

Food processing in global dietary guidelines: Current status and future directions

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ABSTRACT

The increasing debate on the potential detrimental role of food processing on human health led to the incorporation of processing-related terms also in nutritional policies, particularly Food-Based Dietary Guidelines (FBDGs).

For this reason, the present review systematically examines national FBDGs to assess how they incorporate recommendations on food processing. Specifically, it analyzes the terminology and descriptions used to communicate these concepts to consumers.

The analysis included the most recent national FBDGs available in English, French, Italian, or Spanish from the FAO repository and official health websites, targeting the general adult population. References to food processing were identified through keyword searches and manual review, then classified by consideration: nutritional, non-nutritional, or environmental. FBDGs were also categorized by region, income level, and publication date.

Of the 100 FBDGs reviewed, 72 met the inclusion criteria. Most FBDGs were published between 2011 and 2019 and originated primarily from Latin America and Europe. Sixty-one FBDGs included at least one reference to food processing, with 90% addressing it explicitly. Terms like “ultra-processed” or “highly processed” appeared in 31% of guidelines, while only 11% mentioned the NOVA classification. References largely focused on nutritional impacts, particularly in relation to processed meat, while non-nutritional and environmental aspects were rarely addressed. Among the 61 FBDGs that referenced food processing, environmental considerations appeared in just 11%.

The concept of food processing is now increasingly incorporated into FBDGs. Continued monitoring will be essential to ensure that the information included in the guidelines is aligned with the latest scientific evidence on processed foods.

Abbreviations

IARC-EPIC International Agency for Research on Cancer – European Prospective Investigation into Cancer and Nutrition
DASH Dietary Approaches to Stop Hypertension
DRV Dietary Reference Values
FAO Food and Agriculture Organization
FBDG Food-Based Dietary Guidelines
IFIC International Food Information Council
IFPRI International Food Policy Research Institute

NIPH National Institute of Public Health
RCT Randomized Controlled Trial
SHDs Sustainable Healthy Diets
UNC University of North Carolina
UPF Ultra-Processed Food
WHO World Health Organization

1. Introduction

A growing body of evidence, largely derived from observational

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studies and meta-analyses, has linked higher ultra-processed food (UPF) consumption to adverse health outcomes, including obesity, cardiovascular disease, and metabolic disorders. The strength and interpretation of these associations remain a matter of ongoing scientific debate (Lane et al., 2024). However, these findings have brought the degree of food processing to the forefront of the nutrition science agenda, prompting part of the scientific community to argue that the health effects of a diet cannot be explained solely by its nutrient composition, but also by the nature and extent to which its foods are processed.

This emerging perspective complements the well-established understanding of healthy dietary patterns. The scientific literature robustly supports the association between healthy dietary patterns – such as the Mediterranean Diet, the Dietary Approaches to Stop Hypertension (DASH), the Nordic diet, and plant-based dietary patterns – and improved health outcomes across diverse populations and geographical contexts (Bakhshimoghaddam et al., 2025; Dinu et al., 2018; English et al., 2021; Lu et al., 2024; Massara et al., 2022; Pagidipati et al., 2025). Despite their regional differences, these patterns share common nutritional principles, being generally characterized by high intakes of plant-based foods such as fruits, vegetables, legumes, nuts, and whole grains, alongside limited consumption of animal-derived products, processed meats, and sugar-sweetened beverages (Massara et al., 2022; Sofi et al., 2025). Conversely, Western dietary patterns, which are characterized by low intakes of whole grain cereals, and frequent consumption of red and processed meats, animal-derived fats, sweets, and sugar-sweetened beverages, are consistently associated with a higher risk of chronic diseases globally (Pagidipati et al., 2025). Another characteristic attributed to healthy dietary patterns is the abundant consumption of fresh and raw foods. However, as society's dietary habits have changed in recent decades, dietary surveys point out that even in Countries following healthy dietary pattern, such as Mediterranean Countries, there is an increasing consumption of processed foods (Marino et al., 2021; Ruggiero et al., 2025). For this reason, it has been suggested that in the relationship between nutrition and health, the issue is not food, nor nutrients, so much as processing (Monteiro, 2009). As a consequence, in recent years it has been proposed that traditional nutrient-based food classification systems, which group foods into categories such as dairy products as sources of calcium, grains as sources of carbohydrates, and meat or fish as sources of protein, reflecting their role in meeting specific dietary requirements (EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA), 2010), should be complemented or replaced by classification systems based on the extent and purpose of food processing.

Several food processing classification systems have been developed, including IARC-EPIC (International Agency for Research on Cancer – European Prospective Investigation into Cancer and Nutrition) in Europe, NOVA in Brazil, SIGA in France, NIPH's food classification system (National Institute of Public Health) in Mexico, and IFPRI's food classification system (International Food Policy Research Institute) in Guatemala. In the United States, frameworks such as those proposed by IFIC (International Food Information Council) and UNC (University of North Carolina) have also been used, though they were primarily developed for consumer communication or research purposes rather than public health policy (Sadler et al., 2021). The NOVA classification, introduced by Monteiro and collaborators from the University of São Paulo, coined the term “ultra-processed” to describe industrially manufactured food products that typically lack whole foods, are pre-prepared or require minimal heating (Monteiro et al., 2018). The term Ultra-Processed Food (UPF) refers to a mix of concepts that are more accurately the setting of processing (industrial production versus home preparation), product formulation (such as the number and type of ingredients), and nutritional characteristics, while the actual technological processes and their impact on food quality and on human health are not considered (Visioli et al., 2023). UPFs are described as industrial products typically composed of five or more ingredients and characterized by high levels of fat, salt, and sugar, while being low in dietary

