APRIL 2026

WHY FOOD PROCESSING IS IMPORTANT TO US

The Role of Food Processing in Building Sustainable Food Systems

ABOUT FOOD INDUSTRY ASIA

Food Industry Asia (FIA) was formed in 2010 to enable major food and beverage manufacturers and ingredients suppliers to speak with one voice on complex issues such as health and nutrition, food safety, sustainability, and regulations and trade. From its base in Singapore, FIA seeks to enhance the industry's role as a trusted partner and collaborator in the development of science-based policy across Asia. To do so means acting as a knowledge hub for Asia's national industry associations and affiliated groups, to support with their engagement of public bodies and other stakeholders across the region.

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Executive Summary

Food processing is essential to modern food systems, making food safe, nutritious, affordable, and accessible. From basic methods like freezing and canning to advanced innovations such as high-pressure processing, food processing ensure food safety, extends shelf life, enables fortification, reduces waste, and supports resilience against challenges like climate change and urbanisation. At the same time, food processing supports economic growth and food security worldwide.

Despite these benefits, public discourse has increasingly focused on classification systems such as NOVA, which label broad categories of food as “ultra-processed”. While widely used in research and policy discussion, these systems oversimplify a complex reality and overlook the role of processing in safety, nutrition, and sustainability. They also group together vastly different foods, creating confusion for both policymakers and consumers. However, evidence linking processed foods to poor health is largely observational and shaped by lifestyle and socioeconomic factors; stronger research into causality is needed.

This has led to a misconception that the level of processing alone determines a food’s healthfulness. In fact, assessing a food requires a broader perspective. Nutritional quality, which is the balance of essential nutrients relative to added sugars, sodium, and saturated fats, is most important. Portion size and dietary context also matter.

Against this backdrop, focusing on processing level alone risks overlooking the essential functions that processing provides. Processed foods are an important part of the food supply, helping to connect farm to fork, and are essential to deliver safe, affordable, and palatable food options.[1]

When viewed through this broader lens, the the value of food processing becomes clear. Processing is not a single, uniform concept but a spectrum of techniques that underpin sustainable and resilient food systems. It contributes by:

- Safeguarding food safety through validated processing techniques.
- Improving nutritional security through fortification and enhanced nutrient bioavailability.
- Supporting food security by stabilising supplies and reducing post-harvest losses.
- Delivering safe and nutrient-dense foods in humanitarian and crisis settings.
- Creating specialised foods that cater for individuals with different nutritional requirements such as those with chronic conditions, as well as the elderly.
- Advancing sustainability through upcycling, waste reduction, and circular economy models.
- Applying food additives responsibly, under rigorous safety standards, to maintain quality, safety, and accessibility.

In addition, as consumer expectations shift, the industry is reformulating to reduce sugar, salt, and fat, fortify foods, and adopt sustainable practices. Therefore, policies must be grounded in science, not symbolism, as oversimplified classifications risk limiting choice and deterring innovation.

Recognising food processing as a safe, science-driven approach enables the development of foods that are nutritious, accessible, and sustainable. By aligning science, innovation, and policy, food processing can continue to strengthen food systems and support the health of diverse populations – both today and in the future.

1. The Legacy and Evolution of Food Processing

Food processing is often viewed with scepticism today; however, it is far from a modern invention. Across civilisations worldwide, humans have developed and refined different processing methods to preserve food, enhance its quality, and improve its safety for thousands of years.

From the earliest fire-based cooking over two million years ago to traditional methods such as fermentation, drying, pickling, and curing, food processing has been central to preventing spoilage, improving digestibility, preserving nutrients, and ensuring food safety.[2,3] These practices supported the development of settled societies and helped mitigate food shortages. Across Asia, long-standing food processing traditions illustrate how these methods have contributed to nutrition and food security: in China, as early as the 3rd century BCE, soybeans were fermented into *jiang*, an ancestor of soy sauce that preserves protein content while enhancing flavour and meal versatility; in Korea, vegetable fermentation practices dating back over 2,000 years created foods like traditional kimchi, enabling communities to retain essential vitamins and minerals through long winters when fresh produce was scarce; and across Southeast Asia, coastal communities developed sun-drying, smoking, and salting of fish and meats, ensuring a stable year-round supply of protein and reducing the impact of seasonal shortages. These techniques were not mere survival strategies—they were innovations that shaped diets, culture, and social life.

Food processing continues to play a critical role today. According to the US Department of Agriculture, it includes any method that transforms agricultural products into safe, edible, and nutritious food, ranging from basic steps like washing and chopping to advanced processes like pasteurising, freezing, and canning[4]. By this definition, nearly all supermarket foods, even fresh produce are processed to some extent to ensure safety and extend shelf life.

2. Modern Processing: Continuing the Legacy

Over centuries, food processing evolved from these traditional preservation techniques to the sophisticated methods we rely on today, such as pasteurisation, fortification, freezing, and high-pressure processing. Modern processing builds on traditional knowledge but leverages scientific innovation to enhance food safety, extend shelf life, and improve nutritional quality on a vast scale.

This industry is now a major economic driver and a fundamental pillar of modern food systems. It provides consumers with convenience, variety and year-round access to safe food. More critically, it addresses contemporary global challenges: reducing food waste and combating micronutrient deficiencies through fortification.

Far from being "unnatural," food processing is a testament to human ingenuity. It bridges ancient tradition with modern necessity, ensuring everyday staples are safe, available, and nutritious.

3. Why Food Processing is Fundamental to Modern Food Systems

Today, food processing is a major economic driver; in 2018, the ASEAN food and beverage industry employed 115 million people, and by 2021, the agri-food sector contributed USD 809 billion to the GDPs of five ASEAN countries.[7] It also plays a significant role in India's economy and trade, where food processing sector accounts for 20.4% of exports in total Agri-food exports in 2024-25.[11] For modern consumers, processed foods offer convenience, variety, and year-round access, supporting fast-paced lifestyles. Without processing, everyday staples like noodles, rice crackers, curry pastes, condiments, and fish balls wouldn't be as widely available or safe to enjoy.

This industry is vital for addressing contemporary global challenges. Food processing enables shelf-life extension, food safety management, and the reduction of post-harvest losses across the supply chain, yet significant challenges persist within the global food system. With up to 40% of all food produced still lost or wasted along the value chain and over 2 billion people globally suffering from micronutrient deficiencies.

This underscores the need for the continued and effective application of food processing technologies to further reduce food waste and build food systems that are more efficient, equitable, and resilient[5,6] and support progress in addressing micronutrient deficiencies.

