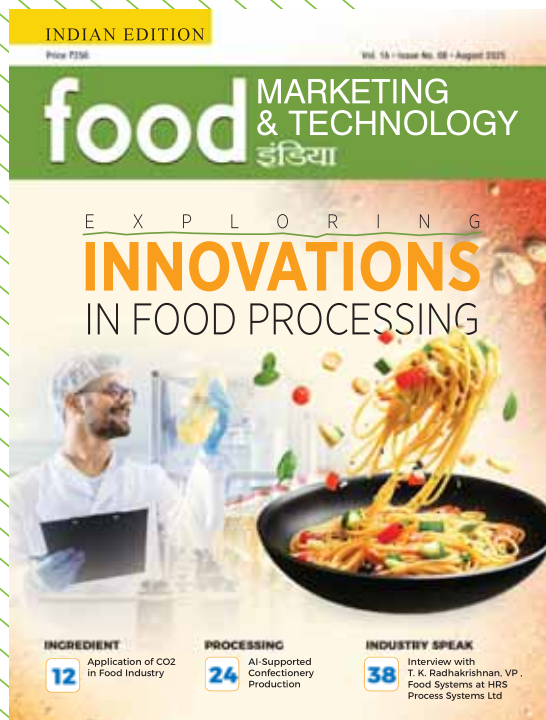
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