Letters in Food Science and Technology

REVIEW ARTICLE

Fast Foods: Preparation, Preservation, Micronutrient Fate, Benefits and Risks

A Narrative Review

Dr. M. A. Pasha, Ph. D.*
Professor (Retired), Bangalore University
Present Address: Chief-Editor, ESRA Publications Pvt. Ltd., Bengaluru-560094, INDIA
**e-mail: chief.editoresra@gmail.com*
ORCID iD: https://orcid.org/0000-0002-7986-0040

ARTICLE INFO

Prepared 23th October 2026,
www.esrapublications.com

Edited & Published 3rd November 2026

ABSTRACT

Fast foods are a heterogeneous group of rapidly prepared or readily available foods, including burgers, pizzas, sandwiches, fried chicken, French fries, wraps, noodles, bakery products and regional street foods. Their nutritional and safety characteristics depend on ingredients, preparation method, processing intensity, preservation conditions, portion size and frequency of consumption. Thermal processing improves palatability, digestibility and microbial safety when correctly applied, but may also degrade micronutrients, oxidise lipids, modify amino acids and form process contaminants such as acrylamide. Refrigeration, freezing, modified-atmosphere and vacuum packaging, dehydration and suitable heat treatments extend shelf life but influence nutrient retention and product quality. Fast foods can supply protein, energy, iron, calcium and vitamins when well formulated; however, many commercial products are high in sodium, saturated fat, refined carbohydrate and energy relative to their fibre and micronutrient content, and frequent consumption within a poor overall dietary pattern may contribute to obesity, hypertension, cardiovascular disease and metabolic dysfunction. This narrative review integrates food chemistry, processing technology, micronutrient stability, food safety, nutritional benefits and public-health evidence; distinguishes nutrient concentration, true retention and bioavailability; and identifies practical strategies to improve fast-food formulation and processing without sacrificing convenience, sensory quality or microbiological safety.

Keywords: Fast food; thermal processing; frying; food preservation; micronutrient retention; vitamin degradation; mineral bioavailability; lipid oxidation; acrylamide; food safety; metabolic health

Highlights

- Fast food is defined by convenience and mode of service, not by a single nutritional or processing category.
- Nutrient concentration, true retention and bioavailability are distinct; mass change during cooking can mislead.
- Vitamin C, folate and vitamin B_6 are among the most vulnerable to hot-holding and reheating; minerals are comparatively robust.
- Risks arise from specific exposures (excess energy, sodium and saturated fat; low fibre) rather than from the label “fast food”.
- Reformulation, process optimisation and validated cold-chain control offer practical routes to healthier products.

1. Introduction

Fast food has become an important component of contemporary food systems because of its convenience, affordability, accessibility, standardised production and sensory appeal. The category

Copyright: The author © 2026. This is an open-access article distributed under Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

includes freshly prepared meals and industrially manufactured products that require only reheating or final assembly, and its relationship with cardiometabolic risk has been widely examined [1].

Fast food is defined primarily by convenience and mode of service, not by a single nutritional or processing category. A freshly prepared grilled fish wrap with vegetables differs substantially from a large serving of deep-fried chicken, refined-flour bread, cheese and a sugar-sweetened beverage. Processing intensity and nutritional quality are related but are not interchangeable concepts; classification systems such as NOVA group foods by the extent and purpose of industrial processing rather than by the setting in which they are eaten [2].

Three dimensions should be examined separately: (i) food preparation and the physical and chemical transformations occurring during cooking; (ii) preservation and distribution technologies that control microorganisms, enzymatic activity, oxidation and moisture; and (iii) the dietary consequences of individual foods and of repeated consumption within the overall diet (Figure 1). Public-health guidance emphasises dietary diversity and moderation of sodium, free sugars and unhealthy fats rather than treating all convenience foods as nutritionally equivalent [3].