3.1 Key Statistics: The Impact of Food Processing

Up to 40%

of 2021 GDP in Indonesia, Malaysia, the Philippines, Thailand and Vietnam comes from the agri-food sector[7]

Around 40%

of all food produced are wasted along the value chain[5]

126.8 million

of jobs across the five Southeast Asian economies supported by the agri-food sector[7]

870 million

people could be fed for a year by reducing food waste by just 25%[8]

147 countries

mandate or allow salt iodisation, virtually eliminating iodine deficiency and goitre in much of the world[9]

72%

of people believe that extending the shelf-life of food would help them reduce food waste[10]

1,478,081 MT*

*MT = Metric Tonnes

fortified food were distributed by the World Food programme in 2021[6]

92 countries

have implemented cereal grain fortification programmes and more than 30 countries fortify edible oil, reducing the prevalence of deficiencies in folate, iron, vitamin A, vitamin D and zinc[9]

4. The Essential Spectrum of Food Processing: Techniques, Roles, and Impact

4.1 The Multifaceted Role of Food Processing

4.1.1 Food Processing Role in Food Quality, Accessibility and Sustainability

With sophisticated array of techniques, strategically developed to tackle critical challenges related to safety, nutritional integrity, shelf life, and evolving consumer demands. Each intervention plays a pivotal role in safeguarding food quality, enhancing accessibility, and strengthening the resilience and sustainability of contemporary food systems. Thermal processing methods, such as pasteurisation and canning, apply precise heat to eliminate pathogenic microorganisms and deactivate spoilage enzymes.[1,12-14]

This cornerstone of food safety is exemplified by shelf-stable canned goods and pasteurised dairy products, which prevent foodborne illness and enable the global distribution of perishable items.

Fermentation, one of the oldest biotechnologies in humanity, utilises controlled microbial activity to preserve and transform raw ingredients. This process enhances flavour profiles, improves digestibility, and can introduce beneficial probiotics, as seen in staples like yogurt, kimchi, and soy sauce.[1,15,16]

Freezing and refrigeration preserve the freshness, texture, and nutritional content of foods – such as dairy, fresh meats, seafood, fruits, vegetables, and ready-to-eat meals – by drastically slowing biological and chemical degradation, while also extending storage life and helping reduce food waste across the supply chain.[17]

4.1.2 Food Processing and Nutrition Security

Modern processing also includes targeted nutritional interventions. Fortification and enrichment involve adding essential vitamins and minerals to staple foods such as iodised salt or flour fortified with iron and folic acid to combat population-wide micronutrient deficiencies, representing a powerful public health tool.[18-25]

Advancements in technology have given rise to novel and minimal processing techniques, like High-Pressure Processing (HPP), which ensure microbial safety without the need for chemical preservatives or additives, thereby supporting the growing demand for "clean-label" products. By applying uniform pressure instead of heat, HPP helps preserve a food's sensory and nutritional qualities, minimising protein denaturation and vitamin loss that can occur in thermal processing. This method is commonly applied in products such as cold-pressed juices, deli meats, and ready-to-eat meals.[1]

4.1.3 Food Processing and Shelf Stability in Daily Life

Finally, traditional methods like dehydration, smoking, and curing continue to be vital. By removing water or leveraging the preservative effects of smoke and salt (with nitrates in some curing processes), they enable long-term storage, reduce food waste, and create distinctive flavours, as evidenced by products ranging from dried pasta and smoked fish to cured meats.[26]

Collectively, these diverse techniques illustrate that food processing is not a singular concept but an essential, multifaceted discipline that ensures safety, enhances nutrition, provides convenience, and builds upon centuries of culinary tradition through scientific innovation.

4.2 Responsible Use of Food Additives

Integral to these diverse processing techniques are food additives – scientifically evaluated substances that reinforce safety, preserve quality, and enable functional innovation.

Food additives are substances intentionally added during manufacturing to fulfil specific, essential technological functions that underpin the safety, quality, and consistency of the modern food supply.[18]

All additives are subject to a rigorous, independent safety evaluation process conducted by global scientific authorities, including the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the European Food Safety Authority (EFSA), and the U.S. Food and Drug Administration (FDA), which set conservative exposure limits to protect consumers.[18]

4.2.1 Food Additives & Their Role in Food Safety, Quality, Nutrition Security and Accessibility

Their responsible use is fundamental across several critical domains. Primarily, additives are indispensable for ensuring safety and extending shelf-life; preservatives inhibit the growth of pathogenic microorganisms to prevent foodborne illness, while antioxidants prevent oxidation that can compromise safety and quality.[27,28]

Furthermore, additives are crucial for maintaining product quality and consistency. Emulsifiers prevent separation of immiscible ingredients, stabilisers maintain structure and texture, thickeners provide the desired mouthfeel, and colouring and flavouring agents ensure products are visually appealing and taste as intended across batches, a necessity for consumer trust and efficient large-scale production.[29,30]

Beyond preservation and quality control, additives also enable functional innovation, allowing for the development of foods that meet specific dietary demands, such as the use of non-sugar sweeteners to create low-sugar, and sugar-free products without sacrificing taste.

Food additives use is common in home use, traditionally yeast have been used as leavening agent; edible gum (acacia) used for making sweets across Asia.

It is important to recognise that public concerns about additives often arise from studies examining them in isolation rather than within the finished food product where ingredients interact, and actual realistic consumption amount and are metabolised as part of a normal diet. Within the framework of strict, science-based regulations, food additives are not merely permitted but play a vital role in maintaining a safe, stable, and diverse global food supply, particularly in regions facing heightened food safety challenges.[31]

Key Takeaways

- **Processing is a spectrum:** It ranges from basic (washing, freezing) to advanced (fortification, HPP). The vast majority of foods we consume benefit through food processing, which enhances safety, shelf life, and nutritional quality.

- **Safety is the foundation:** The primary driver is preventing foodborne illness and spoilage. Processing techniques like pasteurisation are non-negotiable for public health.

- **Nutrition can be enhanced:** While some processing methods may reduce certain nutrients, others like fortification restores or adds essential vitamins and minerals, fermentation can improve bioavailability, and processes such as cooking or heat treatment can increase the bioavailability of compounds like carotenoids.

- **Food additives:** Scientifically regulated substances that play a vital role in ensuring safety, preserving quality, maintaining consistency, and enabling innovation within food supply chain.

- **Support modern life:** Processing provides the convenience, variety, year-round availability, and food security that urban, global societies depend on.

- **Tradition informs innovation:** Today's advanced methods are direct descendants of ancient practices like fermenting, drying, and curing, refined with scientific precision.

5. Rethinking Food Classification: Moving Beyond Processing Level to Nutritional Value

Despite its long history and essential contributions to safety, nutrition, and accessibility, food processing is often viewed with scepticism in contemporary discourse, where it is narrowly associated with so-called "ultra-processed foods" (UPFs). This perspective is reflected in food classification frameworks, such as the NOVA system, which categorises foods based on the extent of industrial processing.[1,12-14,32-34] These frameworks can oversimplify the multifaceted role of processing and lead to misconceptions about a food's healthfulness.

