



## Conference on ‘Nutrient–nutrient interaction’ Plenary Lecture 1

### Food processing: criteria for dietary guidance and public health?

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The NOVA food categorisation recommends ‘avoiding processed foods (PF), especially ultra-processed foods (UPF)’ and selecting minimally PF to address obesity and chronic disease. However, NOVA categories are drawn using non-traditional views of food processing with additional criteria including a number of ingredients, added sugars, and additives. Comparison of NOVA’s definition and categorisation of PF with codified and published ones shows limited congruence with respect to either definition or food placement into categories. While NOVA studies associate PF with decreased nutrient density, other classifications find nutrient-dense foods at all levels of processing. Analyses of food intake data using NOVA show UPF provide much added sugars. Since added sugars are one criterion for designation as UPF, such a proof demonstrates a tautology. Avoidance of foods deemed as UPF, such as wholegrain/enriched bread and cereals or flavoured milk, may not address obesity but could decrease intakes of folate, calcium and dietary fibre. Consumer understanding and implementation of NOVA have not been tested. Neither have outcomes been compared with vetted patterns, such as Dietary Approaches to Stop Hypertension, which base food selection on food groups and nutrient contribution. NOVA fails to demonstrate the criteria required for dietary guidance: understandability, affordability, workability and practicality. Consumers’ confusion about definitions and food categorisations, inadequate cooking and meal planning skills and scarcity of resources (time, money), may impede adoption and success of NOVA. Research documenting that NOVA can be implemented by consumers and has nutrition and health outcomes equal to vetted patterns is needed.

**Nutrient density: Added sugars: Dietary guidance: Processed food: Ultra-processed food**

The rise in the availability and intake of processed foods (PF) and ultra-processed foods (UPF) has been posited by some public health authorities and organisations to be a prime cause of poor diets and rising rates of obesity and chronic disease<sup>(1–10)</sup>. Therefore, Montiero and others published the NOVA (not an acronym) categorisation, which divides foods into four categories: minimally PF-NOVA (MPF<sub>n</sub>); UPF<sub>n</sub>; processed culinary ingredients (PCI); PF<sub>n</sub>. Designation of NOVA categories in the present paper will carry the subscript <sub>n</sub>; for example UPF-NOVA is UPF<sub>n</sub>. By contrast, for generic PF and UPF there is no subscript. Those classified by

International Food Information Council (IFIC) will be MPF<sub>i</sub> and PF<sub>i</sub><sup>(1,2,11)</sup>. NOVA proponents suggest that shifts from ingestion of the two latter categories to MPF<sub>n</sub> and PCI<sub>n</sub> will improve nutrition and health.

Category designations in NOVA are controversial because they imply their basis on the complexity of food processing, however, this is not the case. For example, foods with added sugar are deemed as PF<sub>n</sub> or UPF<sub>n</sub> regardless of processing methods or technology used. Foods processed by innovative, non-traditional techniques such as electric or magnetic fields may be deemed as MPF<sub>n</sub> despite the use of non-traditional, complex processes<sup>(12–14)</sup>.

**Abbreviations:** DASH, Dietary Approaches to Stop Hypertension; E, energy (in terms of the energy %); IFIC, International Food Information Council; MPF, minimally processed food; PCI, processed culinary ingredients; PF, processed foods; RTE, ready-to-eat; RTEC, ready-to-eat cereals; UPF, ultra-processed foods.

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Studies using NOVA demonstrate that PF<sub>n</sub>/UPF<sub>n</sub> deliver most of the added sugars and are associated with obesity and other health risks<sup>(6–9,15)</sup>, but other categorisations yield different results<sup>(16–18)</sup>. Further, placement of foods into categories among NOVA studies is inconsistent<sup>(6–9,19)</sup>.

The present paper will compare the NOVA definition with legal, technical, popular press and public health definitions. The NOVA categorisation will be compared with that of the IFIC. Designation of foods with more than five ingredients or presence of ‘added sugars’ or additives as UPF<sub>n</sub> will be challenged. Further, analyses documenting that foods categorised as PF<sub>n</sub>/UPF<sub>n</sub> provide much of the ‘added sugars’ will be shown as tautological logic.

Nutrient intakes and health outcomes using the NOVA system will be compared with those recommended in dietary guidance such as Dietary Approaches to Stop Hypertension (DASH)<sup>(20)</sup> or the United States Department of Agriculture MyPlate<sup>(21,22)</sup>. NOVA’s adherence to requirements for dietary guidance: understandability, adaptability, applicability and practicality, will be questioned<sup>(23,24)</sup>.