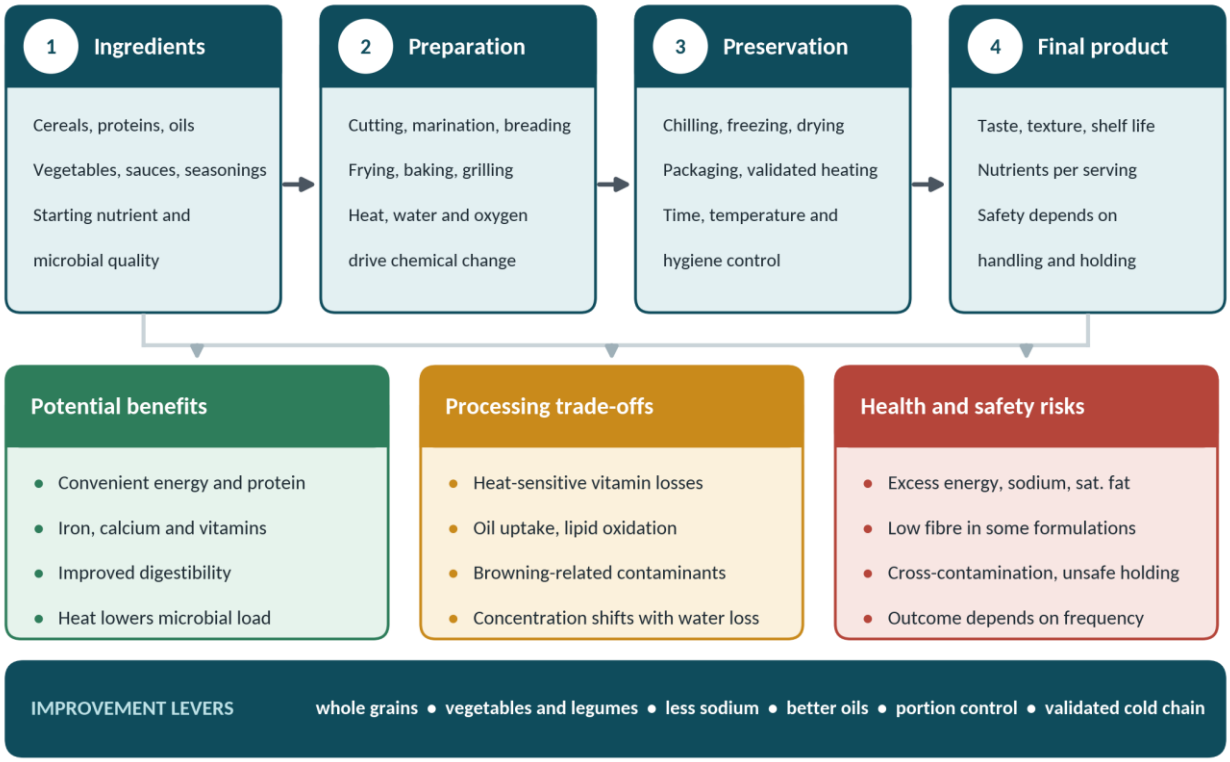


Figure 1. Integrated framework linking ingredients, preparation, preservation and the final product to potential benefits, processing trade-offs, and health and safety risks. Conceptual infographic; not a quantitative risk estimate, and product-specific validation is required.

2. Scope and approach

This article is a narrative synthesis of established food-science principles, selected peer-reviewed reviews and primary studies, and public-health guidance. It is not a systematic review or meta-analysis, and no formal protocol, database search strategy or risk-of-bias appraisal was applied; sources were selected for their relevance to mechanisms and evidence on processing, preservation, nutrient fate and health. Figures 1–3 are conceptual and summarise mechanisms or qualitative tendencies rather than measured data. Figure 4 is a worked numerical illustration of a calculation, not experimental data. Statements about nutrient behaviour are qualitative tendencies unless a quantitative source is cited; actual values depend on food matrix, recipe and process conditions.

3. Classification and composition of fast foods

Table 1. Categories of fast food, potential nutritional contribution and common concerns.

Category	Potential nutritional contribution	Common concern
Freshly assembled or grilled foods	Protein; vegetables may provide fibre, folate and carotenoids	Sodium-rich marinades and sauces
Deep-fried foods	Carbohydrate, energy, some minerals and vitamins depending on ingredients	High energy density, salt, possible acrylamide and oil degradation
Baked or oven-cooked foods	Protein, carbohydrate, calcium or vegetables depending on recipe	Sodium, saturated fat and large portions
Ready-to-heat foods	Convenient energy; some products are fortified	High sodium and low fibre or protein in some formulations
Legume- or vegetable-rich wraps	Plant protein, fibre, folate and minerals	Sodium and oil depend on preparation

These are qualitative descriptions rather than universal nutrient values. Actual composition varies by recipe, brand, serving size, cooking method and fortification.

4. Preparation and processing

4.1 Raw-material selection and pretreatment

Preparation begins with the selection and handling of cereals, meat, fish, eggs, milk products, vegetables, oils and seasonings. Washing, peeling, cutting, marination, blanching, breading, dough fermentation and partial cooking can affect the starting nutrient profile and microbial burden. Washing and peeling may remove surface contaminants but also remove nutrients concentrated in outer tissues. Cutting increases surface area and may accelerate oxidation. Blanching inactivates selected enzymes but can cause leaching of water-soluble vitamins and minerals.

4.2 Major cooking methods

Deep-fat frying commonly uses oil temperatures of about 160–190 °C, depending on product and process. Surface dehydration produces a crust, while internal moisture heats and escapes as steam; oil may enter the food, particularly during cooling, and the amount taken up depends strongly on the water content of the raw material [7]. Frying oil undergoes oxidation, hydrolysis and polymerisation as heating continues, and temperature, time, oil replenishment and (where used) vacuum are among the most influential process parameters for oil and product quality [5,6]. From a nutritional standpoint, the high temperature and short cooking time of frying cause less loss of heat-labile vitamins than several other cooking methods, and protein and mineral contents are little affected, although fat uptake raises energy density [4].