Since the early 2000s, food classification systems have become more commonly used in research and policy in attempts to describe dietary patterns and health outcomes. Among these, the NOVA system, introduced in 2009, is the most widely used. It groups foods into four categories based on the extent of processing: unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and UPFs.[1,12-14,32-34]

NOVA has been adopted in nutrition research and in several national dietary guidelines, particularly in Latin America, and it is frequently cited in discussions on public health and sustainable diets.[33,35] However, these systems have significant limitations:

- **Oversimplification**: NOVA prioritises processing level rather than nutritional value. This means nutrient-rich foods like fortified wholegrain cereals may be labelled "ultra-processed," while minimally processed foods high in sugar, fat, or salt, such as butter or traditional desserts, may appear healthier by comparison.[18,19]
- **Inconsistency:** Expert reviews have shown disagreement on how to classify specific foods, even among trained assessors. For example, wholegrain bread or flavoured yoghurt may fall into different categories depending on interpretation of ingredients and processing steps.[12,13]
- **Cultural limitations:** NOVA was developed in Brazil and may not reflect traditional food practices elsewhere. In some contexts, long-standing artisanal or fermented foods are categorised as "ultra-processed," despite their cultural and nutritional importance.[18] For instance, traditionally fermented soy foods such as tempeh and miso are integral to many East and Southeast Asian diets and have been consumed safely for generations may be categorised as ultra-processed when produced at scale using industrial processing steps and additional ingredients, even though their fundamental preparation methods and cultural roles remain rooted in traditional fermentation practices.
- **Symbolic framing:** Terms such as "ultra-processed" carry negative connotations and can influence consumer perceptions and policy debates, even when the scientific evidence linking processing level to health outcomes is inconclusive.[1,14]
- **Evidence gaps:** Most studies linking UPFs intake to poor health are observational. They often fail to control for confounding factors such as diet quality, lifestyle, or socioeconomic status, making it difficult to separate the effects of processing from broader dietary patterns.[1,14]

While NOVA and similar systems may be useful for tracking broad consumption trends and raising awareness of dietary shifts, they should be interpreted with caution. Overreliance on processing-based classifications risks misrepresenting the role of food processing, overlooking its contributions to safety, nutrition, and sustainability.

In this context, international scientific organisations such as the International Union of Food Science and Technology (IUFoST), the International Union of Nutritional Sciences (IUNS), and the United Nations Industrial Development Organization (UNIDO) have emphasised that food classification systems should move beyond processing level alone and instead reflect nutritional quality, technological function, and public health outcomes. These organisations highlight that processing is not inherently detrimental and should be assessed based on its purpose and nutritional impact rather than treated as a proxy for health risk. [36-38]

A more holistic evaluation that considers the purpose and nutritional outcomes of processing such as whether it enhances safety, nutrient density, or accessibility is essential. Instead, complementary approaches that consider nutrient composition, portion size, and dietary context provide a more accurate basis for assessing how foods affect health and guiding effective policy.[5,6,17]

To avoid repeating the limitations observed in existing frameworks, the development of future food classification and guidance systems should occur through inclusive, science-based processes with broad stakeholder engagement, including within international standard-setting bodies such as the Codex Alimentarius Commission. Engagement across governments, scientists, industry, and public health experts is essential to ensure that classifications are evidence-based, globally coherent, and aligned with food safety, nutrition, sustainability, and food security objectives.

6. Processing and Health: Examining the Evidence

The evidence directly linking the level of food processing to human health outcomes is not conclusive and remains scientifically weak[39]. While a growing number of observational studies over the past decade have reported associations between higher intakes of foods classified as "ultra-processed" by the NOVA system and increased risks of chronic diseases, this body of evidence faces significant methodological criticisms that limit its validity.

The core issue is that the vast majority of these studies are observational in nature, which inherently prevents the establishment of causality. Their findings are highly vulnerable to confounding by factors such as overall diet quality, socioeconomic status, and lifestyle, making reverse causality a strong possibility. This limitation is compounded by the reliance on dietary recalls or food logs, which typically do not capture food processing characteristics in detail and often require researchers to infer processing levels, introducing additional assumptions and potential misclassification.

Furthermore, the research shows glaring inconsistencies; for instance, the threshold of UPF intake associated with increased mortality risk varies dramatically across countries, and no significant risk was found in some cohorts with very high consumption, questioning the universality of the effect. A major flaw in interpreting this evidence is the failure of the NOVA classification to stratify nutritional quality within its broad "ultra-processed" category. This results in nutrient-poor items like sugary drinks being grouped with nutrient-rich, fortified, or whole-grain foods, for which health associations are inconsistent, demonstrating that the degree of processing is a poor proxy for a food's actual health impact.

Compounding these issues are the inconsistent and unvalidated methodologies used to assess UPFs intake in population studies, which often cannot reliably distinguish between homemade and industrial foods, a key NOVA criterion, leading to potentially erroneous data and conclusions.

This collective uncertainty is reflected in the cautious positions of authoritative bodies like the UK's Scientific Advisory Committee on Nutrition (SACN) and House of Lords, which have highlighted the low quality of evidence and scientific uncertainty regarding causal links, with scholars arguing that policy action based on the current NOVA framework is premature.

Similarly, France's food safety agency (ANSES) concluded that the UPF concept has yet to be scientifically substantiated and that the NOVA classification is characterised by the use of certain processing methods and the addition of 'cosmetic' additives and substances, in general, this system is based on the presence of additives and substances without clear distinction, making its application subjective. Nevertheless, following ANSES's expert appraisal, that classification of foods based on their degree of processing cannot be translated into health risks, hence cannot be used for the purpose of nutritional education, highlighting the need for further studies to assess the impact of formulation and processing methods. [40]

The Nordic Nutrition Council (composed of Denmark, Finland, Iceland, Norway, Sweden, Estonia, Latvia and Lithuania) declined to include UPFs in the Nordic Nutrition Recommendations (2023), with no recommendations on given on UPFs. Recommendations on specific food groups sufficiently covers current evidence.[41]

In line with this cautious approach, the German Nutrition Society has noted that there is currently no scientific consensus on uniform and objective criteria for classifying foods by degree of processing, highlighting the methodological limitations of existing processing-based classification systems. It had further emphasised the importance of using a uniform, robust classification system in future studies to elucidate the influence of various potential factors, such as energy density, food structure/matrix, process contaminants, and additives, on diet-related diseases.[42,43]

Key Takeaways

- **Evidence limitations:** The current evidence linking food processing levels to health is predominantly observational and cannot establish causality, leaving findings vulnerable to confounding by broader dietary and lifestyle patterns.