fiber, essential nutrients, and other health-promoting components. This overlap of criteria may lead consumers not to differentiate foods belonging to NOVA groups, particularly when detailed information on ingredients, processing methods, or brand-specific formulations is unavailable. In particular, the NOVA classification divides foods into four groups: Group 1 includes unprocessed or minimally processed foods (e.g., vegetables, fruits, grains, meat, or eggs); Group 2 encompasses processed culinary ingredients (e.g., oils, salt, or honey); Group 3 consists of processed foods (e.g., canned vegetables, sugared nuts, or unpackaged bread); and Group 4 represents ultra-processed foods (e.g., ice cream, burgers, packaged breads, or breakfast cereals) (Monteiro et al., 2018). The NOVA classification is currently the most widely applied in research and has been suggested as a key framework for formulating FBDGs (Sadler et al., 2021).

Current research on UPFs primarily consists of observational studies investigating their widespread consumption and potential health implications, particularly assessing associations with obesity, cardiovascular diseases, and metabolic disorders (Pagliai et al., 2021; Vitale et al., 2024). Proposed mechanisms include their low nutrient density, high energy density, and presence of additives that may impact gut microbiota composition, inflammation responses, and nutrient bioavailability (Beslay et al., 2020; Martínez Steele et al., 2020; Martini, Godos, et al., 2021; Tristan Asensi et al., 2023). Additionally, concerns arise from the “cocktail effect” of multiple food additives and endocrine-disrupting chemicals in packaging (Lane et al., 2024). However, it remains unclear whether the adverse health effects linked to high UPF consumption stem from the foods themselves or the poor overall dietary quality of individuals who consume them (Dinu et al., 2022).

It is noteworthy that UPFs contribute significantly to daily energy intake, although this proportion varies substantially across countries. Some populations report relatively low intakes, while others exhibit markedly high consumption levels (Marino et al., 2021). In Italy, for instance, UPF intake accounts for approximately 17.3% of total energy in adults and 25.9% in children, with higher consumption associated with poorer health indicators (Ruggiero et al., 2025). Similarly, in France, UPFs contribute to 35.9% of total energy intake, while in the UK the figure rises to 58.6% (Julia et al., 2018; Rauber et al., 2021). These findings led a part of the scientific community to argue that there is an urgent need to promote dietary patterns rich in whole and minimally processed foods (Wolfson et al., 2025). In 2019, the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) introduced 16 guiding principles for SHDs, defining them as “based on a great variety of unprocessed or minimally processed foods [...] while restricting highly processed food and drink products” (World Health Organization & Food and Agriculture Organization of the United Nations, 2019). Sustainable healthy diets (SHDs) aim to reduce the risk of diet-related diseases through the adoption of food-based dietary guidelines (FBDGs) that are adapted to national contexts. These guidelines also emphasize the importance of respecting local culture, culinary practices, traditional knowledge, and consumption patterns, highlighting that the mode of food preparation and consumption is integral to dietary sustainability (World Health Organization & Food and Agriculture Organization of the United Nations, 2019). This broader conceptualization of dietary guidance is increasingly reflected in contemporary frameworks that define diet quality as a multidimensional construct encompassing nutritional adequacy, environmental sustainability, degree of food processing, and socio-cultural dimensions such as acceptability and affordability, as recently highlighted in a position paper by the Italian Society of Human Nutrition (Dinu et al., 2026).

Despite the growing body of evidence linking food processing to health outcomes, and the increasing calls for processing-based recommendations in public health nutrition, a systematic evaluation of how food processing terminology is incorporated into consumer-directed dietary guidance globally remains lacking. In particular, no study has yet comprehensively mapped the language and terms used across

national FBDGs to describe processed foods and their counterparts, nor assessed the extent to which frameworks such as the NOVA classification have been translated into public health recommendations. The objective of this review is to investigate whether and how recommendations concerning terminology often associated with food processing are incorporated into consumer-directed dietary advice and thus provide a systematic review of FBDGs in this context. Specifically, this study analyzes the language and terms used to describe processed food and its counterparts in FBDGs.

2. Methods

2.1. Selection and collection of FBDGs

This review utilized the FAO's online repository of FBDGs as the primary source of information (FAO, 2018). The FAO repository was initially set-up following a global survey conducted in 2013–2014 on the development, use, and evaluation of FBDGs, and it has been regularly updated since its launch in 2014. It provides comprehensive access to the majority of FBDGs worldwide, organized by geographical regions, including Africa, Asia and the Pacific, the Near East, Europe, Latin America and the Caribbean, and North America. The repository aims to include every new version or first edition of a country's FBDGs.

For each country, the repository typically provides the official name and publication year of the national dietary guidelines, the intended audience, a description of the food guide, and key messages issued by national authorities. Additionally, the FAO repository often includes the food guide itself, along with links to downloadable resources, such as the full guidelines and communication materials. All information is sourced and verified by the responsible government agency in each country. The FBDGs for each country were initially retrieved from the FAO repository in September 2024. To ensure completeness, further checks were conducted on official national health websites to obtain the most up-to-date versions of the guidelines. The dataset was subsequently updated to include revisions available through May 2026. The analysis therefore reflects the versions accessible at that time, and any guidelines published after May 2026 were not included. The inclusion criteria for this review stipulated that FBDGs had to be available in English, French, Italian, or Spanish, and they must specifically address the general, healthy adult population. These four languages were selected as they are among the most widely spoken and understood globally, allowing the inclusion of a greater number of documents while maintaining the feasibility of the analysis. Where multiple versions of guidelines existed, only those targeted at the general population were considered. Ultimately, only the most recent version of each country's FBDG was included in the review, and if multiple formats were available, only the complete version of the guidelines was used for analysis.