### Processed food: history and definitions

‘Cooking, which is one part of processing, went hand-in-hand with becoming human. Human food is processed food,’ according to food historian Rachel Laudan<sup>(25)</sup>. PF enabled world exploration and settling of territories and continents. PF’s ability to extend the food supply yielded the highest accolades from Napoleon, who awarded 50 000 francs to Nicholas Appert for developing canned food to feed French troops<sup>(26)</sup>. PF became vital to a country’s food supplies and as such, they became the purview of governments to ensure their safety<sup>(27)</sup>. Thus, they were regulated and defined<sup>(28–36)</sup>.

#### *Definitions of processed foods: legal and food science*

Regulatory and food science definitions are found in Table 1A<sup>(28–36)</sup>. These definitions show strong congruence but differ in detail. All agree that one or more physical, chemical or microbiological steps change raw commodities into ingredients or foods. All allow formulations with any number or type of ingredients. The United States Department of Agriculture also has a legal definition of MPF<sup>(31)</sup>.

Goals of food processing are also aligned in this group of definitions. These include increasing shelf life, maintaining or enhancing safety and nutrient quality, addressing specific nutritional requirements and adding variety and convenience.

### Newer usages and definitions of processed foods and ultra-processed foods

Bibliographic citations in PubMed about PF until 10 years ago were about the intersection of food science and nutrition and presented data on the impacts of

processing techniques on food safety, nutrient retention or availability and microbiological quality. In 2009 UPF emerged as a term and transmuted (along with the term PF) from food science to public health. It defined the degree of processing non-traditionally and added presence or absence of certain food components as a dimension<sup>(1–4)</sup>. This prompted studies that documented the penetration of PF and UPF into diets and that tested associations between their intake and nutrient quality, obesity and disease<sup>(2–4,6,7,9,37)</sup>. This spawned promotion of the NOVA dietary system that recommended the use of MPF<sub>n</sub> and avoidance of PF<sub>n</sub>/UPF<sub>n</sub>.

### Definitions of processed foods: dictionary, consumer organisations and popular press

Among this group (Table 1B)<sup>(38–43)</sup>, definitions and connotations vary greatly. Only two, Wikipedia<sup>(38)</sup> and IFIC<sup>(39)</sup>, show alignment with legal or food science definitions. Several recognise that most foods are processed in some way to improve nutrient absorption, to make food safer and to prevent waste and that they are ‘not all bad’<sup>(40–45)</sup>.

Many websites and popular press definitions (Table 1B) describe PF as requiring complex processes and having lengthy ingredient lists including chemicals and additives<sup>(46–49)</sup>. Regardless of nutritive value, PF are often presented pejoratively with comments such as ‘not whole or found in nature’, ‘sold in packets or tins’, ‘fast or junk foods with minimal nutrients and fiber’, ‘less satisfying’ and ‘use fewer calories to metabolize than whole foods’<sup>(50–56)</sup>. Web images most frequently depict sugary drinks, candy, crisps, chips (fries) and frozen or baked sugary, fatty or salty treats. However, some also show bread, canned fish and fruit, baby foods, infant formula and ready-to-eat cereals (RTEC)<sup>(57,58)</sup>.

The diversity of foods, images and descriptions portrayed demonstrate lack of agreement as to definition or food categorisation in the popular press. Further confusing consumers is the suggestion that home-prepared foods are always nutritionally superior and are not processed, even when techniques and ingredients are identical<sup>(59)</sup>.

### Processed foods: continuums and categorisations

#### *Food scientists*

PF exist on a continuum that food scientists base on the complexity of processes, not numbers or kinds of ingredients. Additives, salts and sugars are regarded as part of the recipe, not as processes, and can add flavour but also extend shelf life and preserve nutrients<sup>(60)</sup>. These components help to fulfill the goal of processing, which is to reduce pre- and post-harvest losses, to minimise resource use, to decrease waste, to maintain safety and quality and to offer convenience<sup>(61,62)</sup>. These may address food supply issues and lower costs<sup>(63,64)</sup>.

