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FOOD, NUTRITION & SAFETY MAGAZINE

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MANGO:

Nutritional Composition, Phytochemical Properties, Therapeutic Applications, and Functional Potential of Peel, Pulp, and Seed

Dr Bharti Shah & Dr Shobha A Udipi

The Science of Safety: Deep Evolution and Global Impact of FSSC 2200

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Building Effective Standards:

Why Cost - Benefit Analysis is Critical

Mr Rajendra Dobriyal

Importance of Flavours in Innovative Food Design

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Effects of Processing on Dietary Fiber

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Food Fortification in India: Challenges and Future Directions

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Seminar Report on the "Next Generation Food Design:

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Exaggerated & Unsubstantiated Claims should be Avoided



Recently FSSAI has issued notices to some companies over claims and labels violations. Some claims may be exaggerated and labels may have used words or phrases that are either not defined or are difficult to verify or unsubstantiated.

Companies are trying to increase their market share in a highly competitive market of some popular food products. Marketing of the companies try to win the consumers by either showing their product is superior to others or has some benefits that others may not have. Most of the times such claims are made after thorough verification and substantiation through rigorous trials. However, sometimes an executive who does not want to wait for such substantiation may risk going under the radar to gain the undue advantage. This sometimes lands the company in trouble.

Unfortunately, it does not stop there as there are many influencers, who are looking for such opportunities to pounce on

the industry take advantage of this and go on to generalize the situation, making the whole industry guilty. Already, currently, they are waiting for such opportunities as this makes their social media pages very popular with many likes and following.

Another undesirable practice is trying to malign competitors' products, rightly or wrongly, to promote own. Some time ago there was a fear of cholesterol in food products, so even some vegetable oil companies were making claim that their oil was cholesterol-free. Some ketchup manufacturers were saying that their ketchup was without pumpkin. This creates unnecessary doubts in the minds of consumers that the oil of competitors may have cholesterol or ketchup may contain pumpkin. This vitiates the environment for the whole industry.

Claims must be proper and authorized. The companies must also ensure that they are substantiated. The benefits must be adequately verified and under the conditions of common eating practices.

Advertising Standards Council of India (ASCI) must create awareness about what is proper and what is not. It must not just wait until someone complains and then start investigation. All companies must together ensure that there are not breaches in the propriety of advertising by themselves and others.

Consumers are already getting sensational posts on social media about lacunae in food industry with respect to products safety and quality. If in addition, they are worried about the claims made, then it would be very difficult for good companies to survive.

In general, our industry is producing foods and products that are safe and of quality that is claimed. Just a few instances may create the doubts that would be harmful for whole industry. It is not easy to gain the trust of consumers, but it does not take long to lose it.

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The Meal that Sustains can also Harm



AUTHOR

Dr Joseph I Lewis,
Chairman, Scientific Advisory
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Food is a source of life, and a source of potential harm. The same meal that provides nutrients also includes toxic substances, added or present; the more we eat, the greater the amount ingested. Yet we are safe. An ancient quote by Paracelsus, a toxicologist, explains the paradox: "What is there that is not poison? All things are poison, and nothing is without poison. Solely, the dose determines that a thing is not poison" — offers a simple explanation of a risk-based Act (FSSA). We are safe until our exposure reveals "the thing(s) is not poison". While populations across the globe eat differently and exposures vary, established safety thresholds remain fixed and apply to all. What really matters is not the presence of a toxic substance(s) but the distance the amounts ingested are away from these thresholds.

Whenever a maximum limit is breached in the marketplace, safety concerns are vociferously

raised by government agencies, institutions, consumer advocates, and the media, alarming an innocent public. Every food law operates on two limits. Administrators (FSSAI) prescribe maximum limits (mg/kg) for commercial products to measure "presence". They are legally binding but do not represent safety limits. Scientific Experts and Toxicologists establish safety thresholds: TUL (Tolerable Upper Level); ADI (Acceptable Daily Intake); TDI (Tolerable Daily Intake) or (MoE: Margin of Error) for carcinogenic substances. The gap between the total intake of vitamins, minerals, additives, toxicants, residues and the thresholds is the safety zone. Toxicological (safe) limits are never breached.

Regulators do not set limits between "safe" and "unsafe." If they did, a single product would breach the toxicological threshold; no other product containing the substance, or even nutrients (vitamins, minerals), could be marketed or consumed. When Indian sweets exceed the permitted 100 ppm colour limit, they are condemned as unsafe. Legally noncompliant, but not

unsafe. A country's per capita biscuit consumption is (say) 11kg, with sugar declared at 10g/100g product; its Indian counterpart declares 20g/100g, with a per capita consumption of around 2kg. The lower-sugar label creates the "health halo", whereas, between the two populations, Indian consumption is healthier, though the package may trigger a red warning. Who is at risk here? How did we get to this kind of thinking?

Historically, regulators have treated noncompliance with standards as "adulteration" (implying the food is toxic or fraudulent), creating a black-and-white public perception. Food is either 100% pure or inherently dangerous. For decades, public attitudes have been conditioned on purity or toxicity. Social media influencers (SMI) exploit these rigid binaries: a legacy of the PFA regime. Because the average consumer knows only what is on the label, not law or science, the influencer steps in as the "trustworthy substitute". SMIs - previously rare - now freely enter food science and regulatory, even though they cannot distinguish between hazards (presence) and risk (exposure).

The silence of traditional gatekeepers (academia, industry) creates an information vacuum. Studies in digital ethics reveal why consumers seek connectivity with social media platforms: they are open, participatory and appreciative. Consumers value recognition. Regulatory and Industry are aloof, if not haughty, pontificating adherence to standards as an imperial virtue. Meanwhile, digital utilisation of labelling information (a resource) instead of creating a smarter consumer pushes them closer to SMIs: the rebound effect is hardened positions with the potential to influence policy. Simply communicating the science of safety to consumers is a better strategy than battling influencers.

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MANGO:

Nutritional Composition, Phytochemical Properties, Therapeutic Applications, and Functional Potential of Peel, Pulp, and Seed

AUTHORS



Dr Bharti Shah,
BHMS, PhD,
Sr Nutrition Scientist
and Dietitian



& Dr Shobha A Udipi,
PhD,
Research Director
and Head

Kasturba Integrative Health Sciences-
Medical Research Foundation

Introduction

India is the world's largest producer of mangoes, followed by China, Thailand, and Mexico. Mexico dominates international trade, accounting for a major share of global exports. Mango cultivation originated in South Asia thousands of

years ago and later spread globally, symbolizing prosperity and cultural significance worldwide (Rerkasem et al., 2016).

Mango (*Mangifera indica* L.), a member of the Anacardiaceae family, is among the most economically and nutritionally important


tropical fruits worldwide. Native to India and Southeast Asia, mango has been cultivated for thousands of years and is popularly known as the "king of fruits" because of its attractive appearance, pleasant aroma, delicious taste, and exceptional nutritional properties (Rymbai et al., 2016).

The fruit is deeply associated with traditional medicine systems such as Ayurveda, Siddha, and Unani, where different parts of the mango tree are used therapeutically for digestive disorders, skin diseases, diabetes, respiratory illnesses, and cardiovascular complications (Lauricella, M et al 2017).

Modern scientific research has increasingly focused on mango because of its rich phytochemical composition, including polyphenols, carotenoids, flavonoids,



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vitamins, minerals, dietary fiber, and xanthonoids such as mangiferin. These bioactive compounds possess strong antioxidant, anti-inflammatory, antimicrobial, antidiabetic, cardioprotective, neuroprotective, and anticancer properties (Lauricella et al., 2017). Mangiferin, a bioactive xanthone present in mango seeds (0.42 mg/kg), peel (1690.4 mg/kg), and pulp (4.4 mg/kg), is widely recognized for its potent antioxidant and hypoglycaemic properties.

It helps regulate blood glucose levels by inhibiting carbohydrate-digesting enzymes such as sucrase, maltase, and isomaltose, thereby reducing intestinal glucose absorption. Additionally, the dietary fiber present in mango slows carbohydrate digestion and glucose uptake, further contributing to improved glycaemic control and metabolic health. (Masibo M. et al 2008).

Furthermore, growing evidence suggests that mango consumption contributes positively to

cardiometabolic health, immune regulation, gut microbiota balance, and cognitive function. Burton-Freeman et al. (2025) reported that mango bioactive compounds may reduce inflammation and oxidative stress associated with chronic diseases. Similarly, Minniti et al. (2023) observed that mangiferin and mango-derived polyphenols show promising effects against cardiometabolic disorders through antioxidant and anti-inflammatory mechanisms.

This review article integrates findings from six provided review papers along with additional recent scientific studies to comprehensively discuss the nutritional composition, medicinal importance, therapeutic applications, and biochemical significance of mango peel, pulp, and seed kernel.

Botanical Description of Mango

Mango is a tropical evergreen tree capable of producing 2,000–2,500 fruits annually under favourable environmental conditions. Botanically, mango fruit is classified as a drupe and varies in size, shape, texture, flavour, and colour according to cultivar and climatic conditions. The fruit generally consists of

three main components: peel (exocarp), pulp (mesocarp), and seed kernel (endocarp).

The peel is smooth, waxy, aromatic, and changes colour from green to yellow, orange, or reddish pink during ripening. The pulp is soft, juicy, sweet, and rich in sugars, carotenoids, and vitamins. The seed kernel is enclosed within a fibrous endocarp and contains proteins, oils, carbohydrates, and medicinally important phytochemicals.

Mangoes are consumed in both ripe and unripe forms and are processed into juices, jams, jellies, candies, chutneys, pickles, bakery products, frozen pulp, dehydrated slices, and nutraceutical supplements. India remains the largest global producer of mangoes, followed by China, Thailand, and Mexico (Moorthi, 2025).

Nutritional Information and Biochemical Composition

Mango fruit is composed of diverse nutritional and bioactive components, including macronutrients (carbohydrates, proteins, amino acids, lipids, and organic acids), micronutrients (vitamins and minerals), and phytochemicals such as phenolic compounds,

pigments, and volatile constituents (Yahia et al., 2011; Lebaka et al., 2021). Structural carbohydrates like pectin and cellulose also contribute to fruit texture and firmness. The amino acid profile includes lysine, leucine, valine, arginine, phenylalanine, methionine, and cysteine, supporting its nutritional value. Lipid content, particularly beneficial fatty acids including omega-3 and omega-6, increases during ripening. Pigments such as chlorophylls (a and b) and carotenoids influence fruit color and antioxidant capacity, while organic acids like citric and malic acid determine acidity and taste. Volatile compounds contribute to aroma and flavor development. During maturation and postharvest handling, significant biochemical and structural changes occur, affecting antioxidant levels, phenolic content, vitamin C concentration, and overall sensory quality.

Mango Pulp

Mango pulp is considered the edible and nutritionally richest portion of the fruit. It contains approximately 17-25% carbohydrates, primarily sucrose, fructose, and glucose. During ripening, starch is enzymatically hydrolysed into sugars, leading to increased sweetness and improved palatability. The energy content of mango

pulp typically ranges from about 60 to 190 kcal (250 to 795 kJ) per 100 g, depending on the variety and ripening stage. Mango pulp contains low protein (0.5-5.5%), very low lipids (~0.8-1.36%), and citric acid (0.13-0.71% FW), with ripening increasing carotenoids. Mango provides minerals such as potassium (~156-250 mg/100 g), calcium (~10-20 mg/100 g), magnesium (~9-15 mg/100 g), phosphorus (~11-20 mg/100 g), iron (~0.1-0.5 mg/100 g), zinc (~0.04-0.2 mg/100 g), and copper (~0.05-0.1 mg/100 g), with higher levels generally present in peel and seed than in pulp. (Yahia, E. M et al 2023). Mango contains low vitamin E (α -tocopherol ~1.33 mg/100 g), moderate vitamin K, and no vitamin D, varying with ripening (Saleem-Dar et al., 2016; USDA, 2018; Robles-Sánchez et al., 2009). Carotenoid content in mango increases approximately 6-8 times during ripening, with lutein predominant in unripe fruit and β -carotene and xanthophylls (e.g., violaxanthin, zeaxanthin) becoming dominant in ripe stages (Haque et al., 2015; Bramley, 2013; Ediriweera et al., 2017).

The pulp is an excellent



source of vitamin C, vitamin A, vitamin E, vitamin B6, and folate. About 25 carotenoids have been identified in mango pulp, with β -carotene being the dominant carotenoid responsible for the characteristic yellow-orange colour of ripe fruits. Beta-carotene serves as a precursor of vitamin A and supports vision, immune function, and skin health.

Mango pulp also contains several important polyphenols such as Mangifera, quercetin, gallic acid, chlorogenic acid, catechins, kaempferol, fisetin, and ellagic acid. These compounds contribute significantly to antioxidant and anti-inflammatory properties.

According to Burton-Freeman et al. (2025), mango pulp consumption may improve markers associated with inflammation, oxidative stress, and cardiometabolic disorders because of the synergistic action of polyphenols and dietary fiber.

Organic acids such as citric acid, malic acid, succinic acid, tartaric acid, and ascorbic acid contribute to flavor and preservation qualities. Essential minerals including potassium, magnesium, calcium, copper, zinc, and iron support metabolic and enzymatic functions.

The Indian Food Composition Tables (2017) provide information on seven commercial ripe varieties, namely Banganpalli, Gulab khas, Himsagar, Kesar, Neelam, Paheri, Totapari. The range of values for different nutrients is given herein (Table 1):

Medicinal Uses

Mango has been extensively used in traditional medicine for centuries. In Ayurveda, ripe mangoes are considered rejuvenating, cardiotoxic, aphrodisiac, and restorative tonics. Unripe mangoes are used as digestive stimulants and antiscorbutic agents.

Mango pulp is traditionally used for treating anemia, fatigue, constipation, indigestion, and heat stroke. Mango peel and bark have been employed for wound healing and skin diseases, while seed kernels are used to manage diarrhea, dysentery, asthma, hemorrhoids, vomiting, ulcers, and intestinal worms.

Table No. 1: The range of values for different nutrients in mangoes as per IFCT 2017

Parameter	Value / Range
Moisture	84-88%
Protein	0.41-0.68 g
Total fat	0.49-0.53 g
Total dietary fibre (TDF)	1.61-2.02 g
Insoluble fibre	0.82-1.09 g
Soluble fibre	0.64-0.98 g
Energy	42-59 kcal
B vitamins	Not a good source of B1, B2, B3, B6
Total folate	68-90 µg
Total ascorbic acid	27-49 mg
β-carotene	(602-1264 µg) 602 in Totapari to 1264 in Neelam
Total carotenoids	1210-1632 µg
Minerals	Poor source of Ca, Fe, Zn, Mg
Total available carbohydrate (CHO)	7.77-9.41 g
Fructose	(2.38-7.33 g) 2.38 in Banganpalli to 7.33 in Totapari
Starch	Very little
Glucose	0.55-2.71 g
Sucrose	0.89-4.66 g
Total free sugars	(7.77-9.24 g) 7.77 in Banganpalli to 9.24 in Totapari
Total polyphenols	14.74-23.87 mg Small amount
Oligosaccharides	No value specified
Phytate	75-90 mg

A recent ethnopharmacological review by Sharma et al. (2024) emphasized that mango phytochemicals possess broad-spectrum

pharmacological properties including antimicrobial, antiviral, anti-inflammatory, and hepatoprotective effects.

Mango shows a relatively low glycemic response in type II diabetic subjects due to its fiber content, organic acids, and lower fructose levels, which slow glucose absorption. Compared to high-GI fruits like pineapple and papaya, mango produces a smaller postprandial glucose rise, supporting its moderate suitability in diabetic diets (Guevarra & Panlasigui, 2003).

The health-promoting effects of mango (*Mangifera indica* L.) and its bioactive components have been widely investigated in relation to several non-communicable diseases, including obesity, type 2 diabetes, hypertension, and cancer. Research in this area can be broadly categorized into three approaches: (i) epidemiological and clinical studies assessing the direct impact of mango consumption on human health, (ii) *in vitro* and *in vivo* experimental studies exploring the physiological effects and molecular mechanisms of mango pulp, peel, and seed extracts or isolated compounds, and (iii) preclinical and clinical investigations evaluating the pharmacological potential of mango-derived products. Overall, current evidence suggests that regular consumption of mango and its by-products, which are rich in bioactive phytochemicals, may

contribute to improved health outcomes and reduced risk of chronic diseases when included as part of a balanced diet. (Yahia et al., 2023)

Pharmacological Activities

Mango exhibits multiple pharmacological activities due to its rich bioactive compounds such as phenolics, flavonoids, carotenoids, vitamins, and mangiferin. It shows strong antioxidant effects by scavenging reactive oxygen species and reducing oxidative stress (Moorthi, 2025; Shah et al., 2024). Anti-inflammatory action occurs through inhibition of cytokines and NF- κ B pathways (Lauricella et al., 2017). Anticancer properties involve apoptosis induction and cell-cycle arrest (Palafox-Carlos et al., 2012). It also has antidiabetic effects by improving insulin sensitivity (Moorthi, 2025). Cardioprotective, gastroprotective, neuroprotective, and dermatological benefits further contribute to overall health improvement through lipid regulation, gut health, neuronal protection, and skin repair (Lauricella et al., 2017; Shah et al., 2024).

Several studies have highlighted the role of mango phytochemicals in



disease prevention and metabolic health. Shah et al. (2024) and Moorthi (2025) reported that mangiferin and other xanthenes exhibit antioxidant, anti-inflammatory, antidiabetic, and anticancer activities through modulation of oxidative stress pathways and inflammatory mediators. Research by Kim et al. (2010) demonstrated that mango polyphenols can induce apoptosis and suppress proliferation in cancer cell lines. Furthermore, Ediriweera et al. (2017) emphasized the role of mango bioactive compounds in regulating glucose metabolism, lipid profiles, and immune responses.

Functional and Industrial Applications

Mango and its by-products have wide applications across food, nutraceutical, pharmaceutical, and cosmetic industries. The pulp is extensively used in beverages, jams, dairy products, desserts, and bakery formulations due to its flavour and nutritional richness.

Overall, mango demonstrates strong potential as a multi-functional fruit, where each component pulp, peel, seed and leaves contribute uniquely to nutritional value, health benefits, and industrial utilization, supporting its role in sustainable food and nutraceutical development.