This review does not analyze the types of evidence used in formulating each FBDG, the development processes employed, or the involvement and roles of various stakeholders. Moreover, the review does not evaluate the impact of FBDGs on dietary consumption patterns or behavior.

2.2. Data collection from FBDGs

For each FBDG, the following details were recorded: the official name of the guideline, the year of publication of the most recent version, the language of the document, the target population, the availability of a "find text" search function, and whether the latest version was included in the FAO repository. When multiple language versions were available, the English version was preferred for documentation. After selecting the FBDGs that met the inclusion criteria, the first step of the analysis involved categorizing the countries by their economic classification according to the "World Bank Country and Lending Groups for fiscal year 2026" (World Bank, 2025). The publication years of the guidelines were grouped into three categories: (i) those published up to 2010, (ii) those

published between 2011 and 2019, and (iii) those published from 2020 onwards.

The analysis focused on evaluating the inclusion of food processing concepts within the FBDGs. This process involved searching for specific terms related to food processing in the original language of each document. Terms were selected based on a structured conceptual framework encompassing three categories: (1) terms directly referencing degree of food processing or established processing-based classification systems (e.g., "processed," "ultra-processed," "NOVA," "Monteiro"); (2) terms commonly used in FBDGs to describe food categories or preparation methods associated with varying degrees of processing (e.g., "processed meat," "industrial," "ready-to-eat," "fast food," "canned," "fresh," "natural," "packaged"); and (3) terms reflecting the integration of environmental sustainability into dietary guidance (e.g., "environment," "ecological"). The terms analyzed included "processed," "ultra-processed," "highly processed," "minimally processed," "NOVA," "Monteiro," "processed meat," "industrial," "ready-to-eat," "ready for consumption," "fast food," "junk food," "canned," "fresh," "homemade," "natural," "packaged," "environment," and "ecological" (see Supplementary Table 2 for terms in Italian, French, and Spanish). These terms were identified using the "find text" function when available or, for scanned PDFs without this feature, through manual review. The results were then stratified by geographical area, economic classification, and publication date. Only FBDGs that referenced these terms in the context of food processing were included in subsequent analyses. For example, the term *environment* was included in the analysis only when used in reference to the environmental impact of food processing.

For each FBDG, specific terms and phrases related to food processing were documented. The guidelines were then categorized based on whether they explicitly mentioned processing (e.g., using terms such as "processed" or "ultra-processed") or implicitly referred to it (e.g., mentioning industrial food, ready-to-eat or ready-for-consumption products, fast/junk food, canned food, or packaged food). The categories were mutually exclusive, and each FBDG was assigned to only one classification. Furthermore, the FBDGs were analyzed based on whether food processing was discussed from a nutritional perspective (e.g., highlighting ultra-processed foods' high content of calories, sugar, salt, or fat), a non-nutritive perspective (e.g., mentioning harmful substances like acrolein, phthalates, or endocrine-disrupting chemicals in ultra-processed foods and their packaging), or an environmental perspective (e.g., discussing the higher environmental impact of UPF). In this case, these categories were not mutually exclusive, thus a single FBDG could be assigned to more than one perspective when applicable.

All data were independently extracted by two reviewers (V.L. and B.P.). Discrepancies were resolved through discussion with a third reviewer (D.M.).

3. Results

3.1. Selection of FBDGs

Of the 100 FBDGs from 100 countries listed in the FAO repository, 11 were from Africa, 18 from Asia and the Pacific, 6 from the Near East, 34 from Europe, 29 from Latin America and the Caribbean, and 2 from North America.

After the initial analysis summarized in **Supplementary Table 1**, 28 FBDGs did not meet the inclusion criteria. As a result, 72 FBDGs were included for further analysis.

3.2. Analysis of FBDGs

Of the 72 FBDGs included in the analysis, a total of 52 FBDGs were written in English, 17 in Spanish, 2 in French, and 1 in Italian. The most frequently represented publication years were 2013, 2015, and 2016, each comprising 8 FBDGs, with the oldest one dating to 1991, Venezuela's, and the most recent ones being United States' and Sweden's,

published in 2026 (Supplementary Table 1). Fig. 1 presents the geographical distribution of the countries (n = 72) whose FBDGs were included in the analysis. Most FBDGs were published by countries in Latin America and the Caribbean (n = 29), followed by Europe (n = 15), Asia and the Pacific (n = 11), Africa (n = 11), the Near East (n = 4), and North America (n = 2).

After having grouped the publication years of the guidelines, it was noted in Table 1 that 13 FBDGs (18%) were published up to 2010, 37 (51%) between 2011–2019 and 22 (31%) from 2020 onward.

In terms of economic classification, as seen in Table 2, 2 countries (3%) are defined as “low income”, 13 (18%) as “lower middle income”, 25 (35%) as “upper middle income”, 30 (41%) as “high income” and 2 (3%) were not classified (Metreau et al., 2024).