Food scientists recognise processing may alter nutrient content and bioavailability, either positively or





**Table 1.** Representative definitions and descriptions of food processing (FP) and processed food (PF)

Organisation or entity	Definition of FP or PF	Descriptions or notes
<b>(A) Legal and food science definitions and descriptions</b>		
Food and Agriculture Organization (FAO/WHO) <sup>(28)</sup>	FP is any change made to a food to alter its eating quality or shelf life.	FP involves the application of science and technology: (1) to preserve or inhibit decay, (2) to maintain or enhance the eating and quality of foods, (3) to provide a range of products for consumers of varying ethnicities and nutritional needs, (4) to reduce waste along the food chain.
European Food Safety Authority (EFSA) <sup>(29)</sup>	PF is defined with the definition of food. Food is any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by human subjects.	FP applies to all stages of food production, processing and distribution of food and feed.
UK National Health Service (NHS) <sup>(30)</sup>	PF is any food that has been altered from its natural state in some way, either for safety or convenience	
US Department of Agriculture (USDA) <sup>(31)</sup>	PF is any raw agricultural commodity that has been subject to washing, cleaning, milling, cutting, chopping, heating, pasteurising, blanching, cooking, canning, freezing, drying, dehydrating, mixing, packaging, or other procedures that alter the food from its natural state.* Minimally processed foods (MPF) are defined as retaining most of their inherent physical, chemical, sensory and nutritional properties.	Includes ingredients and additives such as preservatives, flavours and nutrients. USDA comments that processes or additives may reduce, increase, or leave unaffected the nutritional characteristics of the raw agricultural commodity. MPF are noted to have the nutritional value of their raw counterparts USDA notes that some nutrients may be more or less available than in more processed forms.
US Food and Drug Administration (FDA) <sup>(32)</sup>	Similar to USDA	
Food Standards Australia New Zealand (FSANZ) <sup>(33)</sup>	Similar to USDA	FSANZ Standard 3-1-1 and 3-22
The European Food Information Council (EUFIC) <sup>(34)</sup>	FP is any method used to turn fresh foods into food products. This can involve one or more steps. It includes adding components to food, e.g. to extend shelf life, or adding vitamins and minerals to improve the nutritional quality of the food (fortification).	
Food Science Textbook <sup>(35)</sup>	FP is the transformation of animal and plant materials into intermediate or finished value-added food products that are safe to eat.	FP requires the application of labour, energy, machinery and scientific knowledge in one or of steps FP's goal is (1) to extend the period during which food remains wholesome (microbially and biochemically), (2) to provide nutrients required for health, and (3) add variety and convenience.
Food Science Journal <sup>(36)</sup>	PF are raw ingredients transformed by physical or chemical means into food ingredients and foods.	PF are marketable food products that can be easily prepared by consumers.
<b>(B) Popular press and consumer definitions and descriptions</b>		
Wikipedia <sup>(38)</sup>	FP is the transformation or combining of raw ingredients by physical or chemical means to produce marketable food products.	PF can be incorporated into recipes or prepared and served by the consumer.
International Food Information Council (IFIC) <sup>(39)†</sup>	FP is any deliberate change in a food.	FP can be simple e.g. freezing or drying or complex with many processes and ingredients.
Organic Consumers Association <sup>(46)‡</sup>	PF are convenient, 'easy-to-eat' products.	PF are altered through the addition of artificial ingredients, synthetic flavourings, fillers and chemical or genetically-engineered additives. They are more likely to have longer ingredient lists.
SF Gate (for <i>San Francisco Chronicle</i> ) <sup>(47)§</sup>	PF are foods in boxes, cans or bags and often containing additives, artificial flavourings and other chemical ingredients	PF often needing numerous complex processing steps and may not be found in nature.



Concentra differentiates between *mechanical* (e.g. grinding meat) and *chemical* processing (e.g. addition of additives), which is deemed as not 'natural'<sup>†</sup>. PF are alleged to have 'barely any nutrients and fibre', to be less satisfying, and to use less energy to metabolise than whole foods. FP can prevent waste and make food safer, but can contain chemicals that should not be ingested.

PF refer to most foods, since most are processed in some way.

Concentra Health Newsletter<sup>(49)</sup>

WellWisdom<sup>(49)</sup>\*\* Newsletter

\* Nearly all legal and food science definitions of food processing have similar examples and allow additions to the list as new processed emerge.

† Example of a consumer education group using dietitians and food professionals as spokespeople.

‡ Example of an organic agricultural products marketing and trade resource that is not in favour of biotechnology or pesticides.