Conclusion

Mango (*Mangifera indica* L.) is a nutritionally dense tropical fruit possessing exceptional medicinal and therapeutic properties. The peel, pulp, and seed kernel collectively contain carbohydrates, proteins, dietary fiber, carotenoids, polyphenols, vitamins, minerals, and bioactive compounds such as mangiferin that contribute to antioxidant, anti-inflammatory, antimicrobial, antidiabetic, anticancer, cardioprotective, neuroprotective, and gastroprotective activities. Future research should prioritize clinical validation, elucidation of molecular mechanisms, development of sustainable processing technologies, and enhanced utilization of mango by-products to fully realize their health benefits and economic value

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The **Science** of **Safety:** **Deep Evolution** and **Global Impact** of **FSSC 2200**



AUTHOR
 Dr Sidhishwarr N Rindhe,
 Technical Director Paradigm Services Pvt Ltd,
 Executive Director Paradigm Law Associates

Global food safety was not always the cohesive web of standards we see today. Before the mid-2000s, the industry was fragmented, relying on a patchwork of private and national standards that often-created confusion for international suppliers.

The true genesis of FSSC 22000 emerged from a critical scientific critique of existing frameworks. While ISO 22000:2005 provided a groundbreaking management structure, it was initially rejected by the Global Food Safety Initiative (GFSI). The point of

contention was fundamental: the standard lacked specific, measurable requirements for Prerequisite Programs (PRPs)—the foundational environmental and operational conditions like sanitation, pest control, and personal hygiene that are non-negotiable for safe food production.

In response to this gap, the Foundation for Food Safety Certification was established in the Netherlands. The scientific community recognized that a management system without rigorous operational "teeth" was insufficient to mitigate modern microbiological and chemical risks. By coupling the ISO 22000 management framework with specific technical specifications—initially PAS 220 and later codified as ISO/TS 22002-

1—the Foundation created a hybrid model. Launched in 2009, FSSC 22000 successfully integrated the "What" (the management system) with the "How" (the technical execution). This evolution transformed food safety from a bureaucratic exercise into a data-driven discipline, ensuring that every high-level policy had a corresponding physical control on the factory floor.

Structural Evolution: Navigating the Version History

The strength of FSSC 22000 lies in its refusal to remain static. As our understanding of foodborne pathogens, toxicology, and supply chain complexity has advanced, so too has the standard. The transition to Version 5 in 2019 represented a paradigm shift toward "Risk-Based Thinking."



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By adopting the High-Level Structure (HLS) shared by other ISO standards, FSSC 22000 moved beyond a narrow focus on immediate hazards to a broader assessment of organizational risk. This introduced the concept of "Context of the Organization," forcing companies to analyze external economic, social, and environmental factors that could indirectly compromise safety.

Furthermore, the introduction of Dual PDCA (Plan-Do-Check-Act) cycles brought a new level of scientific rigor to the audit process. One cycle manages the overall system, while the second cycle focuses specifically on the HACCP principles. This ensures that while the business side of food safety is being checked, the technical "kill steps" and critical control points are being verified with equal intensity. With the mandatory implementation of Version 6 in 2024 and Version 7 in 2026, the standard has reached a new scientific frontier. It now addresses emerging threats such as

food loss and waste, which, beyond sustainability, have significant implications for shelf-life stability and the potential for microbial proliferation in neglected waste

streams.

Beyond the Technical: The Rise of Food Safety Culture

One of the most revolutionary aspects of FSSC 22000 is the formal integration of Food Safety Culture. Historically, safety was viewed as an engineering or microbiological problem. However, forensic analysis of major foodborne illness outbreaks often pointed back to human behaviour—cutting corners, lack of communication, or management pressure. All the transition steps from a purely technical requirement to a behavioural science requirement have helped the industry to continually improve. It mandates that senior management foster an environment where food safety is an intrinsic, shared value. This is not a "soft" requirement; it is a scientific acknowledgement that the most advanced sanitation technology in the world is useless if the personnel operating it are not psychologically engaged

in the mission of public health.

The 2026 Shift:

Navigating the Transition from FSSC 22000 Version 6 to Version 7

As of early 2026, the food industry is entering a critical period of evolution.

The Foundation FSSC has scheduled the official publication of FSSC 22000 Version 7 for May 15, 2026. This update is not merely an incremental change; it represents a deep integration of modern operational standards, sustainability goals, and the latest Global Food Safety Initiative (GFSI) benchmarking.

Following the May 2026 publication, the industry enters a 12-month transition period. Organizations must be fully compliant by May 2027. During this window, surveillance and recertification audits will gradually shift from Version 6 to Version 7. For organizations, the focus in 2026 must be on gap analysis and the updating of core Prerequisite Programs (PRPs).



Key Scientific and Structural Changes

The most significant technical update in Version 7 is the replacement of the aging ISO/TS 22002 series with the new ISO 22002:2025 series. This restructuring changes how operational controls are organized and verified.

- ISO 22002-100:2025 (The Core Standard): Version 7 introduces this consolidated standard that serves as the foundation for common PRPs across all food, feed, and packaging sectors.
- Climate Action Amendment: Aligning with the 2024 amendments to ISO 22000, Version 7 explicitly requires organizations to determine whether climate change is a relevant internal or external issue that affects the safety and stability of their management system.
- Expansion of Sector Scopes: New specific requirements have been added for Retail and Wholesale (Sector FI) under ISO 22002-7:2025, ensuring that the "last mile" of the supply chain is held to the same rigorous scientific standards as manufacturing.

Strengthening the Behavioural and Ethical Core

Version 7 moves further into the "soft science" of food safety, recognizing that

human behaviour is the ultimate critical control point.

- **Advanced Food Safety Culture:** Building on Version 6, the new version requires measurable indicators and clear leadership accountability to prove that safety culture is being actively managed, not just discussed.
- **Sustainability and the SDGs:** There is a heightened focus on the United Nations Sustainable Development Goals (SDGs). This includes more stringent requirements for managing Food Loss and Waste, which are now audited as part of the overall risk to the supply chain's integrity.
- **Equipment Design and Hygiene:** Version 7 reinforces the science of "Hygienic Design." It mandates stricter procurement and maintenance protocols to prevent the formation of niches where persistent pathogens can hide.

Organizations currently certified under Version 6 should adopt a structured four-step approach to ensure they are ready for their 2026-2027 audits:

1. Gap Assessment:

Evaluate current PRPs against the new ISO 22002:2025 series to



identify where facility or procedural upgrades are needed.

2. Risk Register Update: Re-evaluate the organizational risk assessment to include climate change factors and enhanced supply chain vulnerabilities.

3. Training and Awareness: Ensure that internal auditors and process owners understand the shift from "Compliance" to "Performance" highlighted in the 2026 update.

4. Verification of Sustainability Controls: Begin documenting efforts in food waste reduction and environmental stewardship to meet the new ESG-aligned requirements.

The transition to Version 7 is a clear signal that the global food supply chain is becoming more transparent, digital, and environmentally conscious. It is no longer enough to simply produce safe food; organizations must now prove they can do so sustainably and resiliently in a changing global climate.



Sector-Specific Modules: The Science of Tailored Control

FSSC 22000 is not a monolithic document; its efficacy is maintained through its modularity. The standard acknowledges that the risks in a poultry farm are fundamentally different from those in a plastic bottle manufacturing plant. This is addressed through the application of specific ISO/TS 22002 modules. In the primary production sectors (A & B), the scientific focus is on the "front end" of the chain—controlling pesticide residues, veterinary drug metabolites, and zoonotic pathogens like *Salmonella* and *Campylobacter*. Here, the goal is to prevent contaminants from entering the food system at the source.

In Sector C (Food Manufacturing), the focus

shifts to the physics of food preservation. This involves the validation of thermal processing "kill steps" and the sophisticated management of "Sanitary Zoning." By creating high-care and high-risk zones, manufacturers can prevent post-lethality contamination—a critical defence against environmental pathogens like *Listeria monocytogenes*. Meanwhile, Sector I (Packaging) utilizes toxicological risk assessments to ensure that chemicals from inks, adhesives, and polymers do not migrate into the food. This involves calculating the "Functional Barrier" effectiveness of packaging materials to protect the end consumer from long-term chemical exposure.

**The Scientific Core:
HACCP, TACCP, and VACCP**
At the heart of every FSSC

22000 system is the Hazard Analysis and Critical Control Point (HACCP) system. However, FSSC 22000 ver. 7 goes further by requiring rigorous scientific validation before a control measure is even implemented. A company cannot simply state that a pasteurization process works; they must provide experimental data or peer-reviewed literature proving that the specific time and temperature achieve a 5-log reduction in the target pathogen. This evidentiary requirement moves food safety from the realm of "best guesses" to the realm of proven science.

Moreover, the standard has expanded to address intentional contamination. While HACCP deals with accidental issues, TACCP (Threat Assessment) and VACCP (Vulnerability Assessment) address deliberate acts. TACCP utilizes behavioral and forensic science to assess the risk of sabotage or internal threats. VACCP, on the other hand, is an economic and chemical discipline designed to combat Food Fraud. By analyzing global market trends and chemical markers, organizations can identify if a high-value ingredient like extra virgin olive oil or manuka honey has been adulterated with cheaper, potentially dangerous substitutes.

Implementation and the Path to Continuous Improvement

Implementing FSSC 22000 is a journey from "Compliance" (doing what you are told) to "Performance" (achieving measurable results). This is achieved through the scientific application of the internal audit and management review processes.

When a non-conformity is found, the standard requires a Root Cause Analysis (RCA). Instead of a superficial fix, companies use tools like the "Ishikawa (Fishbone) Diagram" or the "5 Whys" to dig into the systemic origins of a failure. Is the issue a broken machine (mechanical), a poorly trained operator (human), or a flawed procedure (systemic)? By identifying the root cause, the organization ensures that the failure does not recur, creating a cycle of "Continual Improvement."

The Future: Industry 4.0 and the Digital Frontier

As we look toward the

future, FSSC 22000 is poised to integrate with the technologies of Industry 4.0. The standard is a "living document," and future iterations will likely mandate more sophisticated digital tools. Blockchain traceability is already becoming a reality, providing an immutable record of a product's journey from the farm to the consumer's plate. Predictive microbiology—using AI and Big Data to forecast pathogen growth based on real-time sensor data from the cold chain—will allow companies to intervene before a safety breach even occurs.

The next generation of environmental monitoring will also see the rise of Next-Generation Sequencing (NGS). Instead of just knowing if "Listeria" is present, manufacturers will



be able to map the specific DNA of a strain to determine if it is a resident "house strain" that has survived for years or a new introduction from a specific supplier. FSSC 22000 remains the global gold standard because it bridges the gap between the laboratory and the loading dock. It is more than just a certificate on a wall; it is a scientific commitment to the health, safety, and trust of the global population.

By evolving alongside science, it ensures that our global food supply remains resilient in the face of ever-changing biological and logistical challenges.



Building Effective Standards: Why Cost - Benefit Analysis is Critical



AUTHOR
Mr Rajendra Dobriyal,
Member- Regulatory Affairs Committee,
PFNDAI

Regulations and standards in Fast Moving Consumer Goods (FMCG) - as in many other sectors - are paramount to protecting consumers, ensuring fair competition, safeguarding public health, and building trust in products and brands.

They help maintain consumer trust by requiring accurate labelling, transparent ingredients and truthful claims. Regulatory frameworks also promote fair competition by preventing unethical practices such as false

advertising and price manipulation.

Environmental regulations push FMCG companies to adopt sustainable sourcing, packaging, and waste management practices. Regulations further enable consistency across markets, supporting smoother trade and distribution. Overall, strong regulation ensures that consumer needs, public well being, and business integrity are balanced in a highly competitive industry.

However, regulation or standards are not cost free. Every new regulation or standard introduces both direct and indirect costs, which are often diffused across regulators, industry participants, and ultimately, consumers. In a high volume, low margin sector such as FMCG, these costs can materially affect competitiveness,

innovation, and the overall ease of doing business.

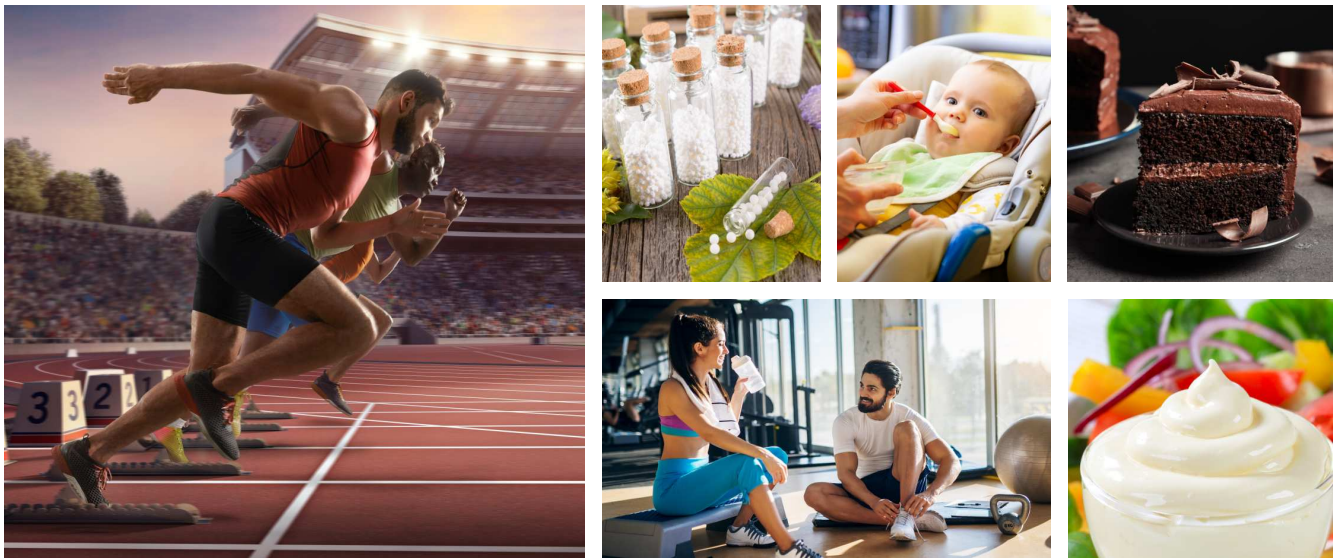
As India advances toward becoming a global manufacturing and consumption hub, particularly under the “*Ease of Doing Business*” initiative championed by the Honourable Prime Minister, it is equally critical that regulatory frameworks also evolve with discipline, proportionality, and economic rationale, indeed without diluting the consumer safety at all.

A key instrument in achieving this balance is a systematic and transparent cost-benefit analysis (CBA) conducted *before* introducing any new regulation or standard. Unfortunately, in India, historically no serious heed was given to the concept of cost-benefit analysis.



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Understanding the Real Cost of a Regulation

It must be appreciated that the cost of regulation is not merely the drafting and publication of a regulation or standard. It extends well beyond framing a rule and notifying it in the Gazette.

For regulators, these costs include research and benchmarking, stakeholder consultations, legal vetting, institutional capacity building, training of enforcement agencies, and ongoing monitoring, audits, and dispute resolution. All these efforts require money and time and focus of all relevant stakeholders.

In addition, the compliance imposes substantial costs on stakeholders. Collectively, these processes require sustained financial and human resources, often stretching already constrained institutional capacities.

For industry, particularly

FMCG manufacturers, the costs are even more immediate and tangible. These include investments in new machinery, reformulation of products, changes in packaging, redesign of labels, supply chain adjustments, testing and certification expenses, documentation requirements, employee training, and IT systems for compliance and reporting.

Small and medium enterprises (SMEs), which form the backbone of India's FMCG ecosystem, face disproportionate burdens as they lack scale to absorb such shocks.

Beyond direct costs, there are opportunity costs like delayed product launches, reduced innovation, restricted market entry, and diversion of management attention away from growth and efficiency. While the above in no way justifies the absence of regulations or standards, when the associated costs do not commensurate with demonstrable public benefits, regulation risks becoming counterproductive.

Over Regulation and the "Implementation Paradox"

A less discussed but equally significant challenge is the *implementation paradox*. By creating too many regulations and standards -

particularly those that offer little or no tangible benefit to consumers or other stakeholders - regulators may inadvertently weaken enforcement.

Limited supervisory capacity becomes stretched across an overcrowded regulatory landscape, resulting in inconsistent implementation, selective enforcement, and increased regulatory uncertainty. Areas with critical consumer safety concerns may fail to receive the necessary attention, as they become lost amid the vast volume of requirements placed on enforcement authorities.

From the industry's perspective, many overlapping or frequently changing standards increases compliance complexity and ambiguity. Businesses struggle to interpret priorities, enforcement varies across jurisdictions, and compliance becomes a defensive exercise rather than a value adding one. This environment undermines the regulatory credibility and trust - key ingredients for effective governance.

In contrast, fewer but well designed, evidence based, and enforceable regulations can deliver stronger outcomes for both public interest and industry compliance.

The Case for Cost-Benefit Analysis in FMCG Regulation

Cost-benefit analysis is a structured approach to evaluating whether the expected benefits of a regulation justify its end-to-end cost. Benefits may include improved consumer safety, public health gains, environmental protection, or market transparency. Costs may include financial outlays, administrative burdens, compliance delays, and economic distortions.

In the FMCG sector, where products reach millions of consumers daily, even marginal regulatory changes can have large economic implications. A CBA analysis helps answer critical questions, some of which are listed below.

- What specific existing or potential problem does the proposed regulation or standard seek to address, and is it clearly defined and supported by robust empirical evidence on its existence, scale, and persistence?
- Why are existing regulations, standards, or enforcement mechanisms insufficient, and what would be the consequences of maintaining the status quo?
- How does the proposed regulation or standard directly and effectively address the identified problem?
- Is regulation the most efficient and effective intervention compared to alternative approaches such as industry self regulation, voluntary codes of practice, consumer information and awareness measures, or incentive based and market driven tools?
- What evidence exists regarding the effectiveness of these alternatives in the FMCG sector, and could a combination of regulatory and non regulatory measures achieve the same objective?
- Why were less restrictive options ruled out?
- What are the expected direct compliance costs for FMCG companies (including reformulation, packaging and labelling changes, testing, certification, and licensing), and what indirect or downstream costs might arise (such as supply chain disruption, reduced product variety, or impacts on innovation)?
- Has the feasibility, cost, and effectiveness of implementation and enforcement been adequately analysed?
- Are the expected benefits

proportionate to the anticipated costs?

- Could the same objectives be achieved with fewer compliance requirements, greater regulatory flexibility, or longer transition periods, especially in the backdrop of programs like “ease of doing business” run by the Government.