The analysis then focused on the inclusion of the food processing concept in the FBDGs analyzed. Specifically, Supplementary Table 2 summarizes the terms identified in the FBDGs. Among the 72 FBDGs included in the analysis, the term “ultra-processed” or “highly processed” was present in 22 FBDGs (31%); with 8 FBDGs (11%) mentioning the NOVA classification. No references to other classifications of UPFs were found in the FBDGs. A total of 20 FBDGs (28%) included the term “processed” and 40 FBDGs (56%) included recommendations regarding processed meat consumption. The term “industrial” food was included in 8 FBDGs (11%). Moreover, 40 FBDGs (56%) included recommendations regarding the consumption of “fresh or natural” products. Recommendations against “ready to eat/ready for consumption” and “fast/junk food” were included in 17 (24%) and 18 FBDGs (25%), respectively. The terms “canned” and “packaged” food were mentioned in 27 (38%) and 22 FBDGs (31%), respectively, and only 7 FBDGs (10%) reported the environmental impact of food processing. The stratified results by geographical area, economic classification, and publication date are summarized in Fig. 2.

From a geographical perspective, given the marked variability in sample sizes across regions, results are presented as both absolute counts and proportions to avoid over-interpretation. References to the NOVA classification were found in 1 out of 11 African FBDGs, 2 out of 11 Asian/Pacific FBDGs, 3 out of 15 European FBDGs, and 2 out of 29 Latin American FBDGs, while none of the 4 Near East FBDGs and none of the 2 North American FBDGs referenced it. Similarly, mentions of UPFs or “highly processed” foods were found in 4 out of 11 African FBDGs, 5 out of 11 Asian/Pacific FBDGs, 3 out of 15 European FBDGs, 8 out of 29 Latin American FBDGs, and 2 out of 2 North American FBDGs, but none of the 4 Near East FBDGs. Across all regions, references to “environment” were the least frequent, whereas mentions of “processed meat” and “fresh/natural” products were the most common. These regional comparisons should be interpreted with caution, particularly for the Near East (n = 4) and North America (n = 2), where the small sample size limits generalizability.

In terms of economic stratification, the low-income group included

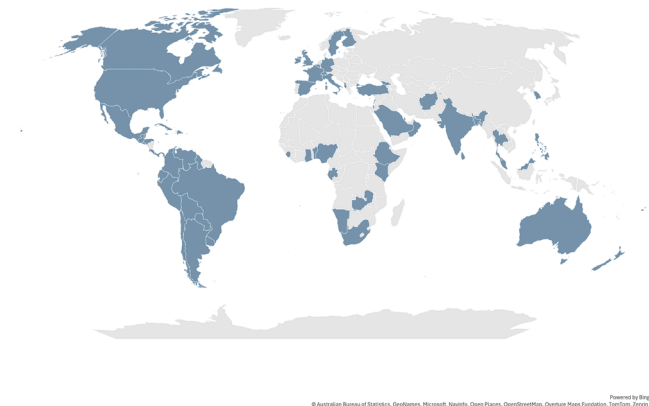


Fig. 1. Geographical distribution of the 72 dietary guidelines.

Table 1
Publication timeline of 72 dietary guidelines.

Up to 2010 (n = 13)	Albania, Bahamas, Costa Rica, Cuba, Dominica, Dominican Republic, Georgia, Namibia, Nigeria, Oman, Saint Kitts and Nevis, Saint Lucia, Venezuela.
2011–2019 (n = 37)	Afghanistan, Antigua and Barbuda, Argentina, Australia, Bangladesh, Barbados, Belgium, Belize, Benin, Bolivia, Brazil, Canada, Colombia, El Salvador, Fiji, France, Guatemala, Guyana, Honduras, Ireland, Israel, Italy, Jamaica, Kenya, Lebanon, Malta, Mexico, Panama, Paraguay, Philippines, Qatar, Republic of Korea, Saudi Arabia, Sierra Leone, South Africa, Turkey, United Kingdom.
2020 onwards (n = 22)	Chile, Ecuador, Ethiopia, Finland, Gabon, Germany, Ghana, Grenada, India, Malaysia, New Zealand, Peru, Saint Vincent and the Grenadines, Seychelles, Spain, Sri Lanka, Sweden, Switzerland, Thailand, United States of America, Uruguay, Zambia.

Table 2
Stratification of 72 dietary guidelines by country income level¹.

LOW INCOME (n = 2, 3%)	Afghanistan, Sierra Leone.
LOWER MIDDLE INCOME (n = 13, 18%)	Bangladesh, Benin, Bolivia, Ghana, Honduras, India, Kenya, Lebanon, Namibia, Nigeria, Philippines, Sri Lanka, Zambia.
UPPER MIDDLE INCOME (n = 25, 35%)	Albania, Argentina, Belize, Brazil, Colombia, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Fiji, Gabon, Georgia, Grenada, Guatemala, Jamaica, Malaysia, Mexico, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, South Africa, Thailand, Turkey.
HIGH INCOME (n = 30, 41%)	Antigua and Barbuda, Australia, Bahamas, Barbados, Belgium, Canada, Chile, Costa Rica, Finland, France, Germany, Guyana, Ireland, Israel, Italy, Malta, New Zealand, Oman, Panama, Qatar, Republic of Korea, Saint Kitts and Nevis, Saudi Arabia, Seychelles, Spain, Sweden, Switzerland, United Kingdom, United States of America, Uruguay.
NOT CLASSIFIED (n = 2, 3%)	Ethiopia, Venezuela.