Shallow frying and stir-frying often use shorter cooking times, but nutrient retention depends on temperature, surface area, oil and whether cooking liquid is discarded. Baking and roasting promote moisture loss, starch changes, protein denaturation and browning. Grilling can reduce added fat, while excessive charring and smoke exposure may generate or deposit undesirable compounds.

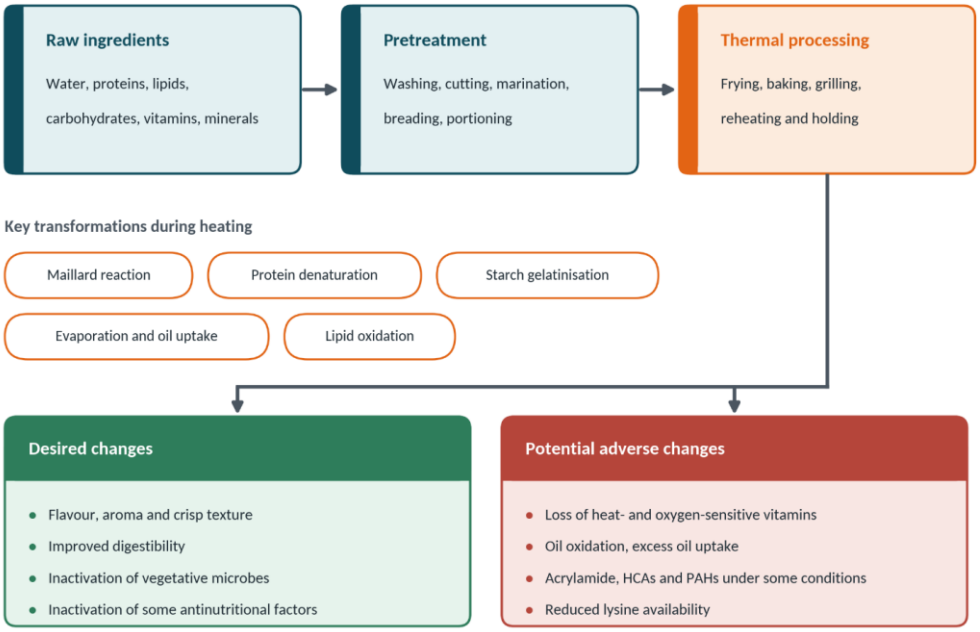


Figure 2. Conceptual processing pathway showing desirable and potentially adverse changes. Actual outcomes depend on food matrix and process conditions. HCAs, heterocyclic amines; PAHs, polycyclic aromatic hydrocarbons.

4.3 Important chemical reactions

Maillard reaction. Reducing sugars react with amino groups, producing brown pigments and flavour compounds. This contributes to desirable roasted flavours but can reduce reactive lysine and, under suitable conditions, generate acrylamide; asparagine is a key amino-acid precursor [9,10].

Protein denaturation. Heat unfolds proteins, often improving digestibility and inactivating some antinutritional factors. Excessive heat can damage selected amino acids or reduce lysine availability.

Starch gelatinisation. Heat and water disrupt starch granules, generally increasing digestibility. Cooling can promote retrogradation and the formation of some resistant starch.

Lipid oxidation. Oxygen attacks susceptible unsaturated fatty acids, forming hydroperoxides and secondary products such as aldehydes. The extent depends on oil composition, temperature, duration, oxygen exposure and antioxidant content.

Water loss and oil uptake. Evaporation creates pores and a dehydrated crust. Some surface oil can enter these pores, particularly as pressure changes during cooling [7].

5. Preservation of fast foods

Table 2. Preservation methods, mechanisms, nutritional implications and limitations.

Method	Main mechanism	Nutritional implications	Main limitation
Refrigeration	Slows microbial growth and reactions	Generally favourable for short-term retention	Does not eliminate pathogens
Freezing	Ice formation slows deterioration	Often retains nutrients well; pretreatment and storage matter	Texture damage and temperature fluctuations
Pasteurisation	Controlled heat reduces target microbes	Some heat-sensitive vitamin loss possible	Does not sterilise all foods
Commercial sterilisation	More intensive heat controls relevant microbes and spores	Potentially greater heat-induced vitamin loss	Flavour and texture changes
Dehydration	Lowers water activity	Minerals generally remain; oxidation-sensitive vitamins may decline	Texture and rehydration limits
Modified-atmosphere packaging	Changes oxygen and carbon dioxide around food	Can slow oxidation and some spoilage	Requires suitable packaging and temperature control
Vacuum packaging	Reduces oxygen exposure	May slow oxidative deterioration	Not a substitute for refrigeration
High-pressure processing	Pressure inactivates many vegetative microbes	Can retain some heat-sensitive nutrients better than conventional heating	Spores may require additional hurdles

Packaging can provide moisture, oxygen, light and aroma barriers. Multilayer packaging may deliver several barrier properties at once, although recycling and end-of-life management can be more difficult [11].