§ Example of a US newspaper website.

|| Example of health newsletter associated with the large health system.

¶ Natural is not legally defined in many jurisdictions.

\*\* Example of the newsletter from a vendor of supplements and health foods.

negatively<sup>(59)</sup>. Processes and ingredients are adjusted to minimise losses and maintain nutrients. Fortificants may be added to address demonstrated deficiencies<sup>(65,66)</sup>. Additional ingredients can add variety and palatability making nutrients more likely to be ingested<sup>(67)</sup>. While variety may induce overeating, so can food that is unsatisfying, as people eat more to seek satisfaction. Both aspects need more study<sup>(68)</sup>.

*Nutrition and the food processing continuum*

Traditional dietary guidance is based on optimising intakes of food groups and nutrients<sup>(69,70)</sup>. Nutrient-poor foods are to be chosen infrequently<sup>(71)</sup>. Vetted diet plans with proven health benefits, such as DASH, use a mix of foods from all levels of processing to help consumers reach nutrition and health targets<sup>(20,72-77)</sup>. PF are featured in the United States Department of Agriculture MyPlate (ChooseMyPlate.gov) sample menu plans, which are designed to meet recommendations for consumers with limited resources<sup>(21,78)</sup>.

*International Food Information Council categorisation*

Table 2 shows the five categories of the IFIC model. All categories contain foods to choose frequently and infrequently. Addition of sugar, salt or additives or numbers of ingredients had no effect on category placement. Home-prepared foods are categorised with the same criteria as manufactured ones.

*NOVA*

Public Health Professor Carlos Montiero and colleagues initiated the NOVA categorisation of foods found in Table 3<sup>(1-4)</sup>. Initially, there were three categories, MPF<sub>n</sub>, PCI, PF<sub>n</sub><sup>(79)</sup>. Subsequently, PF<sub>n</sub> was split into PF<sub>n</sub> and UPF<sub>n</sub> making four categories. MPF<sub>n</sub> are described as undergoing minimal processing such as washing, milling, chilling, freezing, or vacuum-packing (vacuum-packing, especially of cooked, refrigerated vegetables, is viewed by food scientists as one which requires attention to maintain nutrients and safety and has a degree of complexity). PCI include ingredients found in home kitchens, such as starch, sugar and oil. (PCI initially included starch and pasta.) PF<sub>n</sub> are defined as recognisable versions of original foods that may have added PCI (e.g. sugar or salt) to extend shelf life or modify palatability. They are generally consumed as part of meals or dishes. UPF<sub>n</sub> are described as industrial formulations with five or more ingredients, which are often packaged, branded, convenient and highly palatable and function as snacks or replace homemade dishes. They may include additives, sweeteners and added micronutrients to fortify them.

The NOVA categorisation was enfranchised by the Pan American Health Organisation<sup>(2)</sup>. While Pan American Health Organisation recognises that nearly all foods are processed and notes their benefits and essentiality, they raise concern about and their potential contribution to disease.<sup>(2)</sup> Pan American Health Organisation's document described UPF<sub>n</sub> as



**Table 2.** International food information council (IFIC) processed food categorisation

IFIC category	Examples
Minimally processed: Foods that require little processing at the plant but often require preparation before eating. Processed to help preserve and enhance nutrients and freshness of foods at their peak.	Roasted, chopped nuts; whole & cracked cereals; coffee beans; washed/ packaged fruit, vegetables, bagged salads; pasteurised milk Frozen, canned, or cooked & vacuum-packed & refrigerated fish, meat, fruit & vegetables, and baby foods; UHT dairy
Foods that combine ingredients and additives such as spices, oils, flavours, preservatives and nutrients to ensure safety and sensory appeal. (These usually require further preparation and do not include 'ready-to-eat' foods' (RTE)) listed below. RTE foods that may have many ingredients and processes but need little preparation.	Packaged foods, such as rice or potato side dishes, cake mix, jarred tomato sauce, spice mixes, dressings, sauces, & condiments, gelatin Breads & flat breads, RTE & instant cereals, granolas, nutrition bars, biscuits, jams & jellies, nut butters, ice cream, yoghurt, cookies, fruit chews, rotisserie chicken, luncheon meats, cooked hams, cheeses, spreads, fruit drinks, salted condiments such as olives, carbonated beverages.
Foods packaged to stay fresh and save time.	Prepared refrigerated & deli foods; frozen meals, entrées, sides, pot pies, and pizzas

Adapted from <http://www.ific.org>.