¹ Adapted from World Bank Country Classifications by Income Level for FY2026 (World Bank, 2025).

only 2 FBDGs (Afghanistan and Sierra Leone), which limits the interpretability of comparisons involving this category. Within these 2 FBDGs, 1 referenced “UPF” or “highly processed” foods (50%) and 1 referenced “processed meat” (50%). There were no marked differences between FBDGs from lower-middle (n = 13), upper-middle (n = 25), and high-income countries (n = 30) in the frequency of terms like “NOVA,” “UPF,” “highly processed,” “processed meat,” “fresh,” “natural,” and “canned.” Across all economic groups, the least utilized terms were “industrial,” “environment,” and “NOVA,” indicating that these concepts were mentioned less frequently compared to other processing-related terms. The results from the stratification by publication years indicate that most terms demonstrated an increasing trend in inclusion rates across the three publication year groups. However, the term “industrial” followed a different pattern across the three publication periods, showing a lower frequency in FBDGs published between 2011 and 2019.

From the first analysis summarized in Supplementary Table 2, 11 FBDGs were disregarded in the following analyses because they did not utilize any of the terms included in the research. Thus, a more comprehensive analysis of the language used across the 61 FBDGs containing the specific terms was conducted. Selected sentences illustrating each term’s usage within the FBDGs are presented in Supplementary Table 3, with original-language excerpts included for context. For each term, three representative sentences from three distinct FBDGs were provided to capture the context in which these terms are applied.

To investigate how food processing is addressed across each country’s FBDG, the guidelines were classified into two sub-categories (Table 3). The first sub-category includes FBDGs that address food processing implicitly, meaning that while the term “processed” is not

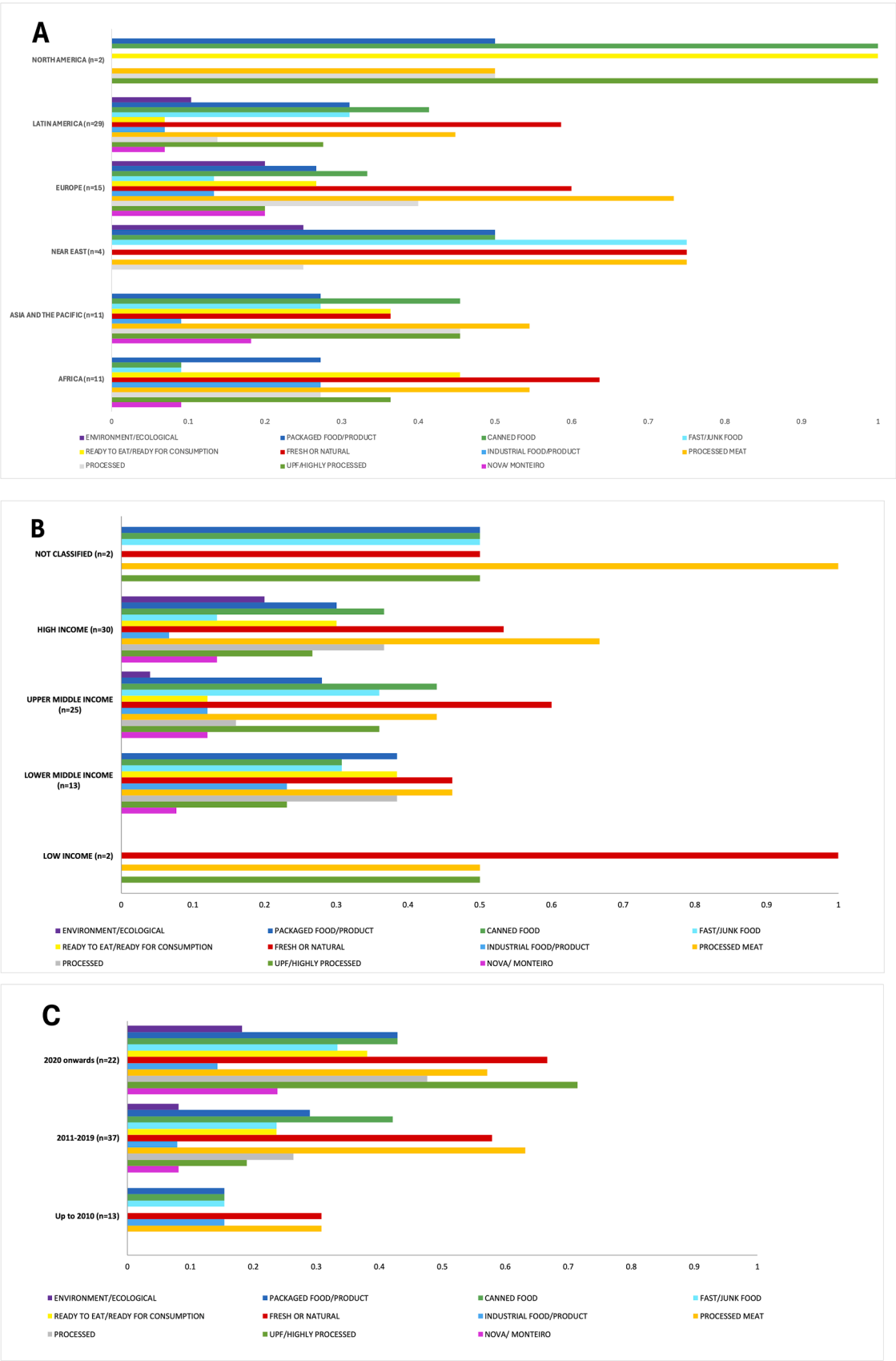


Fig. 2. Rate of inclusion of analyzed terms related to food processing by the 72 FBDGs included in the analysis. A: Stratification by geographical area. B: Stratification by economic classification. C: Stratification according to publication date. Legend: UPF, Ultra-Processed Food.