5.1 Time–temperature control and food safety

- Separate raw ingredients from cooked and ready-to-eat foods.
- Use validated cooking temperatures and check the coldest part of the food.
- Minimise uncontrolled time at temperatures that permit microbial growth.
- Keep chilled foods appropriately cold and hot foods appropriately hot.
- Prevent contamination during packaging, transport, display and serving.
- Follow validated cooling, reheating and shelf-life procedures.

Cook–chill systems add chilling, storage and reheating stages at which sensitive vitamins can be lost [12], so safety controls and nutrient protection should be designed together. Vacuum or modified-atmosphere packaging can suppress some spoilage organisms without necessarily controlling pathogens that grow under reduced-oxygen conditions; product-specific hazard analysis is essential.

5.2 Hurdle technology

A combined preservation system may use thermal treatment, refrigeration or freezing, packaging, hygiene controls and validated storage and distribution. Hurdles can work synergistically, but no single hurdle guarantees safety for every product.

6. Fate of micronutrients

Micronutrient retention depends on initial composition, temperature, exposure time, oxygen, pH, moisture, food matrix and processing method. Nutrient retention, concentration and bioavailability are distinct concepts. Water loss can raise the measured concentration per 100 g even when the total amount of nutrient has fallen.

6.1 Vitamins

Table 3. Qualitative tendencies in vitamin stability during preparation, holding and storage.

Micronutrient	Main mechanisms	General tendency and practical implication
Vitamin C	Oxidation, heat, leaching	Often vulnerable; minimise unnecessary holding and include fresh produce
Thiamine (B_1)	Heat and leaching	Prolonged heating can cause losses
Riboflavin (B_2)	Light and selected processing conditions	Often more heat-stable than vitamin C; protect from light
Folate (B_9)	Heat, oxidation, leaching	Can decline during cooking, holding and storage
Vitamin B_6	Heat and leaching	Retention depends on matrix and conditions; hot-holding losses reported
Vitamin B_{12}	Heat and food matrix	Stability varies by treatment and food
Vitamin A / carotenoids	Oxidation and heat; release from tissue	Some degradation, but heating may improve release of carotenoids
Vitamin E	Oxidation, especially in heated oil	Can decline with repeated oil heating
Vitamin D	Food matrix and processing	Often relatively stable under many conditions, but losses can occur
Vitamin K	Light, oxidation and matrix	Retention varies with form and storage

These are qualitative tendencies, not universal retention percentages. Frying is not necessarily the worst method for every vitamin: rapid cooking and the absence of immersion in water may favour retention of some nutrients compared with prolonged boiling, and vitamin C concentrations in French-fried potatoes have been reported to be comparable to those of raw potatoes [4]—although, as Section 6.4 shows, concentration alone does not establish retention. Fat uptake and oil deterioration remain important concerns.

Holding, chilling and reheating can add substantial losses on top of those from cooking. In a review of 66 hospital food-service studies, vitamin C, folate and vitamin B_6 showed the greatest losses (more than 10% after 2 hours of hot-holding), whereas retinol, thiamin, riboflavin and niacin were comparatively stable; losses of vitamin C and folate exceeded 30% when food stored for 24 hours at 3 °C was reheated [12]. These data derive from institutional catering rather than fast-food outlets, but the mechanisms apply equally to hot-holding and reheating in fast-food service. Figure 3 summarises the qualitative ordering used in this review.