Importantly, CBA analysis does not imply weakening regulation, rather, it is a tool for making regulation smarter, more targeted, and outcome - oriented. By systematically assessing the expected benefits of a rule against its compliance and enforcement costs, regulators can prioritize interventions that deliver the greatest public value.

This approach helps distinguish between measures that meaningfully improve consumer protection, safety, or market integrity and those that impose burdens without commensurate gains.





The CBA analysis also encourages proportionality, ensuring that regulatory responses are calibrated to the scale and severity of the underlying risk. In doing so, it strengthens enforcement by directing limited regulatory capacity toward high impact areas instead of dispersing it across marginal requirements. Ultimately, a rigorous cost - benefit framework enhances the effectiveness, credibility, and legitimacy of regulatory systems rather than diluting their protective intent.

Learning from Developed Economies

Several developed economies have institutionalized cost-benefit analysis as a mandatory step in regulatory decision making, offering valuable lessons for India.

United States:

In the US, federal agencies are required to conduct Regulatory Impact Analysis (RIA) for significant regulations. These analyses are reviewed by the Office of Information and

Regulatory Affairs (OIRA) under the Office of Management and Budget (OMB). Regulations must demonstrate that benefits justify costs and that the chosen approach is the least

burdensome among available alternatives.

United Kingdom:

The UK operates under the Better Regulation Framework, which mandates impact assessments for all major regulatory proposals.

The "One-in, One-out" (OIOO) rule is a regulatory offsetting policy applied to domestic business rules. It requires that whenever a government department introduces a new regulation that imposes a financial cost on businesses, it must identify and remove an existing regulation of an equivalent or greater financial cost.

European Union:

The European Commission requires comprehensive Impact Assessments before proposing new legislation. These assessments evaluate economic, social, and environmental impacts and are subject to scrutiny by an independent Regulatory Scrutiny Board. Stakeholder consultation is a core component, ensuring that real world costs are

understood.

Australia and Canada:

Both countries mandate Regulatory Impact Statements that examine compliance costs, alternatives, and small business impacts. Regulators are held accountable for the quality of their analysis, reinforcing evidence based policymaking.

These systems recognize a simple truth: regulation is an economic decision as much as a legal or moral one.

India's Progress and the Road Ahead:

India has taken important steps toward regulatory reform. Initiatives such as Ease of Doing Business, Jan Vishwas (Amendment of Provisions) Act, and efforts to reduce criminalization of minor economic offenses signal a growing recognition of regulatory burden. Some ministries have begun conducting impact assessments, which need to be adopted by others as well.



In the FMCG domain, where regulations span food safety, legal metrology, packaging, labelling, environment, plastics, recycling, and advertising, coordination and coherence are essential. A structured, mandatory cost-benefit analysis framework - applied uniformly - would help ensure that standards are necessary, implementable, and aligned with national economic priorities.

Toward Fewer, Better, and Enforceable Standards:

The objective of regulatory reform should not be deregulation, but better regulation. This means:

- Introducing standards only when there is clear evidence of market failure or public risk
- Quantifying costs and benefits transparently
- Consulting industry, consumers, and experts meaningfully
- Providing adequate

transition timelines

- Periodically reviewing and sunseting outdated or ineffective regulations

By focusing on quality rather than quantity, regulators can strengthen compliance, improve consumer outcomes, and free up both public and private resources for innovation and growth.

Conclusion:

In a rapidly growing economy like India, especially in a critical sector such as FMCG, regulation must be both protective and enabling. Every new regulation or standard carries a cost, and those costs - if unexamined - can undermine competitiveness, employment, and consumer



welfare. Rigorous cost-benefit analysis offers a practical, globally proven tool to strike the right balance.

As India aspires to global best practices and seeks to further improve ease of doing business, embedding economic rationality into regulatory design is no longer optional - it is imperative. Fewer, smarter, and well implemented regulations will serve not only industry and regulators, but ultimately, the Indian consumer.



Importance of Flavours in Innovative Food Design



AUTHOR
Ms Bharti Rawat,
 Senior Flavourist,
 Norex Flavours Private Limited

Flavour First - The Core of Innovative Food Design Where Science Meets Sensation

Introduction

The food and beverage industry is experiencing unprecedented transformation as consumer expectations continue to evolve. Today's consumers seek products that offer more than nutrition; they desire memorable sensory experiences, authenticity, wellness benefits, and emotional engagement. In this dynamic environment, flavour has become one of the most influential

elements in food innovation. It shapes first impressions, drives repeat purchases, creates brand differentiation, and builds lasting consumer connections. As food designers and flavourists explore new ingredients, technologies, and cultural inspirations, flavour remains the central force that transforms ordinary products into extraordinary experiences.

The Need for Innovation in Flavours

Innovation in flavours has become essential for the food and beverage industry to remain competitive in a rapidly changing marketplace. Consumers are increasingly adventurous, seeking novel tastes, global

culinary influences, healthier alternatives, and products that align with their lifestyles and values. At the same time, social media trends, clean-label expectations, sustainability concerns, and growing interest in functional foods are creating new opportunities for flavour development.

Traditional flavour profiles continue to have relevance, but brands must continuously innovate to meet emerging consumer demands. Successful flavour innovation helps companies create product differentiation, extend product lifecycles, enter new market segments, and respond to evolving wellness trends.



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~Comparison shown is with a leading competitor brand. [#]Carbohydrates - Electrolyte formulation.





By combining science, creativity, cultural insights, and consumer understanding, innovative flavours can deliver both sensory satisfaction and meaningful experiences.

The Growing Importance of Flavour Innovation

Consumers are increasingly looking for products that offer bold, adventurous, and globally inspired tastes. At the same time, there is growing demand for clean-label ingredients, wellness-focused foods, and authentic cultural experiences.

These evolving preferences are pushing brands to innovate with flavours that are both familiar and exciting. Current flavour trends reveal strong interest in tropical fruits, naturally vibrant ingredients, citrus-forward refreshment, and fermented or pickled profiles.

These flavours not only satisfy taste preferences but also connect with emotional wellness, nostalgia, health consciousness, and social media appeal. Among the emerging trends shaping the

future of food and beverage innovation are pineapple, ube (purple yam), sudachi citrus, and fermented or pickled flavours. Each demonstrates how sensory appeal can transform

ordinary products into engaging consumer experiences.

Pineapple - Tropical Indulgence with Wellness Appeal

Pineapple continues to gain popularity as a versatile tropical flavour that delivers both indulgence and perceived health benefits. Its sweet-tart profile creates a refreshing and uplifting sensory experience, making it suitable for a wide range of food and beverage applications.

One of the key reasons for pineapple's success is its emotional appeal. Consumers increasingly seek comfort, escapism, and positivity through food, and pineapple's bright tropical identity delivers a sense of joy and relaxation. Products inspired by tropical destinations or exotic experiences often use pineapple to create emotional connection and nostalgia.

In addition to its sensory qualities, pineapple is associated with wellness. Rich in vitamin C, manganese, and digestive enzymes such as bromelain, pineapple aligns well with consumer demand for better-for-you indulgence. Its natural fruity profile allows brands to develop products that feel refreshing and health-oriented without compromising flavour.

Pineapple also demonstrates remarkable versatility. It performs successfully across beverages, dairy products, sauces, meat snacks, desserts, and fermented drinks. From tropical sodas and fermented tepache beverages to marinades and ready-to-eat snacks, pineapple enhances both sweet and savoury applications.

Global product launches featuring pineapple flavours have shown consistent growth in recent years, reflecting its strong international acceptance and broad cultural relevance.





Ube (Purple Yam) - Visual Innovation Meets Cultural Authenticity

Ube, a purple yam traditionally associated with Filipino cuisine, has emerged as one of the most visually striking and socially appealing flavour trends in the global market. Its vibrant purple colour immediately captures consumer attention, making it highly attractive for social media-driven food culture.

The popularity of ube is strongly connected to its visual identity. In the age of Instagram and digital food trends, consumers are naturally drawn to colourful and aesthetically appealing

products. Ube's naturally vivid appearance provides brands with an opportunity to create eye-catching desserts, beverages, bakery items, and frozen products without relying heavily on artificial colours.

Beyond its appearance, ube offers a unique flavour profile that combines mild sweetness with creamy, nutty, vanilla-like notes. This approachable taste makes it easy to pair with familiar flavours such as vanilla, coconut, chocolate, and pistachio, helping consumers experience novelty without discomfort.

Ube also represents the growing consumer appreciation for authentic global flavours. For many consumers, it offers cultural nostalgia and emotional familiarity, while for others it provides an exciting introduction to Asian-inspired cuisine.

From a health perspective, ube aligns with the clean-label movement and the growing popularity of naturally functional ingredients. Purple foods are often associated with anthocyanins,



natural antioxidants linked to wellness benefits and overall health support.

Today, ube is finding applications across cookies, cheesecakes, pastries, ice creams, frozen desserts, and beverages, proving its adaptability across multiple food categories.

Sudachi - The Next Generation of Citrus Refreshment

Sudachi, a Japanese citrus fruit known for its tart and aromatic character, represents the next wave of citrus flavour innovation. As consumers continue seeking refreshing and clean flavour experiences, citrus and tropical notes are becoming increasingly important in beverage and food development.

Sudachi stands out because of its intense, sharp flavour profile that delivers freshness without excessive sweetness. Its bright acidity and aromatic complexity make it highly suitable for modern beverages such as sparkling waters, mocktails, cocktails, teas, and flavoured alcoholic drinks.





consumers to new sensory experiences.

Fermented and Pickled Flavours - Bold Taste with Functional Appeal

One of the strongest emerging trends in innovative food design is the rise of

fermented and pickled flavours.

Younger consumers, particularly Gen Z and Millennials, are increasingly attracted to bold, tangy, spicy, and complex taste experiences that stand apart from traditional flavour profiles.

Fermented flavours offer a sense of authenticity, intensity, and adventure. Products inspired by kimchi, kombucha, pickles, yogurt, and fermented sauces appeal to consumers seeking both flavour excitement and perceived health benefits.

The connection between fermentation and gut health has played a major role in the growth of this trend.

Fermented foods are commonly associated with probiotics, digestive wellness,

and functional nutrition, making them attractive to health-conscious consumers.

At the same time, fermented and pickled flavours are highly engaging from a sensory perspective. Their tangy, spicy, sour, and umami-rich profiles create memorable eating experiences that break the monotony of conventional flavours.

Brands are successfully incorporating fermented flavours into beverages, sauces, snacks, condiments, cultured dairy products, and modern fusion foods. Visually bold packaging and social media-driven marketing further strengthen the appeal of these products among younger audiences.

The fermented flavour trend demonstrates how modern consumers increasingly value products that combine taste intensity, authenticity, wellness, and cultural storytelling.

The flavour pairs exceptionally well with ingredients like ginger, yuzu, and herbal notes, enabling brands to create sophisticated and layered sensory experiences.

Another important factor behind sudachi's rising popularity is its alignment with wellness trends. Citrus fruits are widely associated with vitamin C, immunity, freshness, and vitality. Sudachi allows brands to create products that feel light, refreshing, and health-oriented while maintaining strong flavour impact.

Beyond beverages, sudachi is also being used in dressings, vinegars, noodles, broths, and savoury applications where its tart profile enhances umami and complexity.

Its growing presence demonstrates how global culinary ingredients can inspire modern food innovation while introducing



The Role of Flavours in Consumer Engagement

Flavours today do far more than improve taste. They shape consumer perception, influence emotional response, and create memorable product experiences. In innovative food design, flavour acts as a bridge between science and emotion, functionality and indulgence, tradition and modernity.

Successful flavour innovation often combines multiple dimensions:

- Sensory excitement
- Visual appeal
- Cultural storytelling
- Wellness positioning
- Emotional connection
- Social media relevance

Consumers increasingly expect products to deliver all these experiences simultaneously. As a result, flavourists and food designers play a critical role in creating products that resonate emotionally while

meeting functional and commercial objectives.

Conclusion

Innovative food design is no longer only about creating products that satisfy hunger. It is about delivering experiences that excite consumers, connect emotionally, and reflect evolving lifestyles and values. Flavours are at the heart of this transformation.

Whether through the tropical optimism of pineapple, the vibrant authenticity of ube, the refreshing sophistication of sudachi, or the bold complexity of fermented flavours, innovation in flavour design is shaping the future of food and beverages. As consumer expectations continue to evolve, brands that embrace creative, culturally inspired, and wellness-driven flavour innovation will be better positioned to build loyalty, differentiation, and long-term success in the global market.



Ultimately, innovative food design does not simply feed people—it creates unforgettable flavour journeys.

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- [Food Business News - Flavor Innovation Coverage](#)
- [FoodNavigator - Global Food Innovation and Consumer Trends](#)



The Untapped Potential of Microalgae



AUTHOR

Ms. Sanyukta Telange,
Food Technologist and
Regulatory Support,
PFNDAI

Microalgae are microscopic organisms found in marine and freshwater environments. In certain parts of the world, they have been consumed by humans for over two millennia.

However, extensive research and large-scale cultivation of microalgae began after World War II, when growing fears of food shortages and rapid population growth pushed scientists to search for sustainable and affordable nutrition sources. During the late 1940s and early 1950s, microalgae such as *Chlorella* gained attention as a promising solution to world hunger

due to their high nutritional value, rapid growth, and low production cost. These organisms convert sunlight into biomass through photosynthesis.

Microalgae comprise various groups of microorganisms, including cyanobacteria, diatoms, golden microalgae, and green microalgae. Among these, *Spirulina* and *Chlorella vulgaris* are the most widely commercialized and are commonly marketed as dietary supplements because of their rich nutritional composition and associated health benefits.

The production of microalgae involves three main stages: cultivation, harvesting, and processing. Commercial cultivation is carried out either in open-pond systems or closed photobioreactors that provide controlled light and

nutrient conditions. Following cultivation, the microscopic cells are harvested from the growth medium. The harvested biomass is then dried and processed, either for direct consumption or for the extraction of valuable compounds. This biomass is composed of nutrients, including 40-70% proteins, 12-30% carbohydrates, 20-50% lipids, 8-14% carotenoids, and substantial quantities of essential vitamins such as B complex, Vitamin E, K.

Researchers are increasingly focused on developing new products from microalgae because more customers are interested in using bioactive compounds from these organisms as ingredients in functional foods. The global market for microalgae-based products, currently valued at approximately

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often exceeding many conventional fish oils, and negligible amounts in most plant oils.

Protein-
Protein content in microalgae can exceed 50% of dry biomass in several species, often

surpassing conventional sources of protein. Glutamate is commonly reported as the predominant amino acid across many species, although composition varies depending on species, cultivation conditions, harvesting, and processing methods.

Species such as *Spirulina* and *Chlorella vulgaris* contain 30-50% essential amino acids, particularly lysine, leucine, valine, and isoleucine, while also being rich in non-essential amino acids like glutamate, aspartate, alanine, arginine, and proline. Digestibility differs among species due to variations in cell wall structure and antinutritional compounds. Digestibility in microalgae varies depending on cell wall composition. *Chlorella vulgaris*, due to its rigid cell wall, has relatively lower digestibility, whereas *Spirulina* shows higher digestibility due to its lower cellulose content. Mechanical and processing treatments can further improve digestibility.

Studies on multiple microalgal species have reported crude protein digestibility values ranging from 71-80%, highlighting strong potential for nutritional and functional food applications (3).

Pigments -

Microalgae contain three major classes of pigments: carotenoids (0.1-0.2% of dry weight and up to 14% in certain species), chlorophylls (0.5-1.0%), and phycobiliproteins (PBPs) (up to 8%). These pigments have gained significant attention as natural colourants and functional ingredients in the food industry. Pigments such as chlorophylls, β -carotene, astaxanthin, lutein, fucoxanthin, phycocyanin, and phycoerythrin are widely used in beverages, dairy products, baked goods, confectionery, nutraceuticals, and functional foods. Besides imparting natural colours, many of these pigments exhibit antioxidant and health-promoting properties, making them sustainable alternatives to synthetic food additives.

Among these, carotenoids are particularly valued for their vibrant pigmentation, antioxidant activity, and clean-label appeal. Microalgae offer advantages over conventional plant sources due to year-round biomass production, higher pigment yields, and faster extraction.

USD 4.96 billion, is expected to grow at a compound annual growth rate (CAGR) of 4.8% to reach USD 9.1 billion by 2032 (1,2).

Nutraceutical components

Microalgae of specific strains are recognized as safe and are rich in proteins, vitamins, and other bioactive compounds. Algae-based foods not only provide essential nutrients but also contribute to sustainability efforts, as microalgae cultivation requires minimal land and water resources compared to traditional agriculture.

Chlorella and *Spirulina* are widely marketed as single-cell proteins, with their dried biomass used in food and dietary supplements such as capsules, tablets, and powders. *Spirulina* contains 60-70% protein, 1.5 times more iron than spinach, and nearly 10 times more β -carotene than carrots. Some microalgae also possess high lipid content. *Schizochytrium* sp. contains up to 50% lipids, including high levels of DHA,

Astaxanthin is widely recognized for preventing lipid oxidation and improving the stability of lipid-based foods, with *Haematococcus pluvialis* being one of the richest natural sources. β -carotene, a precursor of vitamin A, is commonly used as a natural food colourant and nutraceutical ingredient. Lutein is another commercially important carotenoid used as a natural yellow colourant.

In addition to carotenoids, chlorophyll pigments from microalgae are widely used to provide natural green colouration in foods, while phycocyanin is increasingly utilized as a natural blue food colourant. The market for these pigments is estimated to be valued at USD 429.7 million in 2026 and is projected to reach USD 877.4 million by 2036 (4,5).

Lipids-

The increasing shift toward vegan and vegetarian diets has boosted interest in microalgae as sustainable sources of omega-3 and omega-6 fatty acids. Microalgae produce functional triacylglycerols rich in polyunsaturated fatty acids (PUFAs). Compared to terrestrial plants, microalgae contain higher proportions of PUFAs, and their lipid-rich biomass has strong potential for the development of functional

foods and nutraceuticals. Currently, microalgal triacylglycerols are marketed as capsules, powders, and tablets.

Polysaccharides -

Microalgal polysaccharides have varying biological properties based on their structure and have gained interest as prebiotics and dietary fibres. Polysaccharides from *Spirulina* are widely used as food additives and colourants in products such as ice cream, chewing gum, candy, popsicles, dairy products, soft drinks, and jellies. They are also being explored for weight management applications due to their non-digestible nature and potential anti-obesity effects. Studies on polysaccharides isolated from *Chlorella pyrenoidosa* and *Spirulina* demonstrated their ability to reduce excess weight, improve metabolic health, and support beneficial gut microbiota in high-fat diet-induced obese mice (6).