Table 3

List of explicit or implicit terms for food processing.

Explicit	Implicit
NOVA	Industrial
Ultra-Processed	Fresh
Highly Processed	Natural
Processed	Ready-to-Eat
Minimally Processed	Ready for Consumption
	Fast
	Junk
	Canned
	Packaged
	Environment

directly used, recommendations relevant to food processing practices are present. The second sub-category includes FBDGs that explicitly use the term “processed”. In accordance with the study design, each FBDG was assigned to a single, mutually exclusive sub-category.

Among the 61 FBDGs incorporating at least one relevant term, 55 (90%) explicitly referenced food processing, whereas 6 (10%) addressed it indirectly through alternative phrasing or related concepts (**Supplementary Table 4**). For instance, the United Kingdom’s FBDG advises that “*Many packaged foods and drinks contain surprisingly high amounts of free sugars, including some breakfast cereals, yoghurts, and fruit juice drinks*” which implies a reference to processed food without explicitly naming it (**Public Health England, 2018**). Of the 55 FBDGs that explicitly mentioned food processing, 21 exclusively associated the term “processed” with “meat”.

Each FBDG was analyzed to evaluate how food processing was addressed, with particular attention to nutritional, non-nutritional, and environmental factors. As shown in **Fig. 3** and **Supplementary Table 4**, all 61 FBDGs considered nutritional aspects, 22 (36%) considered non-nutritional aspects, and 7 (11%) incorporated environmental considerations. These categories are not mutually exclusive; therefore, a single FBDG may contribute to more than one perspective.

As shown in **Supplementary Table 4**, within the nutritional perspective, references predominantly focused on the nutrient profile of processed and ultra-processed foods. These products were commonly characterized as being high in salt, sugar, saturated and trans fats, and energy density, while being low in fibre and essential micronutrients. Overall, the references were broad in scope and rarely differentiated between distinct types of processed foods or variations within the same category.

For instance, Bangladesh’s FBDG considers food processing solely from a nutritional perspective, advising that “Fast foods, bakery

products, and junk food contain unhealthy trans fats that can elevate LDL cholesterol similarly to saturated fats” (**Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders, 2013**). In contrast, India’s FBDG addresses both nutritional and non-nutritional aspects of food processing. The Indian FBDG includes statements such as, “Ultra-processed foods are usually high in fats/sugar/salt and or low in micronutrients and fibre and mostly calorie dense” (**National Institute of Nutrition, 2024**). Additionally, non-nutritional considerations are also emphasized: “UPF are those that are low in native fibre and micronutrients and have additives added to enhance the sensory qualities and cosmetic appearance” (**National Institute of Nutrition, 2024**). Environmental considerations were addressed in 7 FBDGs (11%). For example, Qatar’s FBDG recommends choosing less processed foods to “minimize environmental impact” (**Supreme Council of Health, 2015**) while Israel’s FBDG explicitly states that “the manufacture of ultra-processed foods negatively impacts sustainable environments: reliance on inexpensive oils, sugars, and other ingredients promotes intensive, non-localized production, resulting in unbalanced energy use, harm to biodiversity, and increased waste” (**Israeli Ministry of Health, 2019**).

4. Discussion

This review examined global FBDGs, emphasizing how they address UPFs and food processing. FBDGs are critical public health tools, translating complex nutritional science into practical, culturally relevant advice for the public (**Food and Agriculture Organization of the United Nations, 2016**). To remain effective, they must be regularly updated to reflect advancements in nutrition science and emerging societal trends (**Food and Agriculture Organization of the United Nations & World Health Organization, 1996**). Among the 72 FBDGs analyzed, 85% referenced food processing, a topic that has only gained significant attention recently. In fact, none of the guidelines published before 2010 explicitly addressed food processing, while all those published after 2020 incorporated it, possibly reflecting the influence of the NOVA classification in 2010. A similar evolution can be observed in the U.S. *Dietary Guidelines for Americans*. Early editions, beginning with the first guidelines published in 1980, focused primarily on nutrient-based recommendations, such as limiting saturated fat, cholesterol, sugar, and sodium, without explicit reference to food processing. Over time, the guidelines progressively incorporated more food-based advice and dietary pattern approaches. In the most recent discussions surrounding the 2025–2030 Dietary Guidelines, the role of highly or ultra-processed foods has received increasing attention in the scientific advisory process, although the official guidelines continue to primarily frame recommendations in terms of dietary patterns and nutrient-dense foods rather than levels of processing (**U.S. Department of Agriculture, 2026**). This shift underscores the growing interest for the topic of food processing that has been progressively included in the FBDGs, despite a large variability among countries for the terms and phrases used for mentioning it.