- **Inconsistent risk data:** Reported health risks from UPFs intake show major inconsistencies across populations and countries, undermining the claim of a universal, mechanistic effect.

- **Limitation of NOVA classification:** The NOVA system fails to stratify nutritional quality within its "ultra-processed" category, incorrectly grouping nutrient-poor items (e.g., sugary drinks) with nutrient-rich, fortified, or wholegrain foods.

- **Scientific consensus:** Leading scientific and policy bodies, including the UK's SACN, France's ANSES, the Nordic Nutrition Council, and the German Nutrition Society – highlight significant scientific uncertainty regarding causal links between processing level and health. These organisations emphasise methodological limitations, lack of validated classification criteria, and insufficient evidence to support policy or dietary guidance based on processing level alone.

- **Focus on nutritional quality:** A more effective approach to public health would focus on improving nutritional quality (e.g., using nutrient profiling models) rather than vilifying processing, which provides essential benefits for safety, shelf-life, and food security.

7. Food Processing: The Bedrock of Safety, Nutrition, and Security

While systems like NOVA focus on the degree of processing as a proxy for healthfulness, this approach oversimplifies reality and overlooks the essential, multifaceted role of food processing. Far from being inherently detrimental, processing is a fundamental pillar of sustainable and resilient food systems, underpinning public health, nutrition security, economic stability, and environmental sustainability by ensuring food safety, improving nutritional quality, stabilising supply, and supporting innovation.

7.1 Food Safety

Food processing serves as a foundational and non-negotiable pillar of public health, with its primary role being to eliminate biological hazards and prevent foodborne illness, thereby transforming raw agricultural commodities into a safe and stable food supply. This function is achieved through a range of techniques, from established methods to modern innovations.

For instance, pasteurisation effectively destroys dangerous pathogens such as *Escherichia coli*, *Listeria monocytogenes*, and *Salmonella* in milk and juices, safeguarding vulnerable groups including children and the elderly.[1,12,13] Similarly, canning and thermal sterilisation provide robust, long-term protection against life-threatening contaminants like Clostridium botulinum, enabling the global distribution of shelf-stable foods.[14] Contemporary non-thermal approaches, such as HPP, further enhance safety by inactivating pathogens while preserving the sensory and nutritional qualities of fresh food, mitigating the nutrient losses sometimes associated with high-heat methods.[39] The systematic benefits of processing for safety are well-documented, including the inactivation of food-borne pathogens and microbial toxins, the neutralisation of natural toxins and enzymes, and the removal of contaminants like pesticides and aflatoxins through refining and milling, as well as controlled processing to reduce the formation of unwanted compounds like acrylamide.[39]

Despite these critical technologies, Southeast Asia contends with disproportionately high food safety risks due to its tropical climate, variable income levels, and infrastructure gaps, resulting in an estimated 150 million cases of foodborne illness and 175,000 deaths annually in the region.[44,45] This stark reality underscores the urgent, ongoing need for effective processing, a need echoed by consumers in the ASEAN Consumer Perception Study 2025, which identifies improving food safety and quality standards as the top action they expect from their governments.[39] Ultimately, processing is the essential first step in ensuring that the nutritional potential of food can be realised without compromising consumer health, making it a vital public health intervention.

7.2 Food Security

Processing extends the shelf life of perishable foods, stabilises supplies, and reduces post-harvest losses, thereby strengthening food system resilience and ensuring a consistent flow of safe, nutritious products to consumers. Drying and milling cassava, for instance, turns a fast-spoiling root into shelf-stable flour, reducing losses that can reach up to 40% for certain crops.[5,46] UHT treatment enables milk storage for months without refrigeration, significantly increasing its availability and safety in remote or infrastructure-limited areas.[47] Freezing preserves the nutritional value and quality of vegetables, ensuring a steady supply regardless of season.[48]

These technologies are particularly important in Southeast Asia, where post-harvest losses remain a major food security challenge. Globally, food loss and waste occur across the entire value chain, with fruits and vegetables among the most affected.[5] Processing interventions such as freezing and canning directly mitigate these losses, increasing food availability and affordability.[48]

Processing also plays a key role in stabilising national and regional food supplies. In ASEAN, where rice is a dietary staple, improved milling and storage systems support buffer stocks and help mitigate seasonal shortages and price volatility.[20] In parallel, the expansion of shelf-stable processed foods, including canned fish and fruits, packaged noodles, and cooking sauces —reduces transport and storage costs, improves distribution efficiency, and enables economies of scale. Together, these factors help lower food prices and increase the availability of safe, nutritious foods, particularly for urban and lower-income populations. In addition to supporting everyday consumption, these products also serve as strategic reserves for emergency preparedness, reinforcing their importance in resilient food systems amid logistical disruptions and climate-related events.[7,20]

7.3 Emergency and Crisis Response

In humanitarian aid and disaster relief, processed foods are critical due to their long shelf life, portability, and concentrated nutrition. Following the 2004 Indian Ocean Tsunami, the United Nations World Food Programme provided essential food to 1.75 million survivors, moving over 50,000 metric tonnes of staples such as fortified biscuits, noodles, rice, oil, sugar, and pulses.[49] Relief foods must meet daily nutritional needs, withstand storage and transport without refrigeration, and include clear labelling for shelf life, nutrient content, and preparation instructions.[50]

Ready-to-use therapeutic foods (RUTFs) like Plumpy'nut® are shelf-stable and require no preparation, making them highly effective for treating severe malnutrition.[51] Long-shelf-life products like fortified biscuits, instant porridges, and military-developed Meals Ready-to-Eat (MREs) support relief efforts under complex logistics.[49,50,52] These examples highlight that processed foods — including fortified staples, ready-to-use therapeutic foods, and long-shelf-life emergency rations play a critical role in emergency and crisis response. Their nutrient density, shelf stability, and ease of transport make them indispensable for delivering safe and reliable nutrition to affected populations under challenging logistical conditions.