Innovations, Industry Challenges & Consumer Acceptance

Microalgae have been incorporated into a variety of food products, including yoghurts, processed cheese, cookies, biscuits, bread, pasta, and extruded snacks. Commonly used species include *Chlorella vulgaris*, *Arthrospira (Spirulina) platensis*, *Haematococcus*



pluvialis, *Dunaliella sp.*, and *Isochrysis galbana*. These microalgae are added to improve techno-functional properties such as texture, stability, water-holding capacity, and colour, while simultaneously enhancing the nutritional profile of foods.

The incorporation of microalgae enriches products with valuable nutrients and bioactive compounds, including proteins, dietary fibre, ω -3 polyunsaturated fatty acids (PUFAs), carotenoids, astaxanthin, phycocyanin, and antioxidants. In bakery and pasta products, microalgae improve protein and mineral content, whereas in dairy products and emulsions, they contribute antioxidant activity, natural pigmentation, and functional stability. Owing to these properties, microalgae are increasingly being explored as sustainable functional ingredients and natural alternatives to synthetic additives in food formulations.



and naturalness also contribute to consumer hesitation toward algae-based products.

In addition to sensory and acceptance challenges, microalgae may

contain antinutritional compounds such as phytic acid, tannins, and oxalates, which can reduce the bioavailability of minerals.

To address these limitations, pretreatment methods, including fermentation and enzymatic hydrolysis, have been investigated and have been shown to reduce

antinutritional factors and improve nutrient bioavailability and digestibility in microalgal biomass.

The commercial production of microalgal

proteins also faces economic challenges associated with cultivation, harvesting, and downstream processing.

The cost of dried microalgal biomass, such as *Spirulina*, remains considerably higher than

conventional protein sources like soybean and whey protein.

While open-pond cultivation systems can reduce operational expenses, they also increase the risk of contamination, creating additional safety and scale-up challenges (1,7,8).

Conclusion

Microalgae represent a promising and sustainable source of nutraceutical ingredients due to their rich nutritional composition.

As naturally vegan sources of nutrients such as protein, DHA, and EPA, microalgae are gaining increasing importance in plant-based and functional food applications.

Their use in dietary supplements, natural food additives, and clean-label products continues to grow alongside rising consumer interest in health, sustainability, and alternative nutrition sources.

Despite its numerous benefits, consumer acceptance of microalgae-based foods remains limited in many regions. Algal foods are well established in East Asian countries, but they are often perceived as niche health products or ingredients in foreign cuisines.

Although consumers show interest in functional foods with health, nutritional, and sustainability benefits, acceptance of microalgae is still emerging.

Sensory attributes such as taste, texture, bright green colour, and fishy odour can further limit acceptance, especially in products intended as alternatives to meat protein.

Cultural attachment to conventional meat and perceptions regarding taste, affordability, convenience,



However, challenges related to sensory acceptance, production costs, and antinutritional factors must still be addressed to support wider commercial adoption. Continued research and technological advancements can further strengthen the role of microalgae in future food and nutraceuticals.

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Effects of Processing on Dietary Fiber



AUTHORS

Dr. Malathy Venkatesan,
Project Coordinator,
PFNDAI

Introduction:

Dietary fiber, or roughage is the portion of plant-derived food that cannot be broken down by human digestive enzymes. Dietary fiber consists of all non-starch polysaccharides and other plant components such as cellulose, resistant starch, resistant dextrins, inulin, lignins, chitins, pectins, beta glucan and oligosaccharides impervious to processing in the small digestive tract and fermentable by microbes in the gut. Dietary fiber can be classified in many different ways based on structure and solubility. Based on solubility, they can be divided into Soluble (SDF) or Insoluble Dietary Fibers

(IDF). Soluble Dietary Fibers include oligosaccharides, including fructo-oligosaccharide (FOS), -glucans (from oat and grain grains), galactomannan gums, alginate etc.

Soluble dietary fibers are generally present in plants including agave, garlic, onions, and wheat. Insoluble fiber includes insoluble strands, similar to those found in wheat, grain, vegetables. Examples are hemicellulose, cellulose, lignin. (1) Other oligosaccharides such as raffinose and stachyose in legumes (especially soybean) are not digested by the human system. However, these oligosaccharides have antinutritional properties and may cause bloating.

Products derived from the manufacturing or processing

of plant-based foods: cereals, fruits, vegetables, as well as algae, are sources of abundant dietary fiber.

Recently, food manufacturers have responded to consumer demand for foods with a higher fiber content by developing products in which high-fiber ingredients are used. The chemical and physical properties of dietary fiber be affected by food processing. The technological effects known as functional properties of dietary fibers depend mainly on their physicochemical properties: size of the particle, solubility, water-holding capacity, viscosity and gel formation, binding ability, bulking ability, swelling, cation exchange, fermentability and antioxidant properties, among others (1).

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vegetable products, extrusion cooking, enzyme treatment and recently microwaving.

Effect of milling and refining on dietary fiber

Cereal grain consists of starch, protein and fiber (in the bran). The fiber portion is rich in highly crosslinked polysaccharides, such as cellulose, lignin and heteroxylan. The milling process separates the bran from the starchy portion (such as refined flour) or the bran is ground into fine particles as in chakki atta process of wheat.

Since bran is separated in refining process, the physicochemical structure of bran is intact (1). In the atta process too, the structure of the bran is unchanged, only broken into small particles. Tempering of wheat grain is a common process used in mills. The tempering processing results in activation of innate enzymes in the grain which could lead to partial degradation of the fiber.

Effect of thermal treatment on fiber

Food legumes form an important part of the human diet, providing a high proportion of proteins, fats, carbohydrates, dietary

fibers, B-group vitamins (thiamine, riboflavin, niacin), and minerals. Some part of fiber in legumes are anti-nutritional factors such as trypsin and chymotrypsin inhibitors, oligosaccharides, lectins and tannins and limits the availability of nutrients present in the leguminous crops.

Removal of these factors is achieved by soaking and cooking of dry grains of legumes. Soaking of legume grains reduces the levels of total sugars, α -galactosides, minerals, phytic acid and proteolytic enzyme inhibitors which can be partly or totally solubilised and eliminated with the discarded soaking solution. This process results in reduction of the fiber in the products. The effect of soaking and cooking has been studied in chickpea (2). Soaking had no significant effect on dietary fiber content of seed.

However, an overall increase in total dietary fiber was observed. This was attributed to losses of soluble sugars, reduction in phytates and minerals, and amylase activity during soaking, before the process of cooking. Effects of soaking, boiling and roasting on TDF (total dietary fiber), SDF and IDF of legumes (mung bean, soya bean, ground nut) and cereals (rice, wheat, barley) were studied (3).

Solubility is an important attribute for fibers such as pectin and beta glucan. Water holding capacity is related to either absorption of water added in the process (e.g. in case of insoluble fiber in cereals) or bound to the fiber (e.g. soluble fibers which entrap water into a gel).

Soluble fibers, such as guar gum and psyllium, promote relatively high viscosities in comparison to insoluble fibers such as cellulose, rice bran, and wheat bran. Soluble fibers form gels, increasing the viscosity of the contents of the gastrointestinal tract. For example; long chain polymers (guar gum, tragacanth gum) bind significant water and exhibit high solution viscosity. This viscosity may also affect the processing parameters such as reduced flowability.

Food processing and effect on dietary fiber

Processing includes refining/milling (cereals), heat treatment such boiling/canning for fruit and



Effects of Processing on Dietary Fiber

The insoluble dietary fiber content showed an increase in cereals as well as legumes. In samples with high protein this could be attributed to the production of Maillard reaction products. The SDF remained unchanged in all samples except in roasted soy beans that was found to increase significantly again due to Maillard reaction.

Canning process in beans resulted in degradation of antinutrients such as lectins, trypsin inhibitors and alpha galactosides while significantly increased the protein (>7%) and dietary fiber (>5%) contents of beans varieties studied. (4).

Effect of dietary fiber on extrusion cooking

Extrusion technology is primarily a high-temperature-short time (HTST) processing method that transforms agricultural commodities into fully cooked products. Extrusion processing has wide applications in breakfast cereal, pet foods, dairy products, baked products, and snacks. The resulting extrudate is low in moisture and considered a generally shelf-stable product. These advantages have resulted in increase in a wide range of extruded snacks. Extrusion increases the solubility and availability of dietary fiber by breaking down the cell walls and other structural components of the material.

In the case of waxy barley flour, extrusion has been shown to increase the amount of soluble dietary fiber, which contributes to an overall increase in the total dietary fiber content. SDF from extruded oat bran was found to have more aggregates, a higher gelatinization temperature, higher solubility and improved foam ability when compared with SDF from untreated oat bran (1). One study evaluated the effects of extrusion on the starch and fiber components of Amarillo peas, Dun peas, chickpeas, faba beans, lentils, and soybean meal (SBM). Results indicate that extrusion increased the starch and SDF content of most pulses. (5).

Effect of enzyme treatment in processing on dietary fiber

Fermentation is a process that uses microbes and desirably modifies food constituents by increasing the palatability, organoleptic properties, bioavailability and alters nutritional constituents. Microbial enzymes act and cause a reduction in the total and insoluble dietary fiber (1). The mechanism of the decrease in fiber in fermented cereal was attributed to the partial solubilization of cellulose and hemicellulose type of materials by microbial enzymes. Examples are: reduction in fiber of

fermented maize flour (by 74%) due to enzymatic breakdown by lactic acid bacteria (LAB), which utilized the fiber as a carbon source, enhanced activity of β -glucanases and carboxypeptidases, resulting in insoluble β -glucan degraded into soluble β -glucan and, activity of other enzymes such as β -glucosidases, cellobiase, etc., could hydrolyse the soluble fibers into glucose, Around 55% decrease in fiber due to enzymatic degradation in fermented pearl millet, while a decrease of 40% in fiber levels in fermented sorghum was attributed to the partial solubilisation of cellulose and hemicellulosic type of material by microbial enzymes. In legume seeds, such as African yam beans and Lima beans, fermentation reduced the crude fiber content, while the insoluble and soluble fibers of pigeon pea and kidney beans was reduced. Enzyme treatment improves processing parameters in fruit processing. Insoluble fibers are degraded into oligosaccharides due to enzyme action which improve the soluble fiber content of the final product with prebiotic effect.



most severe microwave treatment, primarily due to losses of soluble dietary fiber (pectic polymers) (6).

Summary:

The consumers knowledge on the positive health effects of dietary fiber such as bowel function, reduced risk of coronary heart disease, type 2 diabetes and improved weight maintenance has improved significantly in recent years. Food processors are working to increase dietary fiber in their products.

Different processing treatments have different effects on the dietary fiber of cereals and legumes. Some of them might even improve the functionality of fiber. Therefore, they may also be applied as functional ingredients to improve physical properties like the physical and structural

properties of hydration, oil-holding capacity, viscosity.

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Effect of microwave processing on dietary fiber

Microwave technology has been studied for various food processing applications; drying, blanching, pasteurization and cooking. Baking has been successful with appropriate formulation. Effect of microwave processing on structure and functions of macromolecules in food was studied.

High microwave power, promotes the synthesis of resistant starch (for example in rice and lotus seeds). In a study on green beans total fiber content decreased only after the





Food Fortification in India: Challenges and Future Directions

AUTHOR

Ms Simran Vichare,
Nutritionist, PFNDAI



Micronutrient malnutrition is a major public health concern in India, affecting millions across all age groups. Deficiencies of iron, iodine, vitamin A, vitamin D, folic acid, and vitamin B12 continue to contribute to anaemia, impaired immunity, poor cognitive development, and reduced work productivity. To address these deficiencies, the Food Safety and Standards Authority of India (FSSAI) have promoted fortification of staple foods such as rice, wheat flour, milk, edible oil, and salt.

Food fortification is widely recognised as one of the most cost-effective and scalable public health interventions for improving micronutrient intake at the population level. India's success with universal salt iodisation demonstrates its

potential. However, despite its scientific validity and public health benefits, implementing large-scale fortification in India presents several technical, regulatory, economic, and consumer-related challenges.

1) Limited Availability of Accurate Dietary Intake Data

One of the most significant limitations of food fortification is the requirement for accurate dietary data about the target population. Before designing any fortification program, planners must understand what people eat, how much they consume, and how nutrient intake varies across different age groups, genders, and socioeconomic levels (1). Without this information, fortification

efforts may be either insufficient or excessive. Gathering this data can be a complex process.

Choosing the right food vehicles for fortification is also crucial. Planners need to be aware of consumption patterns across population subgroups, particularly the proportion of food processed through commercial channels and therefore "fortifiable." In many low- and middle-income countries, national-level dietary survey data are often lacking or outdated. In such cases, methods like 24-hour dietary recalls and household consumption expenditure surveys can be valuable.



2) Regional Diversity in Dietary Patterns

India's culinary landscape is characterized by a remarkable diversity in eating habits. Unlike countries with more standardized diets, India's food practices vary significantly from region to region. In southern and eastern India, rice serves as the staple food. In contrast, wheat predominates in the northern and western regions, due to agricultural practices and climatic conditions that influence dietary preferences. In certain rural communities, millet is still the main staple in the diet.

This variety of food habits presents a unique challenge for implementing a universal fortification strategy. A particular approach that proves effective in one region may yield limited results in another, due to variations in staple foods and preferences. Even socioeconomic factors and local agricultural practices play a role in establishing dietary habits.

3) Nutrient bioavailability

All chemical forms of a nutrient exhibit different levels of bioavailability. The effectiveness of a fortificant is based on several factors, including the specific

chemical form used, the type of food it is incorporated into, and the interaction with other dietary components. For example, iron's highly bioavailable forms like ferrous sulfate can enhance absorption. This reactivity can lead to undesirable changes in food, such as off-flavours, colour alterations, and gastrointestinal side effects. On the other hand, less reactive forms of iron, though more stable within food products, often exhibit lower absorption rates, making them less effective as fortificants.

Fat-soluble vitamins (A, D, E, and K) require dietary fat for proper absorption. When they are added to low-fat or fat-free products, their bioavailability can drop significantly. For example, skim milk fortified with vitamins A and D may not deliver these nutrients as effectively as whole milk would, because the fat needed for absorption has been removed. Naturally occurring compounds in foods can also hinder mineral absorption (2). An example is phytic acid, which is prevalent in

cereal grains and legumes. Phytic acid binds to essential minerals like iron and zinc, forming insoluble complexes that the body cannot absorb efficiently. Consequently, when wheat flour is fortified with iron, its efficacy may be significantly compromised if the flour's native phytic acid takes a large part of the added iron, thus reducing the health benefits.

To improve the effectiveness, a few dietary strategies can be implemented that reduce the impact of such inhibitors, for example, combining high-phytic acid foods with those rich in vitamin C, which has been shown to enhance iron absorption. Researching and developing new fortification technologies, such as microencapsulation, can help protect sensitive nutrients from adverse interactions in the food matrix, eventually improving the bioavailability of essential micronutrients.

4) Regulatory and enforcement gaps

India's food fortification system involves various stakeholders, including the Central and state governments, FSSAI, and food industries. Coordinating efforts across such a vast system is challenging. One significant challenge is finding the right balance between voluntary and mandatory fortification.

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Also, creating and maintaining fortification standards requires proper regulatory mechanisms. Governments need to establish clear nutrient-level standards, labelling requirements, and quality control measures, along with ensuring compliance.

In many areas, regulatory agencies have limited resources, expertise, or political backing, which makes it hard for them to enforce rules effectively. As a result, food fortification with micronutrients often does not meet the necessary standards. Poor monitoring allows producers to get away with making under-fortified products. This can mislead consumers through under-fortification and false labelling. To ensure that food fortification truly protects public health and provides essential nutrients, we must strengthen laws, enforcement, and regulatory systems. (3).

5) Organoleptic and sensory limitations

One of the major issues faced in food fortification is the unacceptability of fortified foods by consumers. Fortification

must not change the taste, colour, smell, or texture of food in ways that consumers find unacceptable. Unfortunately, some fortificants cause noticeable sensory changes (4). For

example, iron compounds are known for producing metallic off-flavours and discolouration in fortified products such as cereals and bread. These sensory changes can reduce consumer acceptance and ultimately affect the program's outcomes.

To tackle this issue, manufacturers can use encapsulation techniques that mask the taste and odour of certain micronutrients. For instance, using microencapsulation for iron can help prevent the metallic taste from affecting the overall flavour profile of the food. Additionally, blending iron with other ingredients that enhance flavour, such as natural herbs or spices, can further mitigate undesirable sensory impacts.

Not all micronutrients are suitable candidates for fortification due to these organoleptic constraints. Minerals like magnesium and potassium, which are commonly deficient in many populations, present significant technical challenges when added to foods because of the

quantities required and their impact on taste. For example, the addition of magnesium can impart a bitter flavour, making food less palatable. This limits the range of deficiencies that fortification can realistically address.

To overcome these challenges, researchers can explore alternative fortificants that have less impact on taste or seek to develop new formulations. For example, using chelated forms of minerals can improve solubility and reduce adverse sensory effects (5). Beyond this, conducting consumer taste tests during the development phase can provide valuable feedback and guide manufacturers in formulating fortified products that are more likely to be accepted by consumers. These strategies can be employed by the food industry to tackle sensory challenges.

6) Industrial challenges:

The food fortification industry faces significant challenges, particularly due to the varying structures of its different sectors. For instance, in the oil and salt industries, a few major companies dominate production, capturing 40-90% of the market. This consolidation allows for efficient coordination in implementing fortification practices.

In contrast, sectors like rice, wheat flour, and milk are characterized by numerous small-scale informal producers, complicating the adoption of standardized fortification techniques and making coordination among producers and capacity-building efforts more difficult. Many small rice millers, for example, lack the knowledge and resources necessary to invest in fortification machinery or processes.

Investing in the required machinery for food fortification presents another significant hurdle. For small millers, the capital costs associated with obtaining blending equipment can be prohibitively high. While larger companies can easily invest in essential machinery. This financial burden can deter smaller producers from participating in fortification programs, ultimately limiting the reach of fortified products to vulnerable populations (6).