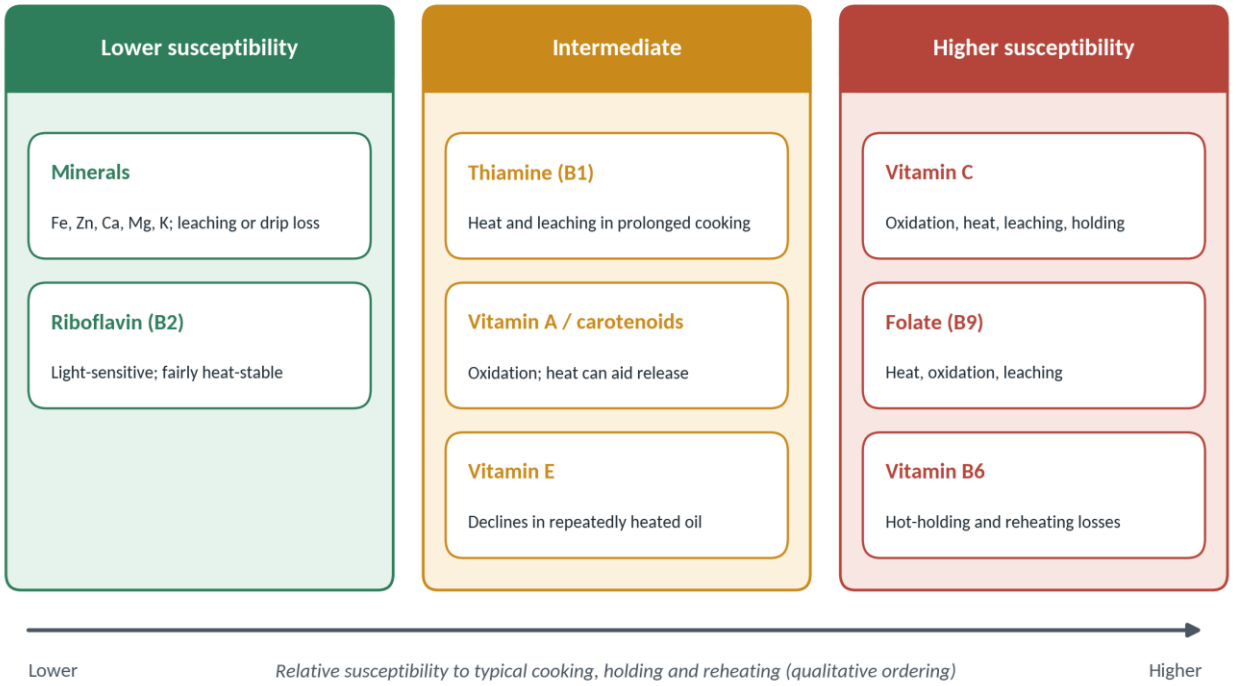


Figure 3. Conceptual ordering of micronutrient susceptibility to typical cooking, holding and reheating. The grouping is qualitative and synthesised from Table 3 and reference [12]; it is not a set of measured nutrient-loss percentages or a universal ranking.

6.2 Minerals: content versus bioavailability

Iron, zinc, calcium, magnesium and potassium are generally more resistant to ordinary cooking temperatures than vitamins. Their measured content can nevertheless change through leaching, dripping, transfer between phases or changes in food mass. Bioavailability is governed by the whole meal: phytate in some cereal and legume ingredients can reduce iron and zinc absorption, and for iron, polyphenols and calcium are also inhibitory whereas ascorbic acid and muscle tissue enhance absorption [13]. Soaking, fermentation, germination and suitable food combinations may improve mineral availability. Estimated iron bioavailability is approximately 14–18% for mixed diets and 5–12% for vegetarian diets in people with no iron stores [13], underscoring that content per serving overstates what is absorbed.

6.3 Nutrient retention through the supply chain

The final micronutrient contribution reflects raw-material content, preparation, cooking, holding, preservation, packaging, transport and reheating. Evaluation should consider nutrients delivered per serving and bioavailability, not concentration alone.

6.4 True nutrient retention

> **True retention (%) = [(final concentration × final food mass) ÷ (initial concentration × initial food mass)] × 100**

Illustrative example: 100 g of raw food contains 20 mg of vitamin C. After cooking, the food weighs 70 g and contains 15 mg per 100 g. Total remaining vitamin C = 15 × 70/100 = 10.5 mg, so true retention = 10.5/20 × 100 = 52.5%. Concentration alone would suggest 75% retention (Figure 4); the example shows why concentration per 100 g can mislead.

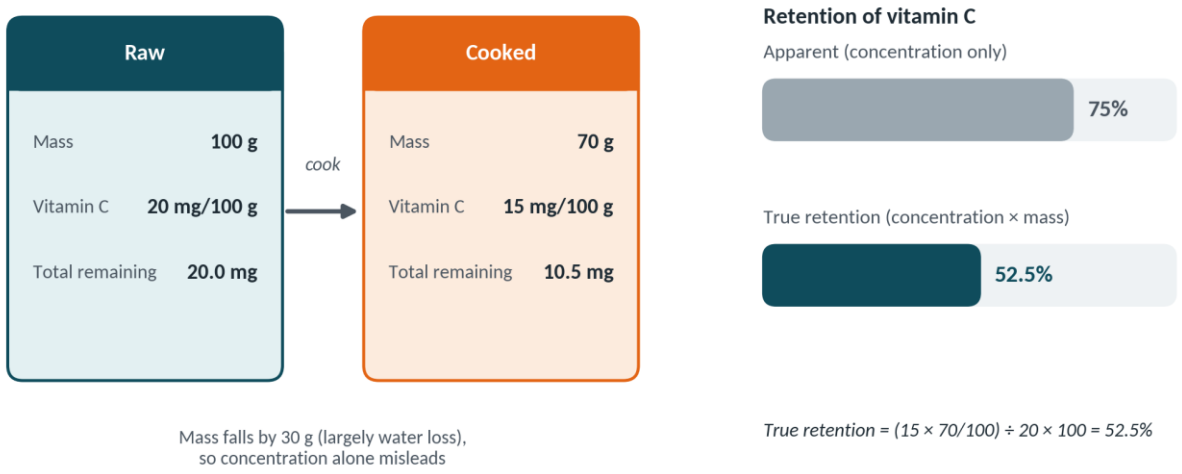


Figure 4. Worked example contrasting apparent retention (concentration only) with true retention (concentration × mass). Values are illustrative and are not experimental data.