7.4 Nutritional Security

Food fortification, which is adding essential vitamins and minerals to staple foods, is a key strategy to address nutrient deficiencies and is supported by WHO's global nutrition strategy (2016–2025).[53] Over 2 billion people globally suffer from micronutrient deficiencies, including one in two preschool-aged children and two in three women of reproductive age.[6] According to the WHO, anaemia affects half a billion women and 269 million children worldwide, mostly due to iron deficiency, while 250 million children are affected by vitamin A deficiency.[54,55] Iodine deficiency remains widespread, and around 300,000 babies are born each year with neural tube defects due to insufficient maternal folate intake.[56]

In Asia, protein-energy malnutrition remain prevalent among children under five, particularly in South and Southeast Asia, where high rates of stunting, wasting and other nutrient shortfalls persist. [57] These forms of undernutrition increase immediate health risks including weakened immunity and higher susceptibility to infections — and are associated with long-term developmental impairments, such as reduced cognitive function, growth faltering, and compromised future productivity. [57,58]

Food processing is therefore essential not only for food security, but also for ensuring the reliable provision of essential nutrients within the global food supply. Fortification and processing enhance nutritional value, bioavailability and stability, while also enabling nutritious foods to be safely distributed and consumed beyond the constraints of perishability. Iodised salt dramatically reduces iodine deficiency.[59] Iron- and B-vitamin-enriched cereals combat anaemia.[60] Converting fresh tomatoes into tomato paste increases the absorption of lycopene, a potent antioxidant.[60]

Nixtamalisation of maize in Latin America improves the bioavailability of niacin, helping to prevent pellagra.[61] Processing technologies also concentrate and preserve nutrients in shelf-stable formats; for example, evaporation and spray drying convert fresh milk into milk powder – a nutrient-dense food that delivers high-quality protein, calcium, and essential micronutrients and serves as a vital nutrition source for many populations, particularly where access to fresh milk or cold-chain infrastructure is limited.[62]

These approaches underpin large-scale and targeted nutrition programmes, the Philippines mandates the use of iron-fortified rice (IFR) in public nutrition programmes, while Malaysia's Food Basket Programme has improved nutritional outcomes for children in low-income families since 1989.[56,63] In 2002, Indonesia launched the Wheat Flour Food Fortification Program, which mandated that wheat flour should be fortified with iron, zinc and B vitamins, alongside with mandatory fortification of cooking oil with vitamin A, and salt iodisation as part of its national strategy to address micronutrient deficiencies.[81,82]

Infant and children's milk powders are scientifically formulated and fortified with iron, nucleotides, DHA, and prebiotics to support development when breastfeeding is not possible.[64] This principle extends to a wide range of staple foods, where nutritional additives are used to restore lost nutrients or fortify foods, such as vitamins A and D added to dairy and cereals, B vitamins added to flour, baked goods, and pasta, and vitamin C added to fruit beverages, cereals, and dairy products.

Despite this clear public health benefit, the processing-based classification systems discourage the addition of nutrients when defining fortified foods as "ultra-processed." This creates a disconnect between symbolic classifications and nutritional need. By focusing on processing level rather than nutritional outcomes, such approaches risk undermining proven fortification strategies that rely on food processing to deliver essential nutrients at scale, particularly for populations with the greatest nutritional needs.

7.5 Functional and Special-Purpose Foods

Processing enables the development of products tailored to specific health needs, supporting dietary management across different life stages and medical conditions. Asia is facing demographic shifts marked by an ageing population and a growing prevalence of chronic illnesses, which is driving demand for targeted nutrition. For adults managing chronic conditions, meal plans and tailored food provision designed according to specific dietary guidelines can improve clinical markers such as blood glucose, lipid profiles, and body composition, demonstrating the benefit of processed foods tailored for metabolic health.[65] This includes lower sugar, fat, and salt options, low glycaemic index foods for diabetes management and renal-friendly foods lower in potassium, phosphorus, and sodium.[32]

Across the life course, processing also plays a critical role in meeting the nutritional needs of vulnerable populations with highly specific requirements. Breastfeeding is the recommended way to feed infants; however, when breastfeeding is not possible, infant formula is the only safe and adequate substitute for breast milk. As a highly regulated category, infant formula relies on precisely controlled processing to ensure prescriptive nutritional composition, delivering essential macro- and micronutrients to support normal growth and development, while meeting stringent safety standards that are paramount for this population.[66]

Furthermore, dairy-based nutritional products play an important role within the functional and special-purpose foods segment, particularly in medical and ageing-related nutrition By leveraging its nutritional composition, dairy delivers high-quality, bioavailable protein, calcium, vitamin D, and essential micronutrients in formats suitable for older adults and individuals with specific clinical needs. Dairy-based nutritional products, including oral nutritional supplements and specialised formulations, have been shown to support muscle maintenance, bone health, and improved nutritional status among populations at risk of malnutrition or managing chronic conditions, reinforcing their role in targeted nutrition strategies.[67,68]

7.6 Sustainability

Globally, about 40% of food is lost or wasted each year[5], demonstrating the importance of food processing in building resilient food systems capable of managing perishability, climate pressures, and complex supply chains. Food loss and waste occur across all stages of the food system, particularly for highly perishable foods such as fruits, vegetables, dairy, and protein sources. In this context, processing technologies are not only helpful but essential for extending shelf life, stabilising supplies, and transforming surplus or by-products into safe, usable food, thereby reducing waste and improving system efficiency.[69]

Processing technologies are therefore essential to reducing food waste and advancing sustainability. Upcycling by-products, a technique of transforming by-products into high-value ingredients, is a key benefit. Examples include converting fruit peels into dietary fibre supplements, repurposing spent grain from brewing into baking flours, drying bananas into flours or powders, and producing protein-rich snacks from edible insects. These approaches contribute to a circular economy, maximising resource efficiency and reducing the environmental footprint of food production.[70,71] Innovative protein sources such as fungal mycoproteins (e.g., from Fusarium venenatum) and edible insects (a growing multimillion-dollar sector in Thailand) provide sustainable alternatives with lower environmental footprints, requiring far less land, water, and feed compared to traditional livestock.[72,73]

Beyond alternative protein sources such as fungal mycoproteins and edible insects, cultivated meat (cell-based meat) emerges as a promising innovation with the potential to substantially reduce the environmental footprint of protein production. Although such products may be classified as 'ultra-processed' under the NOVA system, they offer significant advantages, including lower requirements for land, water, and feed, as well as reduced greenhouse gas emissions relative to conventional livestock. Recognising the role of these novel foods in promoting sustainability shifts the focus from processing level alone to a broader consideration of their impacts on nutrition, resource efficiency, and environmental outcomes.

7.7 Cultural and Historical Perspectives

Food processing is a long-standing human tradition that has shaped regional identities, preserved seasonal abundance, and enabled cultural exchange. Today, it continues to safeguard and evolve culinary practices, making traditional foods safer, more accessible, and sustainable for future generations. Many culturally significant foods rely on long-established preservation methods such as fermentation, drying, smoking, curing, and pickling[74], which advanced processing technologies can replicate these traditional techniques at scale, ensuring safety, consistency, and year-round availability while maintaining their authentic sensory profiles. Traditional foods like Korean kimchi and Southeast Asian tempoyak (fermented durian) can be produced with extended shelf life using methods like HPP without compromising their sensory qualities.[1]

Similarly, nixtamalisation remains integral to large-scale tortilla production in Latin America, preserving its nutritional benefit while ensuring product safety and scalability.[75] Food processing also facilitates the adaptation of traditional foods to modern consumption patterns through convenient formats, including ready-to-heat meals and shelf-stable fermented products, which reduce contamination risks while maintaining familiar attributes.[1,15,18,35,75] Standardisation of recipes, ingredient ratios, and production methods further supports consistency and continuity, helping preserve established flavour profiles and production knowledge across time.