Our analysis revealed that FBDGs mainly focus on the nutrient profile of UPFs, highlighting their low levels of essential nutrients and high content of refined grains, energy, saturated fats, sugar, and salt, while largely overlooking differences between food categories and variations within the same category. Thus, food processing is primarily addressed from a nutritional perspective in FBDGs, a finding supported by a recent global analysis of FBDGs and food processing (**Koios et al., 2022**). This reflects their foundation in Dietary Reference Values (DRVs), which emphasize nutrient intake and health outcomes. Importantly, this nutrient-centered interpretation of ultra-processing should not be conflated with the conceptual basis of the NOVA classification. NOVA was explicitly developed to classify foods according to the extent and purpose of industrial processing, rather than their nutritional composition. However, in practice, ultra-processed foods identified within the NOVA framework often display distinctive nutritional profiles, typically

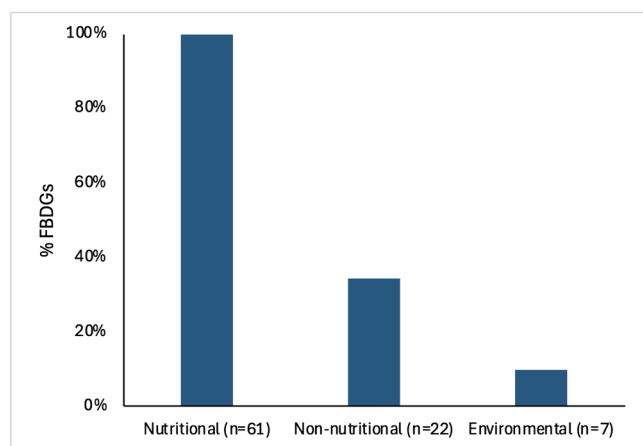


Fig. 3. Rate of inclusion of Nutritional, Non-nutritional and Environmental considerations related to food processing in 61 FBDGs. Legend: FBDGs: food-based dietary guidelines.

characterized by high levels of fat, salt, and sugar, and low amounts of fibre and essential micronutrients. This empirical overlap between the concept of processing and nutritional criteria may partly explain why FBDGs tend to interpret ultra-processing mainly in terms of nutrient content. In addition, non-nutritive components, such as additives and packaging chemicals, receive limited attention in FBDGs. This is likely due to both the nutrient-based orientation of DRVs and the limited, inconclusive nature of current evidence regarding the long-term health effects of these substances (Marino et al., 2021; Martínez Steele et al., 2020).

In the context of the current climate crisis, the WHO and FAO emphasize the need for FBDGs to align with SHDs, which incorporate nutritional, social, economic, cultural, and environmental factors (World Health Organization & Food and Agriculture Organization of the United Nations, 2019). However, environmental considerations remain largely absent in FBDGs, with only 10% ($n = 7$ out of 72) addressing the environmental impacts of food processing. This is in line with previous studies showing that sustainability remains poorly integrated into most FBDGs, with only a few countries, such as Sweden, explicitly addressing it (Bechthold et al., 2018; Martini, Tucci, et al., 2021). Given the significant environmental impacts of food and processing, future FBDGs must prioritize sustainability, expanding beyond nutritional advice to support both human and planetary health (Gil, 2023; Kesse-Guyot et al., 2022). For example, recent analyses of Nordic dietary patterns have shown that minimally processed animal-based foods may contribute substantially to total greenhouse gas emissions. Therefore, future FBDGs should integrate sustainability considerations based on comprehensive life-cycle assessment approaches, rather than assuming a direct relationship between processing level and environmental impact (Slaathaug et al., 2024).

The economic stratification of the data present in FBDGs should be interpreted with caution given that the low-income group included only 2 FBDGs. References to terms like "UPF" and "highly processed" appeared in 1 out of 2 low-income FBDGs (50%), compared with 8 out of 30 high-income FBDGs (27%), primarily in the context of advising a reduction in their consumption. Socioeconomic factors, such as lower maternal education and higher parental unemployment, have been associated with dietary patterns characterized by a higher consumption of processed foods (Parra et al., 2019). In this context, FBDGs in low-income countries may prioritize recommendations to limit processed foods as a preventive public health strategy aimed at reducing the burden of diet-related chronic diseases. However, the development of FBDGs is not solely a scientific effort; it unfolds within broader political, economic, and institutional contexts. Decisions regarding which conceptual frameworks are prioritized, such as nutrient-based versus processing-based approaches, may reflect not only evolving scientific evidence but also governance structures, stakeholder engagement, and policy environments. Recent debates surrounding the development of the latest U.S. Dietary Guidelines, including concerns about committee selection processes and potential conflicts of interest, illustrate how institutional and political dynamics may shape guideline development (Nestle, 2026). At the same time, food processing plays a beneficial role across food systems globally. Processed foods may contribute to improved food safety, extended shelf life, enhanced nutrient stability, fortification strategies, and reduced food loss and waste. These contributions may become particularly relevant in contexts characterized by limited cold-chain infrastructure, seasonal food availability, or micronutrient deficiencies, where such forms of processing can support food security and public health objectives. Therefore, the relationship between food processing and dietary guidance in low-income countries is inherently complex and should not be interpreted solely through a reductionist lens focused exclusively on ultra-processing. Among the 55 FBDGs explicitly mentioning food processing, 34% focused exclusively on processed meat, reflecting robust evidence linking its consumption to adverse health outcomes, including its classification as "carcinogenic to humans" (International Agency for Research on Cancer, 2015). This