'attractive, hyper-palatable, cheap, ready-to-consume food products that are characteristically energy-dense, fatty, sugary or salty and generally obesogenic.'<sup>(2)</sup>.

### Comparison of definitions and categorisations

Legal, food science, Wikipedia and IFIC usage, definitions and categorisations of PF show congruence, but those of NOVA, public health, popular press or website definitions show dissimilarities. Among the IFIC and NOVA categories, MPF<sub>n</sub> foods that require little processing, are most similar<sup>(1-4,16-18)</sup>. However, the addition of sugar or salt moves foods from MPF<sub>n</sub> to PF<sub>n</sub> despite identical processing. Thus, pasteurised milk, yoghurts and roasted nuts are MPF in IFIC and NOVA but only remain MPF<sub>n</sub> in NOVA if no sugar, salt or additives are present. In the IFIC classification<sup>(8,16-18)</sup>, canned or frozen fruit, vegetables, meat or fish would be classed as 'foods processed to help preserve and enhance nutrients' regardless of the numbers or types of ingredients or additives. In NOVA a single food without additives would be MPF<sub>n</sub>, but the addition of sugar or additives make them PF<sub>n</sub>, and more than five ingredients, UPF<sub>n</sub>.

Bread and cereals in IFIC classification would be in the ready-to-eat (RTE) category. In NOVA breads with five or fewer ingredients and unpackaged are PF<sub>n</sub>, but become UPF<sub>n</sub> if packaged or contain more than five ingredients. All cereals containing sugar and salt are UPF<sub>n</sub>.

### Studies on nutrient contribution of foods in International Food Information Council and NOVA categorisations

*Post hoc* analyses using food intake databases have been conducted with the IFIC categorisation and NOVA. The results of the analyses differ because criteria for the food categories are so different.

#### *International Food Information Council*

Analyses of US National Health and Nutrition Examination Survey (*n* 25 351 over 2 years old) showed that MPF<sub>i</sub> contributed 17% of energy (E), but over 50% of the vitamin D (mostly due to fortified dairy) and over 30% of the potassium, calcium and vitamin B<sub>12</sub><sup>(8,16-18)</sup>. Foods processed for preservation (mostly canned and frozen) contributed about 5% of E, but over 30% vitamin C and over 5% of potassium, fibre, magnesium, folate, calcium, vitamin B<sub>6</sub> and iron. This category contributed <5% of the salt but 8% of the sugar.

RTE PF<sub>i</sub> contributed 35% of E, and higher percentages of iron, folate and vitamin B<sub>6</sub>. It also contributed 45% of the added sugars (45%), with major contributions from sugar-sweetened beverages, juice drinks and grain-based snacks and desserts<sup>(8,16-18)</sup>. Sodium contributions were lower than the percent of E.

Mixtures of ingredients provided 17% of E and slightly more carbohydrate, fibre, thiamin, folate, calcium and iron, but a lower percentage of added sugars than the percent of E.