Many culturally significant foods are inherently seasonal or highly perishable, which can limit their availability beyond their region of origin, but processing extends their shelf life and enable wider distribution, reaching diaspora communities and international markets.[1,12-14] Examples include frozen tropical fruits and canned traditional dishes, which allow consumers to maintain dietary habits and food preferences associated with their cultural background.[18]

The safe packaging and export of processed cultural foods are powerful economic and cultural drivers. Extended shelf life and compliance with food safety requirements allow traditional products to access broader markets, supporting local producers and small-scale food businesses.[16,64,76] In Southeast Asia, this commercial and cultural exchange is a significant part of the broader agri-food economy, which contributed over USD 877 billion to the GDP of Indonesia, Malaysia, the Philippines, Thailand, and Vietnam in 2021.[7] Products such as sauces, curry pastes, fermented foods, and shelf-stable snacks have gained international distribution, supporting regional food industries and increasing global exposure to established culinary products.[3] This market access supports economic sustainability while maintaining links to regional food traditions.

Key Takeaways

- **Processing supports food continuity**: Food processing enables established food practices to be maintained over time by improving safety, availability, and sustainability.
- **Turning risk into safety:** Food processing transforms raw ingredients into safe foods, extending shelf life and reducing post-harvest losses to ensure consistent supply.
- **Nutrition made practical and accessible:** Food processing enables fortification, bioavailability enhancement, and specialised formulations address deficiencies and support diverse dietary needs, from children to older adults.
- **Prepared for crisis and everyday resilience:** Food processing delivers ready-to-use, shelf-stable foods that provide essential nutrition during emergencies, while also supporting routine consumption across regions and seasons.
- **Affordability and access strengthened:** By reducing losses, lowering transport and storage costs, and enabling economies of scale, food processing helps stabilise prices and improve the affordability and availability of safe, nutritious foods, particularly for urban and lower-income populations.
- **Culture, heritage, and sustainability preserved:** Food processing allows traditional foods to be produced at scale, maintaining flavour and identity, and cultural relevance, while advancing sustainability through waste reduction, upcycling of by-products, and the development of alternative proteins within circular food systems.

8. Rethinking How We Judge Our Food

Food processing serves as an indispensable foundation for public health and food security, enhancing safety, improving accessibility, meeting specific dietary needs, and preserving cultural heritage. However, these vital functions do not, in themselves, determine whether a specific product is nutritious. The ultimate measure of a food's role in a healthy diet is not how it is made, but what it delivers. Therefore, moving from the broad, system-level contributions of processing to the individual choices consumers make requires a shift in focus: from the method of production to the nutritional attributes of the final product.

Public debate often frames foods using simplified binaries linked to levels of processing. Such distinctions, however, are a weak proxy for nutritional value. In fact, nutritional quality provides a more meaningful basis for evaluation. Nutrient composition, which is the balance of vitamins, minerals, fibre, and protein relative to added sugars, sodium, and saturated fats, remains the strongest determinant of health outcomes.[15,16] Notably, when applied appropriately, processing can play a constructive role by improving nutrient availability, enhance digestibility, reduce nutrients of concern, and address population-level deficiencies through fortification and reformulation.

While nutritional composition provides the foundation for evaluating food, how a food is consumed also shapes its impact on health. Portion size is equally important. Even nutrient-dense foods can contribute to excess calorie intake and weight gain if consumed in large amounts. Conversely, smaller servings of less nutrient-rich foods can be enjoyed as part of a balanced diet, allowing occasional indulgence without compromising overall dietary quality.[76]

The dietary context also matters. Health effects depend on how individual foods interact with the rest of the diet — whether they fill nutrient gaps, maintain energy balance, and align with cultural and personal eating patterns. This perspective aligns with evolving consumer understanding. Research indicates that consumers are learning to manage how they eat rather than what they avoid, prioritising practical actions like eating balanced meals and reducing sugar over eliminating certain food categories.[77]

Importantly, simplified classifications and negative narratives around processed foods can have unintended social consequences. For individuals with limited income, time, cooking skills, or access to adequate kitchen facilities, processed and ready-to-eat foods may represent the most practical and reliable options for meeting daily nutritional needs. Framing these foods as inherently "unhealthy" can stigmatise consumers who rely on them out of necessity rather than preference, and may inadvertently widen health inequalities by promoting dietary ideals that are not equally attainable across populations.

These considerations highlight a critical point: the healthfulness of a food cannot be judged by a single, simplistic classification. Systems that categorise foods based on symbolic criteria rather than nutritional value can create misleading hierarchies. For example, a nutrient-rich, fortified wholegrain cereal may be categorised alongside less nutritious items, while a calorie-dense, high-fat food may receive a more favourable classification, which is a clear misrepresentation of true nutritional quality.[39] At the same time, some minimally processed foods may be calorie-dense and less supportive of long-term health.

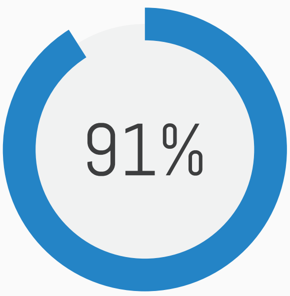
Therefore, evaluating dietary quality requires a holistic approach that integrates nutrient composition, portion size, dietary context and practical constraints related to access and food preparation, rather than relying solely on symbolic classifications.

9. Consumer Insights Shaping the Future of Food in Southeast Asia

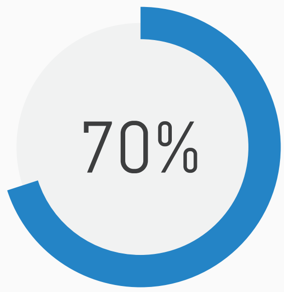
While a holistic, science-based framework is essential for evaluating food, its real-world impact depends on how these principles align with consumer understanding and behaviour. Current evidence from the ASEAN Consumer Perception Study 2025 provides this critical link, revealing how Southeast Asian consumers are translating awareness into action and shaping the future of the regional food landscape.

The study, which engaged 7,500 respondents across Indonesia, Malaysia, the Philippines, Thailand, and Vietnam, identified strong consumer support for product reformulation, enhanced transparency, and strengthened collaboration between government and industry—underscoring the imperative for science-based policies that align public health priorities with continued innovation. The research revealed that consumers are increasingly health-conscious and attempt to source products that align with their health goals, reinforcing the need for clear, trustworthy, and easy-to-understand nutrition labelling that empowers them to make healthier decisions.