Challenges also arise during the production phase. In rice fortification, for instance, the fortified rice must closely mimic the appearance, texture, and cooking characteristics of natural rice to ensure consumer acceptance. Achieving a uniform nutrient

distribution in large batches can be difficult. A common solution is the use of extruded rice kernels (ERKs), which involves blending rice flour with vitamins and minerals and processing it through an extruder to create fortified kernels that resemble natural rice. These ERKs are then mixed with regular rice at a ratio of 1:100 (8). This method enhances nutrient stability during storage and cooking while ensuring a uniform distribution of micronutrients.

Affordability is generally not a significant barrier to consumer access to fortified foods, as fortification typically adds only about 3-7% to the retail price of these products. For example, a regular pasteurized bag of milk costs between 28 and 30 Rs, while milk fortified with vitamins A and D ranges from 35 to 45 Rs. However, a lack of consumer awareness remains a major obstacle. Many people are still unaware that fortified foods exist or do not fully understand their benefits, which hinders market penetration.

In the Indian market, several fortified food products are already available. Fortified milk and milk-based products are



widely marketed by both dairy companies and private producers. Similarly, edible oils and fats are routinely fortified with fat-soluble vitamins due to their stability in lipid-based matrices and broad consumer reach. Apart from staples, breakfast cereals, infant foods, nutritional beverages, milk powders, yoghurt, fruit juices, biscuits, bakery products, and ready-to-eat foods fortified with vitamins and minerals such as iron, zinc, calcium, vitamin A, vitamin D, folic acid, and vitamin B12 are also available. The growing demand for functional and health-promoting foods has also created opportunities for fortification of plant-based beverages, millet-based products, protein bars, and other value-added foods. Such diversification can help improve micronutrient intake.

7) Consumer awareness and acceptance

Cultural habits and 'food aesthetics' also play a crucial role in consumer acceptance of fortified foods.



For example, when double fortified salt contains additional nutrients like iodine and iron, it can lead to discolouration. This change can concern consumers who associate visual appeal with quality, resulting in lower demand for these products. In some cultures, a specific shade of salt is preferred, and any colour changes might be perceived negatively, reducing the possibility of purchase.

Even traditional practices surrounding food consumption might be additional barriers. In communities where rice is a staple, small-scale producers might be resistant to altering their production methods due to adherence to traditional practices, affecting the willingness to adopt fortified versions.

Educating these communities about the health benefits of fortified foods, such as reducing anaemia or improving cognitive function in children, is important for improving acceptance and consumption. For this, targeted awareness campaigns, financial incentives or support for

small producers are crucial.

RECOMMENDATIONS AND FUTURE DIRECTIONS

While there is a right to adequate nutrition, its implementation, especially in developing countries, often falls short. This might be due to a lack of fundamental nutrition programs, strong policies, and collaboration between researchers and policymakers. Improving women's nutrition is crucial for breaking the intergenerational cycle of malnutrition.



Biofortification is a natural alternative to GMOs for enhancing crop nutrition, but its adoption faces several challenges. It is time-consuming, and nutrient levels can vary with soil quality, climate, and farming practices. Consumer acceptance can also be an issue due to differences in appearance or taste.

Recent research has

shown the impact of fortifying foods with iron-rich food-based fortifiers on haemoglobin levels, iron stores, and anaemia reduction. An animal study further confirmed the benefits of iron-rich food fortification on blood parameters and antioxidant enzymes (7).

Improving India's food fortification system requires action in **the food system**.

A strong regulatory framework is needed with increased investment in biofortification and post-implementation monitoring.

Nutrition economics requires new financing mechanisms to address nutritional inequalities and find cost-effective solutions. **Community-based programs** should be supported to provide healthcare and promote nutrition awareness.

Strengthening monitoring systems is required, and trained inspectors can improve quality assurance. Along with this, **India-specific studies** on nutrient bioavailability, fortificant stability, and dietary patterns should guide policy improvements.



In conclusion, while food fortification in India is a promising strategy for addressing micronutrient malnutrition, several technical, regulatory, economic, and consumer-related challenges are present. Recent innovations are helping address many of these barriers.



Microencapsulation technologies can improve nutrient stability and bioavailability while reducing undesirable sensory changes. ERK technology has enhanced the effectiveness of rice

fortification programmes by improving nutrient retention during storage and cooking.

New advances in biofortification are helping to create crop varieties that are rich in nutrients. To make these programs more effective, we can improve how we add nutrients, create better fortifications, and raise public awareness. Combining these improvements with a varied diet, supplements, and nutrition education will be essential for making long-lasting changes in nutritional health across India.

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Seminar Report on the “Next Generation Food Design: on Food Ingredients for Innovative and Healthier Food Products”

held on 8th May 2026 at Fairfield by Marriott, Mumbai



By
 Ms Anuja Padte,
 Food Scientist, PFNDAI

The Protein Foods and Nutrition Development Association of India (PFNDAI) successfully organized a seminar on “Next Generation Food Design: Food Ingredients for Innovative and Healthier Food Products” on 8th May 2026 at Fairfield by Marriott, Mumbai. The seminar brought together professionals from the food industry, regulatory experts, scientists, academicians, ingredient manufacturers, and researchers to discuss emerging trends and innovations in food ingredient technologies for healthier and consumer-preferred food products. The Sponsors for the seminar were **Fine**

Organics, PepsiCo, Glanbia, ADM, Vinayak Ingredients, Mondelez, Nutricircle, Nestle, Barentz, Abbott Healthcare, Marico, Sanofi, Trigon Digipack, Hardcastle Restaurants, Roots Formulations, Norex Flavours Pvt Ltd, Vista Processed Foods Pvt. Ltd., JRS. The event also featured stall sponsorship from **Trigon Digipack, Vinayak Ingredients & Glanbia.**

The programme commenced with registration and networking breakfast followed by the inaugural session. **Ms Dolly Soni, Marketing & Projects Manager at PFNDAI,**



expertly hosted the seminar, gracefully introducing all the speakers and panelists for the event.

Dr.
 Shashank Bhalkar,
 Executive Director,
 PFNDAI,



warmly welcomed the distinguished guests, speakers, delegates, and industry professionals to the seminar. In his opening remarks, he emphasized that food today was no longer merely a necessity but had become an important food design challenge where consumers increasingly expected products that were both indulgent and healthy. He highlighted that the seminar would provide valuable insights into how ingredients such as dietary fibres, specialised proteins,



Delegates

emulsifiers, and flavours were shaping the next generation of innovative food design. He also mentioned that the seminar would address the challenges associated with translating scientific innovation into market-ready food solutions. Dr. Bhalkar encouraged active participation and knowledge sharing among delegates and described the event as an excellent platform for networking and industry collaboration. He expressed his sincere gratitude towards all sponsors and partners for their valuable support in making the seminar successful.



Dr Shatadru Sengupta

Dr. Shatadru Sengupta, Chairman, PFNDAI, emphasized that PFNDAI has always been

committed to promoting scientific awareness in the field of protein foods and nutrition. He highlighted the need for the food industry

to move beyond conventional product development and focus on innovative, consumer-centric food design to meet evolving health and lifestyle expectations. He stated that the seminar was organized to help industry stakeholders understand emerging ingredient technologies and develop healthier, relevant, and competitive food products. He also expressed confidence that the expert deliberations during the seminar would benefit the entire food industry ecosystem.

The keynote address was

delivered by Mr. Varinder Jaswal, Sr. Director - R&D BU Lead India, AMEA R&D Chocolate, Monde z International, on the topic "Ingredient Technologies Enabling Nutrition Without Compromising Sensory Appeal." During his presentation, he discussed the evolution of food



Mr Varinder Jaswal

innovation from traditional processing methods to modern precision fermentation and AI-driven flavour engineering. He emphasized the importance of balancing nutrition with sensory appeal and explained how ingredient technologies such as encapsulation, structured proteins, agricultural waste valorisation, and precision fermentation were transforming the food industry. He also highlighted the role of sustainability, food security, and consumer acceptance in future food innovation strategies.

The seminar also featured a special address by Ms. Pritee Chaudhary, Regional Director, FSSAI, who emphasized the need for the food industry to look beyond food alone and focus equally on food safety and nutrition. She highlighted concerns related to the Global Hunger



Ms Pritee Chaudhary



PFNDAI Team with Speaker Delegates

Index and discussed the importance of India's emerging economy in addressing nutritional challenges at scale. She stressed the significance of food diversification and biofortification as important strategies for improving nutritional security in the country. Ms. Chaudhary also emphasized the need to scale up production while simultaneously reducing costs so that nutritious and innovative food products remained affordable and accessible to the larger population. In addition, she shared insights on upcoming government initiatives supporting food innovation, nutrition-focused product development, and advancement of the food processing sector.

Session 1: Reformulating Food for Better Nutrition

The first technical session focused on reformulation strategies for healthier food products.

Ms. Mamta Budhiraja, Associate Director, Regulatory Affairs, PepsiCo India Holdings Pvt Ltd delivered a presentation on "Science and Strategy in Sugar Reduction." She explained the functional role of sugar in different food matrices and discussed various sugar reduction strategies including the use of sweeteners, polyols, soluble fibres, and portion control approaches. She elaborated on the technological challenges associated with sugar replacement and discussed regulatory aspects, sweetness potency, metabolism, and acceptable daily intake (ADI) considerations for different sweeteners. The session also highlighted how sugar contributed not only to sweetness but also to texture, mouthfeel, stability, and preservation in foods.



Ms Mamta Budhiraja

Mr. Akshay Telang, Manager - Regulatory ADM Agro Industries India Pvt Ltd. delivered a presentation on "Value Addition through Postbiotics and Dietary Fibers." He discussed the importance of gut health in overall wellbeing and explained the emerging role of postbiotics in functional food applications. The presentation covered various health benefits associated with postbiotics including immune support, metabolic health, intestinal barrier function, and mental wellness. He also presented scientific studies demonstrating the effectiveness of postbiotics in digestive health and highlighted their advantages such as improved stability, safety, shelf life, and suitability for diverse food applications.



Mr Akshay Telang



Panel Discussion

Ms. Sumita Trehan
Associate Director, R&D - ASPAC & META, Glanbia presented on “Beyond Protein Content:



Ms Sumita Trehan

Designing the Next Generation of High-Quality, Functional Proteins for Better Nutrition.” She explained that protein quality extended beyond quantity and discussed the importance of amino acid composition, digestibility, bioavailability, and functionality in protein applications. The presentation addressed consumer perceptions regarding protein consumption and why

protein safety. She also discussed the growing interest in vegetarian protein sources and highlighted the importance of designing proteins with improved functionality, texture, and nutritional performance.

An interactive Q&A session followed, during which delegates actively participated and discussed industry challenges related to product reformulation, consumer acceptance, and regulatory compliance.

Panel Discussion: Challenges in Product Innovations

One of the key highlights of the seminar was the panel discussion on “Challenges in Product Innovations”



Dr Subhaprada Nishtala

moderated by **Ms. Subhaprada Nishtala**, Founder - Food Adroit. The panel consisted of distinguished industry experts including **Dr. Prabodh Halde**, Head - Global Regulatory Affairs,

Public Policy and Advocacy, Marico Limited; **Mr. Govind Suryawanshi**, Corporate Affair Director, Royal Canin; **Mr. Jitin Garg**, India Lead - Scientific & Regulatory Affairs, Mondelez India; **Mr. C. S. Jadhav**, CEO and Co-Founder, Nutricircle Ltd.; **Dr. Gaurav Agnihotri**, Lead - Regulatory and Policy Strategy, Science Hub, Sanofi Consumer Healthcare India Limited; and **Ms. Shilpa Wadhwa**, Senior Nutrition & Health Leader, Nestlé India.

The discussion commenced with an opening icebreaker question to all panellists on whether failures in product innovation occurred more frequently due to science, processing, or regulatory limitations. The panellists shared diverse perspectives and agreed that successful innovation required balancing all three dimensions while also considering consumer expectations and commercial feasibility.

During the first round of discussion, the panel explored the challenge of balancing health, taste, and affordability in food innovation. The experts discussed how formulation scientists continuously worked towards achieving nutritional improvements without compromising sensory appeal or cost-effectiveness. The panel highlighted that maintaining this balance remained one of the biggest challenges for food manufacturers, particularly in large-scale consumer markets.

The discussion further addressed the evolving landscape of product claims and regulatory frameworks. The panellists emphasized the growing need for robust scientific substantiation, transparent communication, and evidence-based regulatory practices.

They discussed how recent developments in the food regulatory ecosystem were helping translate scientific innovation into acceptable regulatory evidence while ensuring consumer safety and trust.

The second round of the panel discussion focused on food additives and public perception. The panellists noted that although food additives possessed strong scientific safety data and regulatory approvals, they were increasingly being questioned by consumers. The discussion highlighted that misinformation, social media influence, and lack of scientific communication often created perception-related challenges. The experts stressed the importance of consumer education, transparent labelling, and effective science communication to bridge the gap between scientific evidence and public perception.

The panel also discussed how regulatory advancements and evolving scientific frameworks were facilitating ingredient

innovation and helping companies bring innovative products to market more efficiently. Discussions included the importance of collaboration between industry, regulators, and academia to strengthen innovation ecosystems within the food sector. The session concluded with a rapid-fire round where all panellists shared their views on what would define a successful food product over the next five years. The experts emphasized that future success would depend on a combination of improved nutrition, clean and transparent ingredient lists, sustainability, affordability, and superior sensory experience. The panel discussion was highly engaging and provided valuable insights into the practical realities, scientific challenges, and future opportunities in food product innovation.



Trigon Digipack Team at their Stall



Glanbia Stall



Vinayak Food Ingredient Stall

Session 2: Additive Systems for Enhanced Consumer Experience

The post-lunch technical session focused on ingredient systems and technologies enhancing functionality and consumer experience.

Ms Nidhi Agarwal, Sr Manager Regulatory Affairs Reliance Consumer Products delivered a



Ms Nidhi Agarwal

special talk on "Food Processing: Translating Ingredient Science into Consumer Preferred, Value-Added Products." He discussed the evolution of food ingredients from basic sustenance to strategic value addition. The presentation emphasized the importance of balancing nutrition, sensory appeal, stability, and functionality in product development. He also highlighted challenges related to climate conditions, supply chain variability, consumer perception regarding processed foods, and the increasing influence of digital activism and clean label demands.

Mr. Sanjay Singh, VP -Techno-Commercial, Nutraceuticals Vinayak Ingredients Pvt. Ltd delivered a presentation on



Mr Sanjay Singh

"Microen-capsulation: A Very Creative & Effective Solution for Nutraceuticals & Foods." He explained different microen-capsulation technologies including matrix coating, seal coating, liposomal coating, and target release systems. The presentation showcased various applications of encapsulation in bakery preservatives, vitamins, minerals, nutraceuticals, and food fortification systems. He also discussed the advantages of improved stability, controlled release, enhanced bioavailability, and sensory masking through encapsulation technologies.

Mr. Ganesh Devsarkar, Sr Manager, Technical Sales, Fine Organics Industries Ltd presented on "Speciality Emulsifiers for Innovative and Healthier Products." He highlighted the role of speciality emulsifiers in bakery, confectionery, and food applications. The presentation demonstrated



Mr Ganesh Devsarkar

how emulsifier systems improved product texture, stability, softness, machinability, shelf life, and fat reduction in products such as breads, cookies, cream biscuits, and millet

rusks. Innovative ingredient systems for healthier bakery products and chocolate applications were also discussed.

Ms. Bharti Rawat Sr Flavourist Norex Flavours Pvt. Ltd. delivered an engaging presentation on



Ms Bharti Rawat

"Importance of Flavours in Innovative Food Design." She discussed emerging global flavour trends including pineapple, ube (purple yam), sudachi, and fermented flavours. The presentation emphasized how flavours contributed to emotional appeal, cultural authenticity, wellness positioning, and sensory innovation. She also explained how evolving consumer preferences were influencing the development of adventurous and globally inspired flavour profiles in food and beverage products.

The seminar concluded with an interactive Q&A session followed by closing remarks delivered by **Dr. Malathy Venkatesan**,

Project Coordinator PFNDAI. She summarized the key learnings and discussions from the seminar.



Ms Malathy Venkatesan



Dr Bhalkar felicitating Ms Preeti Chaudhary

She highlighted the keynote presentation by Mr. Varinder Jaswal on the journey of food innovation from traditional processing to precision fermentation and emphasized the importance of balancing nutrition with sensory acceptance.

She appreciated the informative presentation by Ms. Mamta Budhiraja on sugar reduction strategies and the need for moderation in sugar consumption. Referring to the address by Ms. Pritee Chaudhary, Regional

able.

She also appreciated the presentations by Ms. Sumita Trehan on whey proteins, Mr. Akshay Telang on dietary fibres and postbiotics, Mr. Sanjay Singh on microencapsulation technologies, Mr. Ganesh Devsarkar on speciality emulsifiers, and Ms. Bharti Rawat on flavour innovations.

Dr. Venkatesan further mentioned that the panel discussion moderated by Ms.

Director, FSSAI - Western Region, Dr. Venkatesan highlighted the importance of ensuring that innovative food products are both nutritious and afford-

Subhprada Nishtala was highly engaging and brought forward important discussions on scientific communication, food misconceptions, product claims, and opportunities in millet and pulse innovations. She concluded by thanking all delegates, speakers, sponsors, and the PFNDAI team for contributing towards the success of the seminar.



Ms Dolly Soni

At the close of the seminar, Ms. Dolly Soni delivered a heartfelt vote of thanks. She expressed gratitude to all the sponsors, speakers, panellist's, delegates, and the PFNDAI team members and volunteers for their invaluable contributions in making the event a resounding success.



Webinar on 'Nutrition and Lifestyle Interventions for the Prevention and Management of Diabetes and Obesity'



Protein Foods & Nutrition Development Association of India (PFNDAI) organized a Webinar on “Nutrition and Lifestyle Interventions for the Prevention and Management of Diabetes and Obesity” on 22nd May 2026. The event was sponsored by Torrent Pharmaceuticals Ltd. and in collaboration with Diabetes India.

The welcome address of the webinar was given by **Dr Shashank Bhalkar**, Executive Director at PFNDAI.

Ms Samreen Shaikh, Jr. Food technologist at PFNDAI, introduced the speakers for the session, providing a brief about their background, qualifications, and expertise.