**Table 3.** NOVA classification of foods<sup>(2,6)</sup>

NOVA category	Definition	Examples
<b>2010 classification</b>		
Minimally processed foods (MPF <sub>n</sub> )	No processing or minimal (mostly physical processes) used to make single whole plants or animal foods more durable, accessible, convenient, palatable, or safe. Contain few if any added components.	Fresh, frozen, vacuum-packed / refrigerated, & dried fruit, vegetables, meats, poultry, fish, nuts, seeds, grains; 100% juices; eggs, milk & fermented milk, yoghurt; teas, coffee. No added sugar or salt.
Processed culinary ingredients (PCI <sub>n</sub> )	Extracted and purified components of single whole foods. Used in the preparation of meals made with MPF <sub>n</sub>	Fats and oils (not margarine), cream; starches, grits*, meals,* starches,* pastas* noodles* (made only with starch and water); various proteins e.g. soy, casein; gums, preservatives, additives; sugars and sweeteners of all types; salt
Ultra-processed foods (In 2016 this category was divided into Processed and Ultra-processed foods)	Durable, accessible, convenient, palatable, ready-to-eat or -heat foods to replace homemade foods or eaten as snacks and desserts.	Crisps, chips, biscuits, cookies, cakes, pastries, ice creams & frozen desserts, dessert mixes; sodas, carbonated/ energy & 'fruit' drinks/mixes; jams, confectionery - chocolates, candies, sweetened milk & beverages/cocoas, drinks, 'fruit' yoghurts, margarines/spreads, sauces, condiments; rice & noodles sides/mixes; many ready to heat products pre-prepared pies/pasta/ pizza dishes; poultry/fish 'nuggets'/'sticks', sausages, burgers, hot dogs, deli pre-prepared meats, canned or dried soups, noodles, vegetable/ other 'recipe' dishes; pickled, smoked or cured meat/fish, brined vegetables, fish canned in oil; infant formulas, follow-on milk, baby foods, 'health'/'slimming' products /meal replacements
<b>2016 classification</b>		
Minimally processed foods (MPF <sub>n</sub> )	Foods of plant or animal origin that are altered in ways that do not add anything but may remove parts. Minimal processes such as cleaning, peeling, grinding, pasteurising, canning; and vacuum- or gas-packing.	Fresh, frozen, vacuum-packed/refrigerated and dried fruit, vegetables, meats, poultry, fish, nuts, seeds; starches* grains – all types of rice; 100% juices; eggs; pasteurized/dried fresh milk & fermented milk, yoghurt; teas, coffee; pastas* (No additives, added sugar or salt allowed.)
Processed culinary ingredients (PCI <sub>n</sub> )	Extracted from food constituents, these may contain preservatives and additives.	Plant oils; animal fats; starches; sugars and syrups; salt.
Processed foods (PF <sub>n</sub> )	Products (up to five ingredients). May contain, sugar, oil, salt or combinations of PCI to MPF; May be fermented or have additives to enhance preservation or impede microorganisms.	Tinned/bottled vegetables <sup>†</sup> , fruit in juice or syrup <sup>†</sup> , legumes, meat and fish; vegetables bottled or canned in brine <sup>†</sup> ; salted or sugared nuts/seeds <sup>†</sup> ; cheeses; unpackaged freshly made breads (or breads ≤5 ingredients <sup>†</sup> ).
Ultraprocessed foods (UPF <sub>n</sub> )	Industrial formulations (5+ ingredients, containing added sugars or sweeteners, oils, fats, salt, additives and uncommon culinary ingredients. They are convenient, packaged, branded, accessible, highly palatable. Most are consumed as snacks or replace homemade dishes and meals based on MPF <sub>n</sub> .	Chips/crisps; mass-produced breads and buns; breads ≥5 ingredients Breakfast cereals with added sugar, nutrition bars; savory/sweet snack products; biscuits, cookies, cakes, pastries, packaged desserts and mixes ice creams and frozen dessert; sweetened milk/ cocoa drinks, sweetened yoghurts, margarines/ spreads, sauces/ condiments; sodas, energy and 'fruit' drinks; confectionery, jams, chocolates, candies; vegetable, rice & noodles sides and mixes; many ready- to -eat or -heat products and meals; pre-prepared pies/ pasta/ pizza dishes; poultry/fish 'nuggets' / 'sticks', sausages, burgers, hot dogs, deli meats and foods; infant formulas, follow-on milk, baby foods, 'health'/'slimming' products as meal replacements; fortified meal or entree substitutes.

\* PCI<sub>n</sub> –2010; MPF<sub>n</sub>-2016.  
<sup>†</sup> UPF<sub>n</sub> –2010; PF<sub>n</sub>-2016<sup>(1-4,6)</sup>.

Prepared foods and meals provided about 4% of E and 5% of protein and sodium and contributed other nutrients equal to or slightly less than the percent of E.

*All International Food Information Council processed food categories combined*

When IFIC categories containing PF<sub>i</sub> (omitting MPF<sub>i</sub>) were combined, they contributed 57% of E, but they delivered nutrients of concern (designated by the 2010 US Dietary Guidelines Advisory Committee)<sup>(16–18,80)</sup>. Specifically, PF<sub>i</sub> contributed 45–55% of dietary fibre and nearly all the cereal fibre, 48% of the calcium, 43% of the potassium, 34% of the vitamin D, 64% of the iron, 65% of the folate and 46% of the vitamin B<sub>12</sub>. For constituents to limit, total PF<sub>i</sub> contributed equivalent or slightly lower percent of E for saturated fat (52%) and sodium (57%). All five IFIC categories provided about 2300 mg sodium with most coming from mixtures of combined ingredients (approximately 700 mg) and RTE foods (approximately 1000 mg). Foods eaten outside the home provided about 1200 mg<sup>(16–18)</sup>.