emphasis has strengthened public health efforts to limit processed meat intake. In contrast, the broader issue of UPFs remains less prominent, with 31% ($n = 22$) of analyzed FBDGs ($n = 72$) addressing UPFs and just 11% ($n = 8$) referencing the NOVA classification system. While NOVA, developed in Brazil, is widely used to classify foods by degree of processing, discussion around its public-health use highlights the need for clear, operational criteria and transparent links to health outcomes, still absent, to ensure consistent interpretation across settings and policy goals. (Carretero et al., 2020; Lockyer et al., 2026; Monteiro et al., 2016, 2022; Visioli et al., 2023, 2024). Other classification systems, such as SIGA in France and NIPH in Mexico, have also struggled with inconsistencies and misalignment with dietary recommendations (De Araújo et al., 2022). For FBDGs to incorporate food processing in ways that effectively support prevention and broader public health objectives, classification systems like NOVA must provide clear, evidence-based, and operationally defined criteria and be consistently applied by guideline developers and practitioners across diverse contexts.

FBDGs often use consumer-friendly terms like "ready-to-eat" (24%), "junk/fast food" (25%), "canned food" (38%), and "packaged food" (31%) to provide accessible dietary guidance, reflecting their aim to reach the general population. Importantly, differences in terminology across countries may also reflect underlying conceptual inconsistencies. In some settings, the explicit use of the term "ultra-processed foods" may align with national public health campaigns and prevailing scientific discourse. In other contexts, however, more descriptive expressions, such as "processed foods high in sugar, salt, and fat", may be perceived as clearer and more actionable for consumers. Therefore, variation in terminology should be interpreted not only as a lack of standardization, but also as an adaptation to linguistic, cultural, and policy environments in which FBDGs are developed and implemented.

However, research highlights challenges with the clarity and reliability of food classifications. Some studies have shown low consistency among experts in categorizing processed foods using frameworks like NOVA and widespread misconceptions about UPFs among both Brazilian and European populations, although other research has found higher levels of agreement (Braesco et al., 2022; Menegassi et al., 2019; Pedro-Botet et al., 2022). To enhance public understanding and ensure consistency, FBDGs must adopt evidence-based approaches with clear, unified definitions of food processing, acknowledging the current lack of scientific consensus on the nutritional profiles and health impacts of various levels of food processing, including UPFs.

This study is the first to incorporate FBDGs in English, French, Italian, and Spanish (Herforth et al., 2019; Koios et al., 2022; Martini, Tucci, et al., 2021). Another key strength of this study is its focus on evaluating complete dietary guidelines, rather than food guides or summarized versions, ensuring a more comprehensive analysis. However, a potential limitation of this study is that language barriers prevented the inclusion of FBDGs from all countries, meaning 26% ($n = 26$) of the FBDGs were not considered due to language criteria. Consequently, guidelines addressing food processing in languages outside our inclusion criteria may have been missed. A further limitation of this review concerns the representativeness of the included FBDGs within geographical and economic categories. The application of language-based inclusion criteria (English, French, Italian, and Spanish), combined with the unequal availability of FBDGs across countries, results in uneven subgroup sizes. This is particularly relevant for the Near East ($n = 4$), North America ($n = 2$), and the low-income category ($n = 2$), where the limited number of analyzed FBDGs does not allow for robust inference at the regional or economic group level. Our findings should therefore be interpreted as descriptive of the included FBDGs rather than as representative of all FBDGs within these categories.

Future research should aim to broaden the linguistic and geographic scope to provide a more global understanding of FBDG trends. Beyond their content, the effectiveness of FBDGs also depends on how they are implemented. Evidence consistently shows that information provision alone is rarely sufficient to achieve sustained changes in dietary

behavior. The impact of dietary guidelines is typically strengthened when they are embedded within broader policy frameworks, particularly through nutrition education programs. Therefore, the integration of food processing concepts into FBDGs should be assessed not only in terms of scientific validity, but also with regard to how such concepts can be operationalized through societal and policy instruments that shape food environments and influence consumer choices.

In conclusion, this review revealed that the concept of food processing – particularly ultra-processing – is increasingly being integrated into FBDGs, especially in the more recent versions. The NOVA classification is now frequently referenced, marking a shift toward increased attention to the role of food processing in public health.

While systems like NOVA are used to categorize UPFs, their policy uptake may depend on how clearly categories can be operationalized and aligned with the preventive aims of guidelines. More importantly, there is still a lack of clarity regarding whether the adverse health effects are due to the high degree of processing itself or to broader dietary patterns associated with UPF consumption. The few RCTs performed so far do not provide, to date, strong and conclusive associations between UPF intake and adverse health outcomes, and together with the inherent limitations of short-term experimental designs and the potential for residual confounding in observational studies, the scientific community should be cautious in translating this evidence into long-term dietary guidelines. These risks could be premature and potentially misleading from a policy standpoint. Additionally, replicating this analysis in the coming years would be valuable for monitoring progress in the inclusion of recommendations related to processed foods within FBDGs.

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CRedit authorship contribution statement

Vanessa Liium: Writing – original draft, Formal analysis, Data curation. **Beatrice Pellegrini:** Writing – review & editing, Data curation. **Monica Dinu:** Writing – review & editing. **Sofia Lotti:** Writing – review & editing. **Cristian Del Bo:** Writing – review & editing. **Daniela Martini:** Writing – original draft, Conceptualization. **Donato Angelino:** Writing – original draft, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in

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Data availability

All data used in the manuscript are present in the references used and mentioned in the Materials and methods section. Further request about data can be directed to the corresponding author.

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