7. Effects on macronutrients and other constituents

7.1 Proteins and amino acids

Foods containing eggs, dairy, meat, fish, soy, chickpeas or other legumes can provide valuable protein. Heating often improves digestibility and reduces vegetative microbial hazards when adequate conditions are reached. Prolonged or intense heating may reduce the availability of selected amino acids, particularly reactive lysine through Maillard reactions.

7.2 Carbohydrates, dietary fibre and resistant starch

Refined-flour buns, pizza crusts, breading and many instant noodles may contain relatively little fibre. Whole grains, pulses, vegetables and seeds can improve fibre and micronutrient density; vegetable-rich wraps, bean burgers and whole-grain sandwiches are practical examples. Heating often increases starch accessibility, and cooling can form some resistant starch depending on starch source and processing history; an increase in the dietary fibre of fried potato products attributed to resistant starch has been reported [4]. Frying should not, however, be treated as a general fibre-enhancement method, because changes in apparent concentration can reflect moisture loss or analytical factors.

7.3 Fats and oils

Fatty-acid composition depends on ingredients, added oil, frying medium and absorbed oil. Repeated heating can cause oxidation, hydrolysis and polymerisation. Oil selection, temperature, heating duration, replenishment, exposure to air and removal of food debris influence deterioration [6]. Fried foods can remain a useful source of vitamin E, although some unsaturated fatty acids and antioxidant vitamins are lost to oxidation [4].

8. Nutritional benefits

Table 4. Potential nutritional benefits of fast foods and the conditions under which they are realised.

Potential benefit	Food sources	Conditions
Protein intake	Eggs, dairy, fish, poultry, meat, soy and legumes	Appropriate portions and protein quality
Energy provision	Cereals, bread, potatoes, oils	Fits individual energy needs
Iron and zinc	Meat, seafood, legumes and fortified cereals	Source and bioavailability matter
Calcium and vitamin B12	Dairy and selected fortified foods	Suitable formulation and serving
Vitamins and antioxidants	Vegetables, fruits, herbs and selected oils	Adequate inclusion and sensible processing
Food safety	Adequate heat, hygiene and temperature control	Validated procedures and no recontamination

Fast food is not inherently nutritionally poor. A well-composed meal can provide protein, energy, iron, calcium and vitamins. However, high energy density should not be confused with nutritional completeness. Fortification can address selected micronutrient gaps but does not automatically correct excessive sodium, saturated fat or energy.

9. Health risks

9.1 Energy excess and weight gain

Many commercial combinations provide high energy density through added fats, refined carbohydrates, large portions and calorie-containing beverages. Habitual energy intake exceeding expenditure can contribute to weight gain; the outcome depends on total intake, activity, portion size and individual physiology. Reviews of observational studies associate frequent fast-food consumption with overweight, abdominal fat gain, impaired glucose and insulin homeostasis and adverse lipid profiles [1]. Mechanistic support comes from a randomised crossover trial in 20 adults, in which an ultra-processed diet matched for presented macronutrients, sugar, sodium and fibre led to about 500 kcal/day greater ad libitum energy intake and weight gain of roughly 0.9 kg over 14 days [15]. That trial concerned ultra-processed foods generally, not fast food specifically, and was short.

9.2 Sodium and blood pressure

Sodium can enter through bread, processed meats, cheese, sauces, pickles, seasoning mixes and preservatives. High habitual sodium intake can raise blood pressure in susceptible people. Reducing sodium in sauces, seasoning blends, processed meats and dough can improve nutritional quality.

9.3 Saturated fat and cardiovascular risk

Some meals contain substantial saturated fat from fatty meats, cheese, butter, ghee, palm-based fats and selected shortenings. An American Heart Association advisory concluded that replacing saturated fat with unsaturated fats, especially polyunsaturated fats, lowers cardiovascular disease incidence, that replacement with refined carbohydrate does not, and that trans fats increase risk [14]. Industrial trans fats should be avoided.

9.4 Refined carbohydrates, sugars and fibre

Sugar-sweetened beverages, sweet bakery products and refined-grain meals can contribute free sugars or rapidly digestible starch. Low fibre can reduce overall dietary quality. Practical options include water instead of sugary drinks, whole-grain products, vegetables, fruit and legumes.

9.5 Process contaminants

Acrylamide forms in carbohydrate-rich foods through reactions involving asparagine and reducing sugars during high-temperature cooking, particularly when foods become excessively browned [9,10]. In the study that first reported acrylamide in heated foodstuffs, levels of about 150–4000 µg/kg were measured in carbohydrate-rich foods such as potato products and crispbread, compared with 5–50 µg/kg in heated protein-rich foods, and acrylamide was not detected in unheated or boiled foods (<5 µg/kg) [8]. Heterocyclic amines can form in meat at high temperatures, and polycyclic aromatic hydrocarbons can arise through smoke and fat dripping onto flames. Repeatedly heated oils may accumulate aldehydes and other degradation products [6,7]. Concentrations vary substantially by product and cooking conditions; the presence of a compound alone does not establish the magnitude of risk from an individual serving.