While MPF<sub>i</sub> contributed 5% of the added sugars, the four PF<sub>i</sub> combined contributed 75%, and restaurant foods the remainder. The RTE category provided the most added sugars<sup>(16–18)</sup> but most were from foods dietary guidance recommends limiting such as sugary beverages. However, some added sugars were from foods to encourage such as fibre-rich, enriched and fortified bread and cereals, fruit and dairy.

*Diet selection and categorisation*

Authors of the IFIC studies<sup>(16–18)</sup> concluded that diets were more likely ‘to meet... recommendations if nutrient-dense foods, either processed or not, are selected.’ Poti *et al.*<sup>(81)</sup> also concluded that while PF had more added sugars, there was a wide variation in nutrient content within categories and that choice within a category mattered. Similar examples are gleaned from healthy dietary patterns such as DASH and the US Healthy-Style Eating Pattern (as symbolised by MyPlate), that show nutritious diets can be constructed with the right mix of PF and MPF<sup>(66,69,72–78)</sup>.

*NOVA and nutrients*

Several studies correlated the increased availability of UPF<sub>n</sub> over the last 30+ years with a decline in overall nutrient quality<sup>(4,10,37,82)</sup>. Analyses of food intake data from several countries documented that those who chose the most UPF<sub>n</sub> had lower nutrient quality than those who chose the least. In the 2004 Canadian Community Health Survey.2 (*n* 33 694, >2 years), those in the highest quintile of intake of UPF<sub>n</sub>, ate on average 1046 kJ (250 kcals) more, but compared with those in the lowest quintile, ingested lower levels of riboflavin, niacin and vitamins A, B<sub>12</sub>, C, D and B<sub>6</sub><sup>(6)</sup>. Sodium and energy density were higher for the consumers of UPF<sub>n</sub>.

Similar results came from 2008 to 2009 *Pesquisa de Orçamentos Familiares* (Brazilian Family Budgets

Survey of 32 898 individuals over 10 years). UPF<sub>n</sub> contributed 21.5% of E<sup>(7)</sup>. Those in the highest quintile of UPF<sub>n</sub> intake consumed more energy but less fibre and potassium. However, the analysis showed that certain PF<sub>n</sub> and UPF<sub>n</sub>, specifically bread, cheese, processed meats and canned fruit and vegetables, contributed important nutrients. This latter statement agrees with findings from other studies that emphasise choice of foods within a category, not the category itself<sup>(16–18,81)</sup>.

*Added sugars and the NOVA and International Food Information Council classifications*

Since NOVA categorises all commercially prepared foods with added sugars as PF<sub>n</sub> or UPF<sub>n</sub>, it is self-evident that analysis of food intake data would identify them as significant contributors of added sugars. According to the US National Health and Nutrition Examination Survey 2009–2010 (*n* 9317), UPF<sub>n</sub> delivered nearly 60% of E but 90% of the added sugars for children and adults<sup>(8)</sup>. Canadian data showed UPF<sub>n</sub> contributing 49% of E and a significant amount of free sugars<sup>(6)</sup>. Analysis of Chile’s 2010 *Encuesta Nacional de Consumo Alimentario* (*n* 4920, 2+ years) showed that UPF<sub>n</sub> contributed 29% of E and 59% of added sugars<sup>(9)</sup>. In the 22 116 households participating in the 2010 Spanish Household Budget Surveys (food disappearance, not intake data), UPF<sub>n</sub> provided 31.7% of daily E and 80.4% of added sugars<sup>(83)</sup>. In the Brazilian *Pesquisa de Orçamentos Familiares*, UPF<sub>n</sub> provided 21.5% of E and 29% of added sugars<sup>(7)</sup>.

*Ultra-processed foods-NOVA and obesity*

Proponents of NOVA have noted that the rise in obesity over the last 30+ years has paralleled the increased availability of UPF<sub>n</sub><sup>(6,7)</sup>. Specifically, in nineteen European countries, their increased availability between 1991 and 2008 was associated with increased obesity<sup>(84)</sup>. The authors concluded that ‘A significant positive association was found between national household availability of ultra-processed foods and national prevalence of obesity among adults...’ However, further analyses of their data showing UPF<sub>n</sub> availability by country does not show strong concordance with obesity data from the Organisation for Economic Co-operation and Development<sup>(85,86)</sup>. Table 4 compares a few countries with the high and low availability of UPF<sub>n</sub> and obesity percentages. Simple associational data<sup>(84)</sup> fail to consider Food and Agriculture Organization data documenting increased energy consumed over that same time period<sup>(87)</sup>.