Dr Shashank Bhalkar, Executive Director, PFNDAI, started the webinar with the welcome address. He acknowledged the



Dr Shashank Bhalkar

AUTHOR
Ms. Sanyukta Telange,
Food Technologist &
Regulatory Support, PFNDAI

support of Torrent Pharmaceuticals Ltd. and the collaboration of Diabetes India with PFNDAI in organizing the event. He stated that rapid industrialization, urbanization, and increasingly sedentary lifestyles, coupled with changing dietary habits with higher consumption of foods rich in fat, sugar, and salt, have contributed to the growing burden of metabolic disorders. Emphasis was placed on obesity and diabetes, two major public health concerns that are closely linked to modern lifestyles. A multi-step approach involving dietary modifications, increased physical activity, and, where appropriate, medical or surgical interventions was emphasized. He expressed that the speakers, specialists in their respective fields, will give important



insights into these topics.

Dr Banshi Saboo, Secretary, from **Diabetes India**, in his opening remarks, highlighted the organization's ongoing efforts to promote diabetes awareness, prevention, early detection, and effective management. He emphasized that preventing obesity is crucial for reducing diabetes and other metabolic disorders. In India, protein intake is often inadequate, particularly among vegetarians, making it hard to meet daily requirements.



Dr Banshi Saboo



He suggested increasing protein consumption as an effective public health message for overall health and diabetes management. Along with nutrition, regular exercise and lifestyle changes are important. He also highlighted concerns about sarcopenia in individuals with diabetes, stressing adequate protein intake for both diabetics and the general population. Dr Sahoo thanked PFNDAI and Torrent Pharmaceuticals Ltd. for their collaboration with Diabetes India on this important initiative.

Dr Purvi Chawla, Consultant Diabetologist and Director of Clinical Research - Lina Diabetes Care,



Dr Purvi Chawla

delivered the talk on 'Clinical management of obesity- Emerging Approaches'. She focused on the evolving landscape of obesity management, emphasizing that obesity is now widely recognized as a chronic medical disease rather than merely a lifestyle issue or risk factor.

Excess adipose tissue can impair normal physiological functioning and is

associated with more than 200 health complications. Despite its significant health burden, less than 20% of affected individuals receive appropriate care.

She provided a brief overview of the history of anti-obesity medications and the limitations of earlier therapies due to safety concerns and adverse effects, while highlighting the improved efficacy and safety of newer incretin-based therapies, particularly GLP-1 receptor agonists and dual agonists, for long-term weight management. She explained the mechanisms of GLP-1 receptor agonists, including their effects on appetite, satiety, gastric emptying, insulin secretion, and cardiometabolic health.

Evidence from liraglutide and semaglutide was presented, demonstrating significant weight loss, improved glycaemic control, reversal of prediabetes, and reduced cardiovascular risks. She also discussed emerging therapies, including multi-receptor agonists currently under development.

Ms Sheryl Salis, Founder & Director, Nurture Health Solutions, delivered the talk on 'Nutrition in the Era of Diabetes and



Ms Sheryl Salis

Obesity'. Obesity was described as a complex chronic disease requiring an interdisciplinary approach involving physicians, dietitians, psychologists, and other healthcare professionals.

She highlighted the importance of conducting a comprehensive nutritional assessment before initiating GLP-1 RA therapy, as these medications reduce appetite and food intake, making professional dietary guidance essential to ensure adequate nutrient intake and prevent deficiencies. Participants were advised to prioritize protein intake to preserve lean muscle mass during weight reduction.

She also discussed the management of common gastrointestinal side effects associated with GLP-1 therapy, including nausea, vomiting, diarrhoea, constipation, and gastrointestinal discomfort, and outlined practical dietary strategies such as consuming smaller, more frequent meals, limiting high-fat foods, maintaining adequate hydration, and choosing easily digestible foods to improve treatment adherence. The importance of physical activity, particularly resistance and strength-training exercises, was also emphasized.



Panel Discussion
Moderator- Dr Shashank Bhalkar

A panel discussion followed the presentations with **Dr Shashank Bhalkar** as the Panel moderator and **Dr Purvi Chawla** and **Ms Sheryl Salis** as panellists.

The panel discussion highlighted the growing role of GLP-1 receptor agonists in the management of obesity and diabetes, emphasizing their ability to bridge the treatment gap between lifestyle interventions and bariatric surgery.

These therapies offer significant benefits in weight reduction and metabolic health; they must be accompanied by appropriate nutritional management and lifestyle modifications.

Key concerns discussed included the risk of nutritional deficiencies, particularly protein, vitamin

B12, calcium, iron, and other micronutrients, due to reduced food intake associated with GLP-1 therapy.

The panel also emphasised the importance of ensuring adequate protein intake, dietary diversity, supplementation where necessary, and regular monitoring for conditions such as sarcopenia.

Discussions also focused on the need for balanced diets with reduced consumption of high-fat, sugar, and salt (HFSS) foods, increased physical activity, adequate sleep, and sustained behavioural changes.

While pharmacotherapy is becoming an increasingly important tool in obesity management, long-term success depends on integrating medication with nutrition counselling, healthy eating habits, and lifestyle interventions.

At the end of the session, **Ms Samreen Shaikh** gave a vote of thanks to the webinar sponsor, speakers, and panellists, along with her PFNDAI team members for



making the webinar a success. She also thanked the attendees for patiently attending the webinar.

Ms Samreen Shaikh

The entire webinar recording is available on the following link:
<https://www.facebook.com/share/v/1LUvHsNqdS/?mibextid=wwXlfr>



REGULATORY ROUND UP



AUTHOR
Dr Shashank Bhalkar,
 Executive Director, PFNDAI
executivedirector@pfndai.org

Dear Readers,

Please find below the new notifications, orders, etc., since the last round-up

[Implementing the process for prior approval and risk assessment through the single window system \(ePAAS\)](#) :

To ensure uniformity and transparency, the food authority has decided to implement a single window system through the electronic Product and Claim Approval Application System. (e PAAS). All applications, along with a

complete dossier for the risk assessment and approval for the following shall be

submitted through the ePAAS portal: Approval of non-specified Food and Food Ingredient, r-PET authorisation, Approval of claims, Approval of Ayurveda Aahara, FSMP, Vegan endorsement, Notification of esters/derivatives/salts of vitamins, salts/chelates of minerals, and esters/derivatives/isomers/salts of amino acids, Any other food, product, process, or system for which prior approval is required by the Food Authority under the provisions of the FSS Act, 2006, and regulations made thereunder, or as notified from time to time.

All aforementioned applications seeking prior approval or authorisation shall be submitted through ePAAS from 01.06.26.

[Draft Food Safety and Standards \(Food Products Standards and Food Additives\) Amendment Regulations, 2026 relating to Minor seed oils, Edible seeds and Appendix A](#) :

The draft regulations suggest inclusion of standards of Identity for Minor seed oils (Chilly seed, Muskmelon seed, Okra seed, and Tomato seed) that include chemical parameters, permitted food additives, Contaminants levels, etc.,



Standards of Identity for Edible seeds are described. These include Edible Vegetable Seeds (watermelon, cucumber, muskmelon, pumpkin, etc.) and Edible Oil seeds (sunflower, sesame, flaxseed, etc.). Potassium Polyaspartate is proposed to be permitted in Grape wine (Appendix A - Category 14.2.3

Any comments or suggestions in the given format must be submitted within sixty days from 21.05.2026.

[Final FSS \(Contaminants, Toxins and Residues\) amendment Regulations, 2026 relating to provision of metal contaminants, naturally occurring toxic substances, and antibiotic residues](#) :

An amendment of FSS (Contaminants, Toxins and Residues) Regulation, 2011 is notified. The salient changes are as follows

- The category “Pulses” is expanded to include “Pulse

flours” under metal contaminants Lead and Cadmium

- Arsenic levels have been identified for edible fats and oils not elsewhere covered and fish oils
- More clarity has been brought in the requirements of Total Aflatoxin and Aflatoxin B1 in oil and oil seeds
- Saffrole is considered a crop contamination in beverages only if they contain mace/nutmeg kernel as an ingredient
- The Table under the clause - 2.3.2.1 - which specifies levels of Tetracycline, Oxytetracycline, Trimethoprim, Oxolinic acid has been deleted as they are covered elsewhere.
- Levels of antibiotics Trimethoprim and Oxolinic acid have been established for seafoods.

The amendment is effective from 01 December 2026.

[Draft Food Safety and Standards \(Food Safety Auditing\) Amendment Regulations, 2026 relating to qualification of auditors](#) :

This draft regulation suggests qualifications for the auditors, which are quite elaborate, covering a wide range of disciplines as compared to the earlier requirements. The draft suggests that the person should have completed the Lead auditor course in FSMS (ISO 22000).

The work experience of two years is now specified for the food industry for both internal and third-party audits. Any objections or suggestions in the given format must be submitted within sixty days from 21/05/2026.



RESEARCH IN HEALTH & NUTRITION

Microbes Boost Protein Content in Fermented Foods

The study published in *Food and Function* reveals that microbial proteins contribute far more to the nutritional profile of fermented foods than previously understood.

Researchers from North Carolina State University analysed 17 fermented and three non-fermented foods using high-resolution liquid chromatography and mass spectrometry. They found that microbial proteins can account for up to 11% of the total protein volume and as much as 60% of the individual proteins

identified. In products like brie cheese, kefir, yogurt, sour cream, and buttermilk, microbial proteins were more abundant and diverse than those derived from the original food substrates. For example, brie cheese contained 1,573 proteins, of which 65% were microbial in origin.

The findings highlight that fermentation not only transforms raw substrates into digestible foods but also significantly alters their protein composition, with yeast and bacterial proteins becoming a major part of what consumers ingest. This means that when eating bread, for instance, a substantial portion of the protein comes from yeast rather than wheat. The

researchers suggest that these microbial proteins may influence gut physiology, immune responses, and overall health, extending benefits beyond the well-known probiotic effects of fermented foods.

The study underscores the potential for engineering fermented foods with tailored microbial profiles to enhance their nutritional and functional properties. Future research will likely explore how these microbial proteins interact with the gut microbiome and immune system, possibly opening new avenues for functional food development. The work adds to a growing body of evidence that fermented foods are not only carriers of beneficial microbes but also sources of unique microbial proteins that may play a direct role in human health.

<https://www.nutritioninsight.com/news/fermentation-food-gut-microbes-bacteria-protein-probiotics.html>

Nutrition Industry Should Engage with Social Media Health Influencers

The article highlights call for the nutrition industry to take social media health influencers seriously, especially given their impact on Gen Z supplement choices.

Bettina Bendig, Balchem's director of marketing, explains that influencers shape purchasing decisions but often

oversimplify or misrepresent science. Rather than avoiding them, brands should engage strategically by partnering with credentialed creators, providing pre-approved claims, and ensuring regulatory review at every stage. She emphasizes influencer training, monitoring audience reactions, and correcting misinformation quickly to maintain credibility.

The risks of viral fads are significant. Narratives like "carbs = inflammation" encourage restrictive eating patterns that undermine long-term metabolic health and can disrupt adherence to GLP-1

therapies. Cutting carbohydrates reduces essential fibre and nutrients, weakening glycemic control and gut health. Bendig warns that misinformation is becoming a public health threat comparable to sugar, as it drives confusion and relapse into unsustainable habits.

The approach is to make science accessible and transparent. They stress visible human evidence, clear dosing, and safety data, alongside simple, compliant language that brands can use to educate consumers. Their branded ingredients are promoted

with substantiated claims and expert-backed communication. The company sees its role as enabling accurate messaging by equipping brands and

influencers with the tools to share science responsibly. In this way, they aim to counter misinformation at scale and build trust in nutrition

solutions.

<https://www.nutritioninsight.com/news/balchem-social-media-influencers.html>

Longvida Vs. Standard Curcumin: How to Bridge the Bioavailability Gap

The article compares Longvida curcumin formulation with standard curcumin, focusing on how it bridges the bioavailability gap.

Standard curcumin is poorly absorbed, not water soluble, and quickly broken down in the digestive tract, delivering mostly inactive conjugates with short plasma half-lives. Longvida, developed at UCLA, uses a lipid-based delivery system that protects curcumin

through digestion and channels it into the lymphatic system as free curcumin, the biologically active form. This results in 67-285 times greater bioavailability, with a plasma half-life of about 7.5 hours compared to less than one hour for standard curcumin.

Clinical trials highlight Longvida's cognitive benefits. At 400 mg daily, participants saw improvements in spatial memory by 31% and working memory by nearly 20%. Other studies reported enhanced mood, reduced fatigue and anxiety, and acute improvements in attention and working memory within an hour of a single dose. Longvida has

been tested in nearly 40 human trials, making it one of the most substantiated cognitive health ingredients available. Research also suggests potential benefits in lowering hemoglobin A1c in prediabetic adults, improving vascular endothelial function, and supporting quality of life in cancer patients undergoing therapy. Early findings even show reductions in plasma beta-amyloid and detection of retinal amyloid spots, pointing to possible relevance in Alzheimer's research.

<https://www.nutritioninsight.com/news/verdure-sciences-longvida-curcumin-clinical-evidence-cognitive.html>

Saffron Extract's Clinical Efficacy in Boosting Vision Health

Saffron-based ingredient is presented as a next-generation nutraceutical for vision health, standardized to contain 3.1-5% crocuvialides.

This complex combines crocins, known for their antioxidant properties, with kaempferol glycosides that support anti-inflammatory activity. The extract is concentrated and

stabilized at low temperatures without chemicals, ensuring both potency and sustainability.

Clinical studies demonstrate triple mechanism of action – antioxidant, anti-inflammatory, and anti-apoptotic – in protecting retinal cells. Research published in the *International Journal of Molecular Sciences* showed that the extract reduced retinal ganglion cell death in mice with laser-induced ocular hypertension, mimicking glaucoma damage.

Neuroprotective effects were observed up to seven days post-induction, with peak benefits on the third and seventh days. Additional findings in the *Journal of Clinical Medicine* revealed that saffron extract prevented harmful cytokine imbalances and modulated the NF-κB inflammatory pathway, blocking destructive immune responses that typically lead to blindness in glaucoma.

<https://www.nutritioninsight.com/news/affroneye-saffron-extract-pharmactive-eye-supplements.html>

Scientists Engineer Gut Bacteria to Treat Mental Health Issues in Liver Disease

Scientists at the National University of Singapore have developed a groundbreaking

“living medicine” approach to treat hepatic encephalopathy, a neurological

complication of liver disease characterized by anxiety, confusion, memory loss, and in severe cases, coma.

The condition arises when the liver fails to filter toxins such as ammonia, which then accumulate in the brain. Current treatments like lactulose and rifaximin reduce ammonia but fail to address the broader metabolic imbalances driving the disease, and

rifaximin can disrupt the gut microbiome.

The NUS team engineered two strains of the probiotic bacterium *Lactobacillus plantarum* WCFS1 to act as programmable therapeutics. One strain absorbs excess ammonia and converts it into branched-chain amino acids, nutrients often depleted in patients. The other strain prevents L-glutamine from being converted into ammonia, cutting off a major source of the toxin. In mouse models, daily administration of this bacterial cocktail reduced circulating ammonia by up to tenfold, restored metabolic balance, and normalized brain

ammonia levels to those seen in healthy conditions. The treatment also improved anxiety-like behaviours, cognitive function, neuronal signalling, and reduced neuroinflammation, outperforming rifaximin while preserving gut microbial diversity.

Published in *Cell*, the study demonstrated that these engineered strains were well tolerated, showed no systemic toxicity, and were cleared within 72 hours after dosing. The modular design of the bacteria means they can be adapted to target other metabolic and neurological disorders involving the gut-

liver-brain axis, such as urea-cycle defects and hyperammonemic conditions. The researchers have filed a patent and plan to expand their portfolio of engineered microbes, aiming to translate this work into clinical therapies. This innovation represents a new class of precision, microbe-based therapeutics capable of coordinating multiple metabolic corrections simultaneously, offering a promising alternative to conventional single-target treatments.

<https://www.nutritioninsight.com/news/gut-bacteria-microbiome-liver-cirrhosis-brain.html>

Why An Understudied Group of Gut Bacteria Could Transform Probiotic Science

A global meta-analysis of more than 11,000 gut microbiome samples has revealed over 3,000 previously unknown bacterial species, with one genus, CAG-170, standing out as a consistent marker of good health.

The study, published in *Cell Host and Microbe*, constructed a comprehensive reference catalogue of gut microbiome species by cross-referencing samples from 39 countries against the Unified Human Gastrointestinal Genome catalogue. Researchers compared microbiomes from more than 6,000 healthy individuals with those affected by 13 noncommunicable diseases, including Crohn's disease, obesity, colorectal cancer, Parkinson's disease, and

multiple sclerosis. Of the 4,612 bacterial species identified, 3,067 had not been previously characterized, and CAG-170, belonging to the family Oscillospiraceae, emerged as particularly significant.

CAG-170 comprises 13 species, 11 of which showed strong associations with good health, with two species especially linked to the absence of Crohn's disease and ulcerative colitis. Functional analysis revealed that CAG-170 can synthesise high levels of vitamin B12 and produce enzymes that break down carbohydrates, sugars, and fibres. Importantly, its abundance was consistently reduced across all 13 disease states studied, regardless of geography or diet, though the data did not establish whether this reduction was a cause or consequence of disease. Researchers noted that gut inflammation, as seen in inflammatory bowel disease, likely disrupts the environment and diminishes beneficial

bacteria such as CAG-170.

The findings highlight a gap between microbiome science and the probiotic industry, which continues to rely on traditional genera like *Bifidobacterium* and *Lactobacillus*. The discovery of CAG-170 suggests that many overlooked species could hold significant health benefits if harnessed in probiotic development. However, bringing such species to market would require isolating and culturing them, assessing safety and toxicity, and securing regulatory approval. This study underscores the potential of newly identified bacterial groups to reshape probiotic science and broaden the scope of dietary supplements aimed at supporting human health.

<https://www.vitafoodsinsights.com/probiotics-prebiotics-postbiotics/why-an-understudied-group-of-gut-bacteria-could-transform-probiotic-science>



Digital Gut Twins Are a Step Closer to Predicting Probiotic Success

The article explores how cutting-edge microbiome modelling is advancing the concept of “digital gut twins,” virtual simulations of an individual’s gut ecosystem designed to predict the success of probiotic interventions with far greater precision than current methods.

Traditional probiotic science has often relied on a simplistic binary view of microbes as either “good” or “bad,” but this framework fails to capture the immense complexity of microbial communities and their context-dependent effects. Researchers now emphasize that the health impact of bacteria is not universal; it is shaped by the intricate interplay of microbial species, host genetics, diet, and environmental factors unique to each person.