9.6 Microbiological hazards

Foodborne illness can result from contaminated ingredients, inadequate cooking, cross-contamination, unsafe holding temperatures or poor hygiene. Cooking does not prevent later recontamination. Controls should be specific to meat, poultry, eggs, dairy sauces, vegetables and ready-to-eat foods.

9.7 Interpreting health evidence

Associations between fast-food consumption and health outcomes should be interpreted within overall dietary patterns. Observational studies may be influenced by physical activity, socioeconomic factors, smoking, sleep and other behaviours [1]. It is more precise to identify specific exposures—excess energy, sodium, saturated fat, low fibre and inadequate fruit and vegetable intake—than to attribute every outcome to the label “fast food”.

10. Nutritional trade-offs and product development

The same process can have both beneficial and adverse effects. Heating can improve texture, flavour, digestibility and microbial safety, while causing vitamin losses, oil oxidation, excessive oil uptake or process contaminants. These outcomes depend on ingredient composition and process conditions.

10.1 Factors governing nutrient retention

Table 5. Process factors influencing nutrient retention and their qualifications.

Factor	Expected direction	Qualification
Higher temperature	May accelerate degradation and browning	Time and matrix strongly modify effect
Longer holding	May increase loss of susceptible vitamins and fat deterioration	Depends on temperature, oxygen and packaging
Appropriate refrigeration	Often protective	Does not stop all deterioration or guarantee safety
Reduced oxygen exposure	Often slows oxidation	Packaging must suit the food and hazard profile

10.2 Strategies for healthier fast foods

Table 6. Reformulation and process interventions, expected advantages and technical considerations.

Intervention	Expected advantage	Technical consideration
Partial replacement with whole-grain flour	More fibre and potentially higher micronutrient density	Dough rheology and texture
More vegetables and legumes	Fibre, folate, potassium and other nutrients	Moisture, microbial safety and shelf life
Lean protein sources	Can reduce saturated fat while maintaining protein	Moisture retention and palatability
Replace some saturated fat with unsaturated oils	Improved fatty-acid profile	Oxidative stability under frying
Optimise frying time and temperature	May reduce excess browning and oil deterioration	Maintain validated cooking safety
Reduce sodium in sauces and seasonings	Lower sodium per serving	Flavour and preservation requirements
Portion design	Can reduce energy and sodium per eating occasion	Fit within total dietary needs
Improved packaging barriers	Can slow oxidation and moisture changes	Compatibility, recycling and cost
Cold-chain management	Reduces microbial growth and deterioration	Continuous monitoring and validation

Vacuum frying, microwave-assisted frying, ultrasound-assisted processing and hybrid technologies are being studied to improve heat and mass transfer, reduce oil uptake or degradation, and preserve quality [16]. A technology that reduces oil uptake does not automatically eliminate contaminants or prove long-term health benefits; product-specific validation is required.

11. Research gaps and future directions

- Develop realistic nutrient-retention datasets spanning cooking, cooling, storage, transport and reheating, using true-retention calculations.
- Investigate interactions between reducing sugars, amino acids, moisture, pH and frying oil in nutrient degradation and contaminant formation.
- Measure bioavailability rather than relying only on nutrient concentration.
- Connect frying-oil degradation markers with realistic exposure levels and health outcomes.
- Quantify the combined effects of packaging barriers, refrigeration, freezing, nutrient retention, food safety and environmental performance.
- Study Indian and regional convenience foods such as dosa, vada, samosa, pakora, kebabs, biryani and rolls using product-specific methods.
- Integrate nutritional quality, safety, cost, energy use, food waste and packaging impacts in future assessments.
- Complement this narrative synthesis with systematic, protocol-registered reviews of nutrient retention and health outcomes in defined fast-food categories.

12. Conclusions

Fast foods represent a diverse category whose nutritional and health implications depend on formulation, preparation, preservation, portion size and frequency of consumption. Thermal processing improves sensory characteristics and can enhance digestibility and microbial safety, but it can also reduce selected vitamins, alter amino-acid availability, increase energy density through oil uptake and generate undesirable chemical compounds under particular conditions.

Minerals are generally more resistant to heat than many vitamins, although retention and bioavailability depend on the food matrix and processing history. Refrigeration, freezing, packaging and controlled thermal treatment can extend shelf life, but no preservation method removes the need for hygiene and validated temperature management.

Fast foods can supply useful protein, energy, vitamins and minerals when they contain appropriate ingredients. Frequent consumption of products high in sodium, saturated fat, refined carbohydrates and excess calories may contribute to poor dietary quality and adverse health outcomes. The most promising approach is evidence-based reformulation and processing optimisation: improving ingredient quality, limiting excess salt and unhealthy fats, controlling browning and oil deterioration, protecting micronutrients, ensuring microbiological safety and designing portions that fit within a balanced dietary pattern.