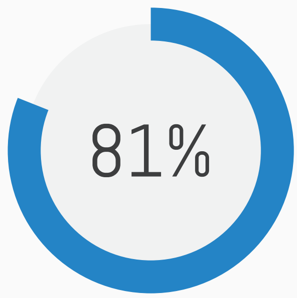
Consumers are increasingly demanding foods that deliver both taste and nutrition, making these factors equally critical in driving their food and beverage purchases, which also underscores how consumers balance taste, nutrition, and health in their food choices, as reflected in their behaviours and attitudes toward nutritional labels, sugar reduction, and reformulation. Notable findings from the survey include:



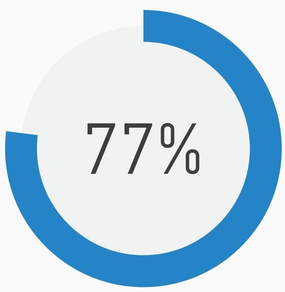
check nutrition information before purchase, either regularly or occasionally



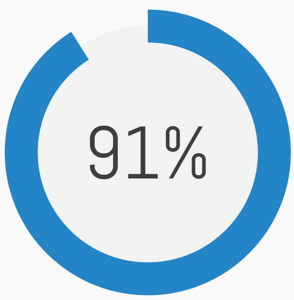
are influenced by nutrition facts and front-of-pack logos



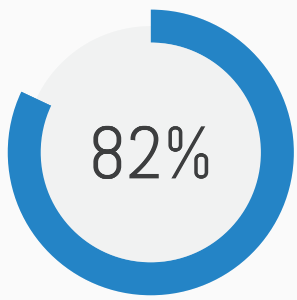
are trying to reduce sugar intake



believe that non-sugar sweeteners are safe for consumption



are supportive of or open to reformulated products aimed at improving health outcomes



are willing to pay a premium for healthier reformulated products

Consumer interactions with nutrition information and corresponding product choices highlight a broader shift in perceptions of processed foods, reflecting an increasing awareness of their contributions to convenience, safety, and overall dietary balance. Indeed, 63% of ASEAN consumers now hold a neutral-to-positive view towards processed foods, recognising practical benefits such as convenience, longer shelf life, and affordability as practical benefits that fit modern lifestyles. Rather than rejecting processed foods outright, consumers are seeking healthier alternatives that allow them to balance convenience with better nutrition. This shift is reflected in behaviour; consumers are prioritising actions like eating balanced meals over eliminating processed categories, focusing on how they eat rather than what they avoid. This presents a clear opportunity for the food industry: strategically developed and reformulated processed foods can play a positive role in improving nutrition and food security.[77]

Yet, understanding of UPFs remains limited. About 65% are unfamiliar with the term, and even among those who claim familiarity, most describe UPFs simply as factory-made, ready-to-eat products or those containing preservatives, showing that public understanding remains vague and inconsistent.[77]

Therefore, introducing or emphasising the term “UPF” in consumer-facing communications is unlikely to improve understanding and may exacerbate confusion, as it adds a technical label without clarifying nutritional quality. This disconnect highlights that processing should not be used as a proxy to assess a product’s healthfulness. Without clear context, the term risks being misinterpreted, potentially leading consumers to make less informed choices. Evaluating foods based on overall nutritional value and dietary role would provide clearer, more actionable guidance.[77]

Key Takeaways

- **Health drives demand:** Health and safety considerations are now dominant factors for ASEAN consumers, with 91% reporting that they check nutrition information before purchasing food and 82% willing to pay more for higher nutritional standards.
- **Active participation:** Consumers are not passive; they are making conscious efforts to reducing sugar (81%) and strongly support reformulation (60%), demonstrating a shift toward proactive dietary management.
- **Pragmatism over rejection:** Despite negative narratives, 63% of consumers hold a neutral-to-positive view of processed foods, valuing their convenience and seeking better-for-you options rather than outright rejection.
- **Focus on 'How,' not 'What':** Modern consumers are prioritising balanced eating and moderation (e.g., reducing sugar) over eliminating entire food categories, indicating a more nuanced approach to diet.
- **Limited "UPF" understanding:** The term "ultra-processed food" is not widely understood (65% unfamiliar) and using it in consumer communication risks confusion without clarifying a product's actual nutritional value.

10. Promoting Robust, Science-Based Policies

The clear, data-driven priorities of ASEAN consumers in demanding healthier, safer, and more transparent products establish a powerful mandate for action. To transform this consumer demand into tangible public health outcomes, there remains a critical need for policies that reflect both scientific evidence and practical market realities. Misconceptions, particularly around technical terms like "ultra-processed foods" and reliance on simplistic classifications, can lead to policies that inadvertently restrict access to nutritious, fortified foods and stifle innovation. To effectively support public health and align with consumer trust, policy frameworks must be grounded in robust, evidence-based science that promotes reformulation, transparency, and sustainability.

Sound public policy is essential to guide the future of food processing. Policies that rely on simplified classifications risk unintended consequences, such as reducing access to fortified foods, limiting consumer choice, or disincentives for innovation in healthier and more sustainable products.[18] Instead, policy development should be anchored in internationally recognised, science-based frameworks, ensuring consistency, credibility and proportionality across markets.

To harness the full potential of food processing for public good, policy should be developed within globally harmonised, science-based systems such as the Codex Alimentarius Commission. Codex provides internationally recognised standards grounded in independent scientific risk assessment, ensuring global alignment on food safety, quality, and nutrition.[78]

Alignment with Codex is essential to avoid fragmented, non-scientific, or trade-distorting national approaches, while enabling coherent regulation, facilitating international trade, and ensuring that public health measures are proportionate, consistent, and evidence-based.

Effective, forward-looking policy should be built on four foundational pillars.

- **Science as the foundation of policy:** Scientific evidence must guide policy design, including the development of food classification systems. A science-based approach ensures classifications are accurate, proportionate, and aligned with evolved food technology, supporting both public health objectives and responsible product development. Policies should move beyond simplistic processing-based categories, which misrepresent nutritional quality, and instead incentivise industry to reduce sugar, salt, and fat while adding beneficial nutrients such as fibre and protein.[24]

- **Supporting consumer-informed choices:** Nutrition policies should prioritise clarity and practicality for consumers. Simple, actionable messages about nutrient quality are more effective than technical labels that most consumers cannot accurately define. Clear, accurate, and accessible product information empowers informed choices.[25,79] This principle extends to support proven interventions like fortification, which addresses widespread micronutrient deficiencies without requiring major dietary shifts.[53]