Digital gut twins aim to

integrate these variables into dynamic computational models that replicate the metabolic capacities and ecological interactions of the gut microbiome. By simulating how different bacterial strains metabolize nutrients, produce bioactive compounds, and interact with resident microbes, scientists can forecast how a probiotic will behave in a specific individual. This predictive capacity could transform probiotic development, shifting from generalized supplements toward precision biotics tailored to the microbiome profile of each patient or consumer.

The implications are profound. Personalized gut models could help identify which probiotic strains are most likely to restore balance in cases of dysbiosis, support immune function, or enhance nutrient absorption. They could also reduce the trial-and-error nature of current probiotic use, where effectiveness varies widely between individuals. Moreover, digital twins could accelerate research by allowing

scientists to test thousands of hypothetical interventions in silico before moving to clinical trials, saving time and resources while narrowing the focus to the most promising candidates.

This approach underscores the recognition that the gut microbiome is not a static entity but a dynamic ecosystem, sensitive to diet, lifestyle, and disease states. By embracing predictive modelling, the field of probiotics may finally move beyond the limited repertoire of strains that have dominated the market for decades, opening the door to novel species with targeted health benefits. In essence, digital gut twins represent a new frontier in microbiome science—one that could redefine how probiotics are designed, tested, and prescribed, ushering in an era of truly personalized nutrition and medicine.

<https://www.nutraingredients.com/Article/2026/03/30/digital-gut-twins-are-a-step-closer-to-predicting-probiotic-success/>



The Aging Microbiome and Its Connection to Muscle Decline

The age-related changes in the gut microbiome may contribute to muscle decline, a condition known as sarcopenia.

As people age, microbial diversity tends to decrease and intestinal barrier function weakens, which can lead to systemic inflammation and impaired nutrient absorption. Researchers are increasingly

investigating how these shifts in microbial composition and gut barrier integrity might directly influence muscle health in older adults.

The review discussed in the piece emphasizes that the gut-muscle axis could be a critical factor in healthy aging. Alterations in the microbiome may reduce the production of metabolites essential for muscle maintenance, while increased gut permeability can exacerbate inflammation, further accelerating muscle loss. This connection suggests that interventions targeting the microbiome—such as prebiotics,

probiotics, or postbiotics—could play a role in preventing or managing sarcopenia.

The research within the broader context of rising global concern about muscle decline in aging populations points to emerging strategies that combine nutritional support with microbiome modulation, underscoring the potential for gut-focused therapies to complement traditional approaches to muscle health.

<https://www.nutraingredients.com/Article/2026/03/17/the-aging-microbiome-and-its-connection-to-muscle-decline/>

Low-Dose Ashwagandha Effective for Exercise Endurance and Overall Performance: RCT

A randomized, double-blind, placebo-controlled trial has shown that a low daily dose of ashwagandha can significantly improve exercise endurance and cardiorespiratory performance.

The study tested a root-derived ingredient standardized to 15% withanolides and 15% of a unique ATP-active fraction. Sixty-six healthy adults supplemented with 30 mg per

day for eight weeks demonstrated a 10.1% increase in VO₂max compared to just 1.2% in the placebo group. They also showed higher maximal heart rates, lower lactic acid accumulation, and reduced creatine phosphokinase (CPK) levels, indicating less muscle damage and prolonged aerobic metabolism.

Participants reported improved ratings of perceived exertion and reduced fatigue, while blood, liver, kidney, and metabolic parameters remained within normal ranges, confirming safety. The product was well tolerated with no

adverse events. Researchers concluded that low-dose ashwagandha supplementation enhances cardiovascular response, delays fatigue onset, and supports endurance performance in healthy adults. Findings highlight the potential of ashwagandha as a clinically validated, low-dose adaptogen that can be integrated into modern nutrition formats, aligning with consumer demand for precise, efficient, and science-backed performance solutions.

<https://www.nutraingredients.com/Article/2026/04/07/low-dose-ashwagandha-effective-for-exercise-endurance-and-overall-performance/>

Japan Study Links Eating Rice to Better Weight Control

A recent study conducted in Hyogo Prefecture, Japan, examined the relationship between rice consumption, dietary behaviours, and weight management among middle-aged adults aged 40 to 59 years.

The research involved 577 participants and assessed healthy diet scores, weight control practices, and eating patterns such as frequency of rice consumption, eating out, and reliance on ready-to-eat meals. The findings showed that maintaining appropriate weight for the prevention of non-communicable diseases was strongly associated with healthy diets that included balanced meals, regular breakfast consumption, and frequent intake of vegetable-based dishes. Rice consumption

was positively linked to healthier diet scores in both men and women, supporting the idea that rice plays a role in promoting balanced eating patterns.

The study highlighted the traditional Japanese washoku meal structure, which emphasizes harmony and balance through a combination of rice, soup, and multiple side dishes. This approach encourages higher vegetable and fibre intake and lower fat consumption, contributing to better weight control. Eating rice, particularly at breakfast, was associated with more complete and balanced meals throughout the day. By contrast, frequent eating out and reliance on ready-to-eat meals were linked to poorer diet quality, with vegetables often being omitted. These findings align with previous research in Japan and abroad, including studies in the United States, which showed that rice consumers tend to have higher

dietary quality.

The researchers concluded that rice may serve as a potential aid for sustainable healthy diets, even in regions where it is not a staple food. However, they cautioned that further research is needed to clarify the relationship between rice consumption and weight management, particularly distinguishing between white and brown rice and conducting longitudinal studies to establish causality. They also emphasized the importance of balanced intake across food groups, in line with World Health Organization recommendations. The study suggests that policies encouraging healthier food environments, such as offering low-salt meals with ample vegetables and fruits, could support weight management and help prevent non-communicable diseases.

<https://www.foodnavigator-asia.com/Article/2026/03/09/japan-study-links-eating-rice-to-better-weight-control/>

How Protein and Fibre Are Reshaping Healthy Beverage Innovation

& FOOD SCIENCE INDUSTRY NEWS

The transformation of the healthy beverage industry, where the emphasis is shifting away from restrictive dieting and toward functional nourishment, with protein and fibre emerging as central drivers of innovation.

It underscores how consumer priorities have evolved: rather than focusing solely on reducing calories, sugar, or fat, people are increasingly seeking beverages that actively contribute to satiety, digestive health, and sustained energy throughout the day. This change reflects a deeper cultural movement toward wellness, where food and drink are expected to play a proactive role in supporting long-term health.

Manufacturers are responding to these demands by

experimenting with plant-based proteins such as pea, soy, and hemp, alongside soluble fibres like inulin and resistant starches. These ingredients are not only chosen for their nutritional benefits but also for their ability to enhance mouthfeel, improve texture, and create a more satisfying drinking experience. The challenge lies in balancing functionality with indulgence, ensuring that beverages remain enjoyable while delivering measurable health benefits. Advances in formulation technology are helping producers overcome issues such as grittiness, bitterness, or instability, making it possible to create drinks that are both palatable and nutritionally robust.

This trend within the broader landscape of food and beverage

innovation, where functionality has become a defining characteristic. Consumers now expect products to go beyond the avoidance of harmful components and instead provide tangible contributions to well-being, whether through immune support, gut health, or sustained energy release. This has led to a surge in hybrid beverages that blur the lines between categories, such as protein-infused waters, fibre-rich smoothies, and functional teas, each designed to meet specific lifestyle needs. The movement reflects a growing recognition that health is not about deprivation but about empowerment, with beverages serving as convenient vehicles for nutrition, performance, and pleasure.

<https://www.foodingredientsfirst.com/news/protein-fiber-functional-beverage-shift.html>

Protein off-notes with neuroscience-driven taste masking

OSF Flavors has introduced a neuroscience-driven flavour masking technology designed to tackle the persistent issue of protein off-notes in beverages, dairy, and bakery products.

The innovation focuses on neutralizing bitterness, astringency, metallic notes, and other undesirable sensory elements by modulating taste receptors and balancing aromatic profiles, rather than

simply overwhelming them with added sweetness or stronger flavours. This approach creates a cleaner, more integrated flavour experience that enhances palatability while maintaining natural and organic positioning, which aligns with consumer demand for “clean label” products.

The technology differs from conventional masking methods by directly suppressing or softening the off-notes before building the desired flavour profile. This layered strategy allows manufacturers to

reduce the amount of added flavouring, resulting in cost efficiency and a more coherent sensory outcome. Each product category presents unique challenges: ready-to-drink protein beverages expose defects due to low fat and viscosity, dairy systems require balancing complex interactions between protein, fat, acidity, and fermentation notes, and bakery products introduce new volatiles during thermal processing that shift flavour dynamics. OSF Flavors' system addresses these complexities through a combination of taste modulation, aroma balancing, and mouthfeel support.

The company's work highlights the role of neuroscience in understanding how consumers perceive flavour, integrating gustatory input, aroma, mouthfeel, and trigeminal signals such as cooling or tingling. By leveraging these pathways, OSF Flavors enhances the overall sensory

experience and reduces flavour fatigue. This development is part of a broader industry movement to solve the plant-based taste challenge, where protein innovation alone is insufficient without addressing sensory barriers.

advanced masking techniques, but OSF Flavors emphasizes its decades-long expertise, beginning with soy systems and expanding into whey, pea, rice, oat, and fermentation-derived proteins.

<https://www.foodingredientsfirst.com/news/osf-flavor-masking-neuroscience-proteins.html>

Competitors are also exploring

New Textured Vegetable Proteins Enhance Taste and Juiciness in Plant-Based Meats

dsm-firmenich has introduced Vertis Textured Vegetable Proteins (TVPs), incorporating its ModulaSense technology to address persistent taste challenges in plant-based and hybrid meat products.

The innovation is designed to reduce bitterness and earthy off-notes while enhancing juiciness and texture, two qualities that have historically limited consumer acceptance of meat alternatives. By embedding taste modulation directly into the protein ingredient, the system reduces

reliance on external masking agents and simplifies formulation, offering manufacturers a cleaner, more cost-efficient solution.

The TVPs are available in minced formats with protein contents of 55% (P55m) and 65% (P65m), providing a naturally neutral flavour profile suitable for applications such as burgers, sausages, meatballs, and hybrid concepts. Their pale-yellow colour integrates seamlessly into both plant-based and meat matrices, supporting visual appeal alongside taste improvements. ModulaSense acts at the molecular level to suppress bitterness and beany notes, functioning as a precision masker that can be incorporated during extrusion, thereby streamlining

production processes.

The launch comes at a time when taste remains the most significant barrier to repeat purchases in the plant-based sector, with consumers dissatisfied with current offerings. Research indicates that juiciness, tied to hydration and protein structure, is a critical sensory factor, and Vertis TVPs address this by combining high protein content with strong water-binding properties. This ensures that products maintain structure and release moisture during consumption, mimicking the sensory experience of meat more closely.

<https://www.foodingredientsfirst.com/news/dsm-firmenichs-new-textured-vegetable-proteins-enhance-taste-and-juiciness-in-plant-based-meats.html>

Scientists Tackle Flaxseed Oil Bitterness to Improve Flavour Stability and Shelf Life

Scientists at the Leibniz Institute for Food Systems Biology at the Technical University of Munich have developed a method to significantly reduce bitterness in flaxseed oil, thereby improving its flavour stability and extending shelf life.

Flaxseed oil, valued for its high omega 3 content and health benefits, typically develops unpleasant bitter notes during storage due to the oxidation of cyclolinopeptides. The research team, led by Roman Lang, identified these compounds as the primary cause of bitterness and devised a treatment using bleaching earth, a magnesium aluminium silicate already approved for edible oil refining.

In their study, flaxseed oil was mixed with bleaching earth, stirred, and then separated by centrifugation. This process

reduced cyclolinopeptides by more than 80% without altering the oil's colour, odour, or fatty acid profile.

Sensory tests confirmed that treated oil retained a mild, fresh taste even after nine weeks of storage, while untreated oil became increasingly bitter. The method offers a sustainable solution that avoids chemical additives or complex refining, aligning with consumer demand for natural and eco friendly products.

The findings are particularly relevant for food and beverage manufacturers seeking to deliver omega 3 rich products with consistent flavour quality. By extending shelf life and reducing waste, the approach supports both consumer

acceptance and sustainability goals. Looking ahead, the researchers plan to refine the process further by studying optimal material combinations, treatment durations, and the stability of polyunsaturated fatty acids, ensuring that

flaxseed oil remains a viable and appealing option in the growing market for plant based health foods.

<https://www.foodingredientsfirst.com/news/flaxseed-oil-flavor-stability-shelf-life.html>

Natural Colour Innovations Approach Synthetic-Level Performance as Biotech Reshapes F&B

Biotechnology is driving a new wave of innovation in natural food colours, pushing them closer to the performance levels traditionally associated with synthetic dyes.

Advances in fermentation, precision extraction, and molecular tailoring are enabling natural pigments to achieve greater stability, vibrancy, and versatility across diverse food and beverage applications. This progress is particularly

significant as regulatory pressure and consumer demand for clean label products accelerate the shift away from artificial ingredients. Companies are investing heavily in scaling production and refining supply chains to ensure that natural colours can meet both compliance requirements and market expectations.

The industry is witnessing breakthroughs in areas such as microalgae derived blues, carotenoid based yellows and oranges, and anthocyanin rich reds and purples, each offering improved pH stability, heat resistance, and shelf life. These developments are reshaping product development pipelines, allowing manufacturers to

reformulate without compromising visual appeal or functionality. Natural colours are increasingly being positioned not only as replacements for synthetics but also as premium ingredients associated with health, authenticity, and sustainability. As biotech solutions mature, they are enabling natural pigments to deliver consistent performance at scale, signalling a pivotal moment in the food colour sector where compliance, consumer trust, and innovation converge to redefine the future of colour in food and beverage products.

<https://www.foodingredientsfirst.com/news/natural-food-colors-innovation-biotech-clean-label.html>

Magnesium Salt Blend Delivers Simplified Sodium Reduction For F&B

Nedmag has introduced Novasal Blend, a magnesium-based salt solution designed to simplify sodium reduction in food production. The blend combines sodium chloride with Novasal Pure, a magnesium salt ingredient, and functions as a direct one-to-one replacement for regular salt.

This approach reduces sodium content by 30% while adding magnesium, a mineral with

strong consumer appeal, without requiring recipe reformulation or process adjustments. The innovation is positioned as a practical solution for manufacturers under pressure from public health targets, retailer nutrition profiling, and labelling systems such as Nutri-Score, which directly incentivize lower sodium levels.

Novasal Blend is suitable for a wide range of applications, including bakery, dairy, soups, sauces, plant-based products, meat, fish, and prepared meals. Its compatibility with existing recipes makes it particularly valuable in categories like ready meals and soups, where operational

simplicity is critical. The ingredient is sourced from the Zechstein Sea, ensuring consistent quality and a reliable European supply chain. Nedmag emphasizes that the blend maintains taste, texture, and technical performance, addressing the common concern that sodium reduction compromises sensory quality.

Real-world applications illustrate its effectiveness. In Dutch speculaas biscuits, replacing 40% of sodium salt with Novasal maintained flavour and authenticity while reducing sodium. In De Veendam Old 50+ cheese, the blend preserved ripening quality and taste while contributing magnesium.

In Mr. Kitchen's Veggie Spread, Novasal helped shift products from Nutri-Score B and C ratings to A, demonstrating its ability to improve nutrition profiles without reformulation

complexity. By offering a straightforward, ready-to-use solution, Novasal Blend positions itself as a scalable and consumer-friendly route to sodium reduction, aligning

health goals with taste and production efficiency.
<https://www.foodingredientsfirst.com/news/nedmag-novasal-blend-sodium-reduction-salt-replacement.html>

Fortification Vs Processing: Why The Line Is Blurring in Food Design

The distinction between fortification and processing in food design is becoming increasingly blurred.

Experts in fats and oils argue that reformulating foods to be more nutrient-dense, functional, and appealing requires smarter processing rather than less. Consumers often express concern about ultra-processed foods, yet simultaneously demand fortified products with added nutrients, creating a paradox that food scientists and technologists are working to resolve.

Processing is described as a prerequisite for nutrient

design, enabling the addition of beneficial compounds while removing stigmatized ingredients such as emulsifiers, artificial colours, excess sugars, or salts. However, reformulation is complex, likened to a Jenga tower where altering one component can destabilize the entire product. Food scientists emphasize that ingredients like salt, fats, and sugars play critical roles in hydration, stability, flavour release, and structure, making their replacement a delicate task.

The role of fats is highlighted as both nutritional and functional. Beyond the distinction between saturated and unsaturated fats, they are powerful tools for delivering texture, satiety, and flavour stability. This is particularly relevant for consumers such as GLP-1 patients who require smaller, nutrient-packed

portions. Ultimately, experts stress that functionality and consumer experience matter as much as nutrient density.

The discussion also extends to molecular and emotional nutrition. Leaders in food technology suggest that the future of food design should not only ensure that molecules meet nutritional needs but also preserve the joy of eating. Accountability, trust, and integrity in how foods are processed and fortified are seen as essential to bridging consumer scepticism. The future of food will depend on reframing processing as a necessary and innovative tool for delivering healthier, more enjoyable products.

<https://www.foodnavigator-usa.com/Article/2026/04/01/fortification-vs-processing-why-the-line-is-blurring-in-food-design/>

Texture Innovation: Confectionery's Next Frontier

The article explores how texture has become the new frontier in confectionery innovation, shifting from a supporting role to a central driver of consumer appeal.

While taste remains essential, texture now defines the sensory experience of sweets and chocolates, from the snap of a bar to the chew of a gummy. Analysts note that

consumers increasingly seek indulgent, multi-sensory products, where mouthfeel, sound, and visual impact combine to elevate enjoyment.

Chocolate is a prime example of this evolution. Hyper-textural formats like Dubai chocolate and Angel Hair chocolate have surged in popularity, while global launches increasingly highlight descriptors such as crunchy, smooth, or chunky. Novel creations like Tokyo-style chocolate and Abu Dhabi chocolate are competing to become the next viral

sensation. Storytelling around texture is also gaining traction, with brands like Meiji using patented production methods to create unique textures and build compelling narratives that resonate with consumers.

In sweets, freeze-drying has emerged as a transformative technique, delivering ultra-light crunch and clean-label appeal. Viral products such as freeze-dried Skittles have captured attention on social media, with their dramatic puffed appearance and ASMR-friendly crunch fuelling widespread popularity.

Freeze-dried chocolate is now following suit, offering aerated structures and intensified flavours that create surprising new eating experiences.

For manufacturers, texture innovation represents a strategic opportunity to differentiate in a crowded market. Investments in

technologies such as aeration, precision layering, scalable freeze-drying, and bespoke moulding can deliver products that feel premium and exciting.