Declarations

Author contributions. Conceptualisation; preparing draft, reviewing and editing.

Funding. "This research received no external funding."

Conflict of interest. "The authors declare no conflict of interest."

Data availability. No new data were generated; all figures are conceptual or illustrative (Section 2).

Use of AI tools. AI-assisted tools, were used during the preparation of this manuscript to assist with literature organization, development of the manuscript structure, language refinement and improvement of clarity and presentation. AI tools were also used to support the preparation and organization of certain tables and illustrative materials.

Acknowledgements. The authors acknowledge the scientific researchers, food technologists, nutritionists, public health professionals and regulatory organizations whose published research and reports have contributed to the understanding of fast foods, their preparation and preservation methods, nutritional composition, micronutrient stability, potential benefits, and associated health risks. The authors also acknowledge the valuable contributions of scientific literature and publicly available resources that facilitated the development of this narrative review.

References

[1] Bahadoran Z, Mirmiran P, Azizi F. Fast food pattern and cardiometabolic disorders: a review of current studies. *Health Promot Perspect.* 2015;5(4):231–240. doi:10.15171/hpp.2015.028

[2] Monteiro CA, Cannon G, Levy RB, Moubarac J-C, Louzada MLC, Rauber F, et al. Ultra-processed foods: what they are and how to identify them. *Public Health Nutr.* 2019;22(5):936–941. doi:10.1017/S1368980018003762

[3] World Health Organization. Healthy diet [fact sheet]. Geneva: World Health Organization. https://www.who.int/news-room/fact-sheets/detail/healthy-diet (public-health guidance; no DOI).

[4] Fillion L, Henry CJK. Nutrient losses and gains during frying: a review. *Int J Food Sci Nutr.* 1998;49(2):157–168. doi:10.3109/09637489809089395

[5] Asokapandian S, Swamy GJ, Hajjul H. Deep fat frying of foods: a critical review on process and product parameters. *Crit Rev Food Sci Nutr.* 2020;60(20):3400–3413. doi:10.1080/10408398.2019.1688761

[6] Hosseini H, Ghorbani M, Meshginfar N, Mahoonak AS. A review on frying: procedure, fat, deterioration progress and health hazards. *J Am Oil Chem Soc.* 2016;93:445–466. doi:10.1007/s11746-016-2791-z

[7] Dangal A, Tahergorabi R, Acharya DR, Timsina P, Rai K, Dahal S, et al. Review on deep-fat fried foods: physical and chemical attributes, and consequences of high consumption. *Eur Food Res Technol.* 2024;250:1537–1550. doi:10.1007/s00217-024-04482-3

[8] Tareke E, Rydberg P, Karlsson P, Eriksson S, Törnqvist M. Analysis of acrylamide, a carcinogen formed in heated foodstuffs. *J Agric Food Chem.* 2002;50(17):4998–5006. doi:10.1021/jf020302f

[9] Mottram DS, Wedzicha BL, Dodson AT. Acrylamide is formed in the Maillard reaction. *Nature.* 2002;419:448–449. doi:10.1038/419448a

[10] Stadler RH, Blank I, Varga N, Robert F, Hau J, Guy PA, et al. Acrylamide from Maillard reaction products. *Nature.* 2002;419:449–450. doi:10.1038/419449a

[11] Anukiruthika T, Sethupathy P, Wilson A, Kashampur K, Moses JA, Anandharamakrishnan C. Multilayer packaging: advances in preparation techniques and emerging food applications. *Compr Rev Food Sci Food Saf.* 2020;19(3):1156–1186. doi:10.1111/1541-4337.12556

[12] Williams PG. Vitamin retention in cook/chill and cook/hot-hold hospital food-services. *J Am Diet Assoc.* 1996;96(5):490–498. doi:10.1016/S0002-8223(96)00135-6

[13] Hurrell R, Egli I. Iron bioavailability and dietary reference values. *Am J Clin Nutr*. 2010;91(5):1461S–1467S. doi:10.3945/ajcn.2010.28674F

[14] Sacks FM, Lichtenstein AH, Wu JHY, Appel LJ, Creager MA, Kris-Etherton PM, et al. Dietary fats and cardiovascular disease: a presidential advisory from the American Heart Association. *Circulation.* 2017;136(3):e1–e23. doi:10.1161/CIR.0000000000000510

[15] Hall KD, Ayuketah A, Brychta R, Cai H, Cassimatis T, Chen KY, et al. Ultra-processed diets cause excess calorie intake and weight gain: an inpatient randomized controlled trial of ad libitum food intake. *Cell Metab.* 2019;30(1):67–77.e3. doi:10.1016/j.cmet.2019.05.008

[16] Yildiz AY, Echegaray N, Öztekin S, Lorenzo JM. Quality and stability of frying oils and fried foods in ultrasound and microwave-assisted frying processes and hybrid technologies. *Compr Rev Food Sci Food Saf.* 2024;23(4):e13405. doi:10.1111/1541-4337.13405