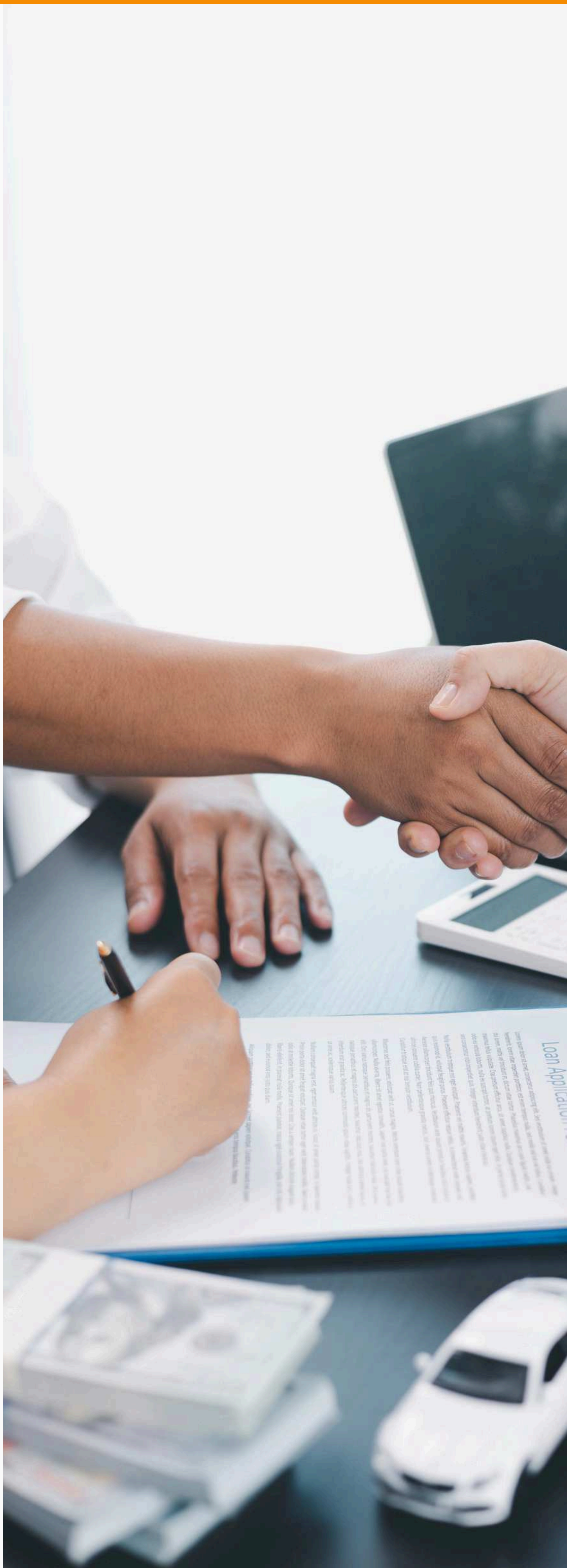
- **Enabling responsible industry innovation:** Policy should encourage the development of nutritious, convenient foods that meet modern needs. This includes supporting innovation in fortified, functional, and specialised products that offer tailored nutrition solutions. Frameworks should also promote sustainability by encouraging upcycling, efficient processing, and eco-friendly packaging to reduce food loss and environmental impact.[70,71,80]

- **Adopting a holistic food systems view:** Effective policy must consider the bigger picture: food safety, nutritional quality, sustainability, and cultural context. A holistic approach avoids unintended consequences of narrow rules and ensures food processing continues to support health, food security, and the development of resilient food systems for all.

The path to a healthier food future requires a coordinated and forward-thinking approach that moves beyond restrictive regulation to create an enabling environment. To translate consumer demand into tangible progress, all stakeholders must act with shared purpose.

- **Foster cross-sector collaboration:** To create policies that genuinely support public health, governments, industry, and the scientific community must work together. Collaborative efforts can ensure modern processing technologies are applied responsibly to enhance nutrition, safety, and convenience, driving the development and availability of healthier foods for all.

- **Recognise the positive role of food processing:** Effective policy must first acknowledge processing as a fundamental tool—one that improves food safety, extends shelf life, enhances nutritional quality, and increases accessibility. Shifting the perception of processing from inherently “negative” to a vital enabler of healthier choices is essential for building policies grounded in reality. This is especially critical as overly simplistic classifications can overlook processing's essential benefits and create public confusion.[39]



- **Create an enabling environment for innovation:** Regulations and incentives should be designed to encourage, not hinder, innovation in healthier food formulations. By focusing on nutrient-based targets rather than symbolic classifications, policy can empower industry to reformulate, fortify, and develop new products that meet public health goals.
- **Empower consumers with clarity and choice:** A collaborative approach ensures consumers have access to a diverse, nutritious, and safe range of food options that fit different lifestyles and cultural preferences. Empowering choice begins with clear, science-based communication—providing information on nutrient composition, portion size, and dietary context—so individuals can make confident, informed decisions. This approach aligns with expert recommendations that food guidance should be based on nutrient profiling and dietary context, not on unsubstantiated processing-level labels.[39]

Ultimately, by advancing evidence-based collaboration and recognising the essential contributions of food processing, stakeholders can co-create a resilient food system that delivers on the promise of safety, nutrition, and sustainability for generations to come.

11. Conclusion: Towards a Safe, Healthier, and Sustainable Future

Food processing is an essential and enduring part of current era, supporting safe, accessible, and reliable food systems for diverse populations across Asia and beyond. From ancient preservation methods to today's innovative technologies, it enables the year-round availability of safe, nutritious, and culturally significant foods.

Far from being a barrier to health, processing should be recognised as part of the solution rather than a health risk. It is a foundational tool that ensures food safety, enhances nutrition through fortification and improved bioavailability, extends shelf life to reduce waste, and strengthens food security in both every day and crisis contexts. Processing also makes essential macro- and micronutrients accessible at scale. When consumed as part of a balanced diet, processed foods can deliver meaningful nutrition and support public health, especially when guided by science-driven reformulation and innovation.

The greater challenge lies not in the technology itself, but in public perception. Overly simplistic debates that define foods solely by their level of processing overlook more meaningful factors—nutrient composition, portion size, and dietary context. Science, not symbolism, must guide how we evaluate and communicate about food.

Looking ahead, continued innovation in reformulation, fortification, upcycling, and sustainable packaging shows how processing can evolve to meet nutritional needs and environmental goals. Policies grounded in robust evidence, alongside collaboration across sectors, will ensure that food processing remains a force for good.

Ultimately, food processing is a key enabler—not a barrier—to building resilient, sustainable, and health-promoting diets for current and future generations. By embracing its full potential, we can create food systems that deliver safety, nutrition, and sustainability for all.

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Acknowledgments

We would like to thank the Processing Squad members of Food Industry Asia (FIA) for their collaboration, input, and contributions in shaping this work, and all those who gave their valuable time to contribute feedback and ideas.

We also acknowledge the Health & Nutrition team for their integral role in the scientific, technical, and editorial review of this report, and the Communications team for their creativity and expertise in shaping its visual identity.

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