With social platforms amplifying bold textures and sensory experiences, confectionery brands have more avenues than ever to

engage younger audiences and drive viral success. The texture, long overlooked, is finally receiving the attention it deserves as a defining element of confectionery's future.

<https://www.foodnavigator-usa.com/Article/2026/03/31/texture-innovation-the-future-of-confectionery/>

From India to Japan: What's happening in the functional protein space?

The functional protein sector across India and Japan is undergoing rapid transformation, driven by both consumer demand and industry innovation.

In India, the market has expanded significantly in the past two years, fuelled by the ability to manufacture protein powders locally rather than relying on imports. This shift has lowered costs and enabled the creation of localized variants such as protein-fortified wheat flour, milk, lassi, and shakes.

Major players like Amul have embraced protein fortification in everyday foods, while startups have introduced clean-label whey protein products. The sector has also seen consolidation, with FMCG giants

acquiring plant-based protein companies like Cosmix and Oziva.

India's protein supplement market, valued at US\$860 million in 2024, is projected to nearly double by 2033, with growth extending into tier-2 and tier-3 cities and consumer interest rising in flavoured, ready-to-drink, and plant-based options.

Japan's protein market is characterized by a focus on high-protein loads and sophisticated formats. Danone has prioritized innovation under its Oikos brand, launching a ready-to-drink protein beverage containing 25 grams of protein per 240ml, the highest in its history, alongside essential amino acids and vitamins.

This product targets individuals engaged in strength training and high-intensity exercise, reflecting the demand for 20 grams or more of protein post-workout. The company has also expanded its protein yogurt line, highlighting the

diversification of formats beyond powders and shakes. The Japanese market emphasizes protein products that deliver functional benefits, aligning with broader consumer trends toward active lifestyles and recovery-focused nutrition.

Together, these developments illustrate how protein is evolving from a niche sports supplement into a mainstream functional ingredient across Asia.

In India, affordability and localization are key drivers, while in Japan, innovation in dosage and format is central.

Both markets reflect a broader global trend where protein is no longer consumed simply for its nutritional value but is increasingly integrated into products that support specific health outcomes, convenience, and lifestyle needs.

<https://www.nutraingredients.com/Article/2026/04/01/functional-protein-trends-from-india-to-japan-and-australia/>



REGULATORY NEWS

India Bans Ashwagandha Leaf Use In Any Form Industry Reacts

India's Ministry of Ayush has issued an advisory banning the use of ashwagandha leaves in any form—whether crude, extract, or incorporated into food products—effective April 16, 2026.

The decision surprised many in the nutraceutical and herbal supplement industry, as ashwagandha has long been

used in Ayurvedic and Unani medicine as an adaptogen to help the body resist stress.

The restriction applies specifically to leaves, not roots, which remain permitted. Industry stakeholders expressed concern over the suddenness of the move, noting that leaves are used in certain formulations and that research has previously suggested safety at high doses. The ban raises questions about supply chains, product

reformulation, and regulatory consistency, particularly given the global popularity of ashwagandha in functional foods and supplements.

The announcement has prompted debate within the sector, with some pointing to the need for clearer scientific justification and others emphasizing the importance of aligning with traditional practices that historically favor root use. The industry is now assessing how to adapt formulations and communicate changes to consumers in light of the new regulatory landscape.

<https://www.nutraingredients.com/Article/2026/04/28/india-bans-ashwagandha-leaf-use-in-any-form-industry-reacts/>

Color-Coded Nutrition Labels Linked to Healthier Consumer Food Choices

The study published in *Current Psychology* highlights how color-coded nutrition labels outperform traditional text-based tables in guiding healthier consumer choices.

Researchers from SWPS University in Poland, alongside colleagues from the University of Wisconsin and the University of Massachusetts, found that colours are processed more quickly by the brain than text, allowing consumers to make instinctive decisions with less effort. Red labels, signalling high fat or sugar, triggered a strong “negative bias,” causing participants to pause and reconsider unhealthy purchases, while green labels indicated healthier options. This asymmetry was far more effective than traditional

labelling, where consumers often struggled to interpret nutrient information.

The urgency of such interventions is underscored by the tripling rates of obesity among U.S. youth over the past three decades, with 37% of children obese and 34% overweight or at risk. Reduced physical activity and overconsumption of high-fat, high-sugar foods are the primary drivers. In Europe, traffic-light labelling systems are already widely used, with the UK coding foods green if they contain less than 15% of the reference intake for nutrients and red if they exceed 25%. These systems simplify decision-making by clearly showing risks and benefits, regardless of a consumer's nutrition literacy.

The experiment involved 79 U.S. participants recruited via Amazon's Mechanical Turk, who rated products such as ranch

dressing, peanut butter, and chicken noodle soup. Products with color-coded labels were consistently judged more accurately than those with traditional front-of-pack text. The findings reinforce theories that negative cues exert stronger influence on behaviour than positive ones, making red particularly impactful in discouraging unhealthy purchases. Professor Andrzej Falkowski of SWPS University emphasized that this “negative bias” is what makes colour systems so effective.

The researchers argue that color-coded labelling represents a simple yet powerful public health tool to combat obesity and poor dietary habits. They note that traditional nutrition information, such as “low fat,” often fails to communicate risks clearly, while colour cues are universally understood. Related research has also proposed

simplified “high in” labels for saturated fat, sodium, and added sugar, which may outperform the FDA’s Nutrition Info Box that tends to favour consumers with higher nutrition

literacy. Collectively, these findings suggest that interpretive, colour-based systems could bridge knowledge gaps and encourage healthier food choices across diverse

populations.

<https://www.nutritioninsight.com/news/color-coded-food-labels-obesity.html>

UK Bans High-Sugar and Deep-Fried Foods from School Menus to Boost Children’s Health

The UK has announced a major reform of its School Food Standards, banning high-sugar and deep-fried foods from school menus for the first time in over a decade.

The initiative is designed to tackle childhood obesity, with one in three primary school children currently overweight or obese. Education Secretary Bridget Phillipson described the move as the most ambitious overhaul of school food in a generation, emphasizing the importance of nutritious meals that children enjoy and that support learning and health. The new standards will replace unhealthy options with fruit, vegetables, and whole grains, while also expanding free breakfast clubs to reach 142,000 children. Enforcement of the standards is scheduled for September 2027, though schools ready to adopt them

earlier are encouraged to do so.

The reforms respond to widespread parental concerns, with 74% reporting issues about their children’s nutrition, particularly excessive sugar and fatty foods. To improve transparency, schools will be required to publish menus and appoint food governors to oversee compliance. The government has shared examples of healthier menus featuring dishes such as spaghetti Bolognese, burritos, cottage pie with root-veg mash, jerk chicken with rice and peas, and roasted chickpea wraps. Health Minister Sharon Hodgson highlighted that children currently consume twice the recommended amount of free sugar, making school meals a critical intervention to reduce obesity and improve long-term health outcomes.

The initiative has received strong support from campaigners, chefs, and public health advocates. Dame Emma Thompson, Jamie Oliver, and

Henry Dimbleby praised the reforms as a landmark moment for children’s health, with Oliver noting that school meals represent the UK’s most important restaurant chain, providing two-thirds of a child’s daily diet during term time. Naomi Duncan of Chefs in Schools emphasized the importance of serving more fruit, vegetables, and fibre, while schools like The Grove in Devon are already integrating food education into their curriculum and sourcing produce locally. The policy aligns with international efforts, as countries such as Jamaica, Spain, Mexico, and Ukraine have also taken steps to improve school meals. In the U.S., health experts have urged the removal of processed meats from school menus as part of updated nutrition standards. Overall, the UK’s new approach is positioned as a transformative step toward raising a healthier generation and reducing the long-term burden of diet-related disease.

<https://www.nutritioninsight.com/news/uk-school-food-overhaul.html>

UK Experts Call for Optional Calorie Labelling Policy to Tackle Eating Disorders

labelling on individuals with eating disorders.

Surveying 1,001 people in England who had been diagnosed with an eating disorder, researchers found that while calorie labels on menus helped some participants—particularly binge eaters, older men, and those with higher BMIs—by giving them a sense of control, they worsened

symptoms for about half of respondents, especially those with restrictive disorders such as anorexia nervosa. This divergence underscores the challenge of designing public health policies that balance obesity prevention with the needs of vulnerable groups. Since 2022, UK foodservice businesses with more than 250 employees

The study from University College London and King’s College London highlights the complex impact of calorie

have been required to display calorie counts on menus, a measure intended to curb obesity. However, the study revealed that mandatory calorie labelling can act as a relapse trigger for individuals recovering from restrictive eating disorders. Researchers therefore recommend optional approaches, such as QR code-based calorie information, which 64% of participants ranked as their preferred policy. This method allows those who benefit from calorie information to access it, while reducing harm for those negatively affected. Broader nutritional information emphasizing positive aspects of food was also suggested as a complementary approach.

The findings are particularly significant ahead of the government's scheduled 2027 review of the policy. Lead author Dr. Nora Trompeter noted that binge eating disorder is often underrepresented in research, yet more than half of the study's participants reported regular binge eating. Corresponding author Dr. Tom Jewell emphasized that eating disorders are highly recurrent, with relapse rates of 30-40% within ten years, making it essential for public health policies to consider both current and past cases. The study also categorized negative responses into groups, ranging from moderate discomfort to strong avoidance of venues with

calorie-labelled menus. Positive feedback included comments that calorie information reduced anxiety in social dining situations.

Overall, the research illustrates that while calorie labelling can support obesity reduction goals, it also carries unintended consequences for people with eating disorders. Optional, flexible labelling strategies—such as QR codes—may provide a more balanced solution, ensuring that public health measures do not inadvertently harm those most at risk.

<https://www.nutritioninsight.com/news/calorie-labels-eating-disorders.html>

US States Create New Ultra-Processed Food Definitions Amid Federal Delay

The JAMA Health Forum analysis shows that U.S. states are moving ahead with their own definitions of ultra-processed foods (UPFs) while federal regulators remain without a national consensus.

At least 17 states have passed or proposed laws, often targeting school meals, but many definitions are narrow and miss the broader harms linked to UPFs. Arizona, for example, limits its definition to foods containing 11 additives, capturing only a small subset. California's law requires foods to be both industrially processed and high in sodium, sugar, or saturated fat, which critics argue creates loopholes for "fake healthy" reformulated products that still contain harmful industrial ingredients.

Massachusetts' bill stands out as the most scientifically aligned, closely matching the Nova classification system and explicitly including nitrates and nitrites found in processed meats, which are associated with cardiovascular disease, diabetes, and cancer. Pennsylvania's bill also aligns with Nova but focuses on excluding products that meet FDA "healthy" criteria, such as those containing fruits, vegetables, or whole grains.

Experts warn that nutrient-based definitions, like California's, risk encouraging the food industry to create "Frankenfoods" that meet nutrient thresholds but remain harmful due to industrial formulations. Over 80 cohort studies have linked UPFs to health risks beyond sugar, salt, and fat, including refined starches, protein isolates, plant-based meat alternatives, and ready-to-eat meals.

The FDA is working with the Department of Agriculture to develop a uniform national

definition, but concerns remain about the "Generally Recognized as Safe" (GRAS) loophole, which allows companies to self-affirm ingredient safety without FDA oversight. Nearly 99% of new food ingredients enter the supply this way, raising questions about transparency and long-term safety. While some advocate closing the loophole entirely, others warn that doing so could overwhelm regulators and remove safe ingredients alongside unsafe ones.

Researchers and public health advocates argue that a strong, comprehensive definition aligned with Nova and inclusive of processed meats is essential to address the 2.3 million annual deaths linked to UPFs. They also call for tobacco-style regulatory tactics to curb harmful corporate practices in manufacturing and marketing ultra-processed foods.

<https://www.nutritioninsight.com/news/us-states-upf-definitions-nova-gras-loophole.html>

Unlocking Consumer Trust: How FDA-Approved "Healthy" Labels Influence Snack Selection

New research from Oregon State University and Tufts University demonstrates that FDA endorsed "healthy" labels significantly influence consumer snack choices and willingness to pay.

Conducted in 2023 with 276 shoppers in Boston, the study found that without labels, healthier snacks were chosen about 60% of the time. When labelled as "healthy," selection rose to 67%, but only the FDA specific label produced a statistically significant effect.

Consumers were also willing to pay an average premium of US\$0.59 for snacks carrying the FDA label compared to unlabelled products, underscoring the value of institutional trust in shaping purchasing behaviour.

The findings arrive as the FDA updates its definition of "healthy" for the first time since 1992, aligning with modern nutrition science and proposing a new "FDA healthy" icon for packaging. The study highlights how trust in government institutions amplifies the effectiveness of such labels, distinguishing them from generic claims that rely more on generalized consumer trust. This credibility gap is particularly important in a marketplace where front of package claims like "natural" or "low fat" often lack

oversight and where consumers report low confidence in health related food messaging.

The research suggests that brands able to adopt the forthcoming FDA healthy icon will gain a competitive advantage, both in consumer preference and in price positioning. It also reinforces the broader policy implication that credible, government endorsed labelling can serve as a powerful signal in guiding healthier eating patterns, especially in communities where misinformation and scepticism about food claims remain prevalent.

<https://www.foodingredientsfirst.com/news/unlocking-consumer-trust-how-fda-approved-healthy-labels-influence-snack-selection.html>

Saltwell Expands Chile Operations to Scale Low-Sodium Salt Production

Saltwell Group has expanded its operations with a new production facility in Santiago, Chile, to scale its low sodium salt solution, branded "Saltwell."

This ingredient delivers up to 35% less sodium than standard salt while maintaining the taste, functionality, and clean label compliance that food manufacturers require. Unlike conventional potassium chloride blends, which often introduce bitterness or metallic notes, Saltwell's mineral balance is naturally formed through solar evaporation of hypersaline waters from the Atacama salt flats. The result is a single crystal structure that preserves the familiar salty

flavour profile and processing performance across diverse applications.

The expansion comes at a time when global health authorities, including the WHO and FDA, are urging sodium reduction to combat cardiovascular risks. Average global sodium intake remains more than double recommended levels, and only a small fraction of countries have comprehensive reduction policies. Saltwell's solution allows manufacturers to meet these targets without sacrificing consumer acceptance, offering a one to one replacement for standard salt that requires minimal process adjustments. Tests have shown that eating quality can even improve in certain applications.

The company highlights the versatility of its product across snacks, bakery, and processed

meats. In snacks, its "Microfine" grade enables up to 40% sodium reduction while maintaining flavour. In bakery, Saltwell supports yeast control, dough handling, and flavour balance, ensuring full functionality with reduced sodium. In processed meats, it delivers comparable performance in flavour and shelf-life extension. By keeping "salt" on the ingredient label, Saltwell also supports clean label demands and helps manufacturers position products more competitively in retail environments. The Chile facility strengthens production capacity to meet rising demand, aligning public health goals with consumer pleasure and proving that sodium reduction no longer requires a sensory sacrifice.

<https://www.foodingredientsfirst.com/news/saltwell-sodium-reduction-regulation-snacks.html>

Eu's Two-Tier Crop Rules Could Reshape Food Sourcing and Labelling

The European Union is preparing to introduce a new regulatory framework for New Genomic Techniques (NGTs) that will establish a two tier system for gene edited crops.

NGT 1 crops, considered equivalent to those produced through conventional breeding, will face lighter rules and will not require general labelling beyond seeds and reproductive material. This category excludes traits such as herbicide tolerance and insecticidal substance production, ensuring stricter oversight remains in place for those modifications. NGT 2 crops, involving more complex genetic changes, will continue to fall under existing GMO legislation, with full requirements for authorization,

traceability, and labelling. Member states will retain the right to opt out of cultivating NGT 2 crops and may introduce coexistence measures to prevent unintended presence in supply chains.

The framework represents a partial easing of Europe's traditionally strict biotechnology stance, aiming to accelerate innovation and provide farmers with tools to adapt to climate change, disease pressures, and environmental stresses. However, it also introduces new complexity for food and beverage companies, which will need to reassess sourcing strategies, compliance policies, and labelling approaches as they navigate parallel regulatory regimes. The rules are expected to take effect in mid 2028 following a transition period, creating both opportunities and challenges for industry stakeholders.

Reactions to the legislation are divided. Supporters argue that NGTs are essential for sustainable intensification, resilience, and competitiveness in European agriculture, while critics warn that removing labelling requirements for NGT 1 crops undermines consumer rights and transparency. Advocacy groups have expressed disappointment that earlier calls for continued labelling were not upheld, while farming organizations welcome the framework as a game changing step toward climate resilient production. The debate underscores the tension between enabling innovation and maintaining consumer trust, with the new rules poised to reshape food sourcing, labelling, and market positioning across the EU.

<https://www.foodingredientsfirst.com/news/eu-two-tier-ngt-crop-regulation.html>

Clean Label Vs Shelf Life: A New Food-Tech Solution Removes the Trade-Off

BioBlends has developed a preservation technology that tackles the long-standing trade-off between clean labels and shelf life.

The startup uses volatile organic compounds (VOCs) derived from bacteria, applied as a liquid spray during packaging. These compounds volatilize to form a protective barrier around food products, controlling spoilage without being incorporated into the recipe. Because they are not ingredients, they do not appear on labels, allowing manufacturers to meet consumer demand for clean

ingredient lists while extending product freshness.

Pilot tests have shown striking results: bread treated with BioBlends resisted mould for up to 80 days, compared to four to five days without preservatives and about 15 days with conventional chemical preservatives. Even factory-produced bread with preservatives typically lasts only 30 days. The company has also seen positive outcomes with tortillas, vegan cheese, and tomato sauces, and is exploring applications in post-harvest produce and meat.

The technology is designed to integrate seamlessly into existing production systems, using methods such as modified atmosphere packaging or gas flushing, without requiring high

capital investment or energy costs. BioBlends is currently working toward regulatory approval, preparing a GRAS dossier for the FDA, and scaling its fermentation process from lab to pilot production. It is raising \$2.5 million in seed funding to support growth and partnerships with food manufacturers.

Looking ahead, BioBlends aims to expand its portfolio to target more fungal strains and bacteria, positioning itself as a platform for shelf-life extension across diverse food categories. The company envisions commercial rollout within three to five years, beginning in the US and expanding to markets such as Argentina, China, Brazil, and eventually Europe.

<https://www.foodnavigator-usa.com/Article/2026/04/08/clean-label-vs-shelf-life-bioblends-new-solution/>