Studies associating UPF<sub>n</sub> with obesity had differing outcomes if they were adjusted for other contributors to obesity. Findings from the 2008 to 2009 Brazilian Dietary Survey showed that those in the quintile eating the most UPF<sub>n</sub>, compared those eating the least, had higher risks of overweight (OR = 1.26) or obesity (OR = 1.98)<sup>(88)</sup>. However, it also showed that energy intakes for the higher quintile were 1255 kJ (300 kcal) more than for the lowest quintile<sup>(7)</sup>. This begs the question about adjusting for energy and whether the cause is more energy consumed or UPF<sub>n</sub>. Findings were similar

**Table 4.** UPF<sub>n</sub> Availability and obesity in selected countries (2008)

	UPF <sub>n</sub> availability %	Obesity rate %
Portugal	10.2	15.4
Italy	13.4	10.3
Germany	46.2	14.7
UK	50.4	26.1

UPF<sub>n</sub>, Ultra-processed foods NOVA.<sup>(84)</sup>OECD, Organisation for Economic Co-operation and Development.<sup>(85,86)</sup>

from Spanish University of Navarra cohort, where those in the highest, v. lowest, quartile of UPF<sub>n</sub> consumption (three NOVA categories, not four) had a hazard risk for obesity of 1.26<sup>(89,90)</sup>. However, there was no relationship between UPF<sub>n</sub> and weight in the UK's National Diet and Nutrition Survey (2008–12; *n* 2174), after adjusting for other causes of obesity. This study did show that diets high in PCI<sub>n</sub> were associated with body weight, indicating that food prepared at home may not stem the rise in obesity<sup>(84)</sup>.

#### Processed foods, nutrient intake, food choice and added nutrients

MPF<sub>n</sub> were shown to contain the greatest share of vitamins and minerals, and UK diets high in PF<sub>n</sub>/UPF<sub>n</sub> were lower in nutrients<sup>(79)</sup>. However, the study affirmed previous findings that not all PF<sub>n</sub>/UPF<sub>n</sub> were of lower nutritional quality. The study's authors emphasised the need for attention to nutrient density, not processing when constructing diets<sup>(16–18,79,81)</sup>.

#### Consumption of ultra-processed foods-NOVA may impact consumption of minimally processed foods-NOVA

Many MPF are processed or combined with other ingredients before eating. This not only may improve safety and acceptability, it may help with nutrient availability. For example, fat-soluble components in raw vegetables are better absorbed with fat from dressings and sauces (UPF<sub>n</sub>) and are more likely to be chosen by children<sup>(91,92)</sup>. Furthermore, homemade oil-based condiments are not inherently healthier than commercial ones.

Consumption of certain UPF<sub>n</sub> appears to encourage consumption of important MPF<sub>n</sub>. For example, children and adolescents who consume RTEC breakfast also consumed more milk, yoghurt and fruit than those who consumed other breakfasts<sup>(93,94)</sup>.

#### Questions about foods categorised as ultra-processed foods-NOVA

UPF<sub>n</sub> as a group contributed smaller amounts of fibre, vitamins and minerals than other groups<sup>(6,7)</sup>. However, placement of foods in various groupings is puzzling. Categorising discretionary foods (candies, sugary beverages and grain-based desserts) with core (staple)

foods such as whole grain bread and cereals, not only fails to make logical sense, it can foster erroneous conclusions about the nutrient contribution of core foods. For example, categorising corn or wheat starch as a PCI<sub>n</sub> but whole grain bread and cereals as UPF<sub>n</sub> does not make sense in terms of many nutrients. Whole grain/enriched/fortified breads are the leading sources of whole grain and fibre and are components that are under-consumed<sup>(95–101)</sup>. Consumption of enriched/fortified RTEC was, in a meta-analysis of sixty-four studies, associated with healthier dietary patterns and more fibre and whole grains intake, despite higher intakes of total sugars<sup>(94)</sup>. Persons consuming RTEC frequently ( $\geq 5$  times/week) were more likely to have adequate intakes of vitamins A and B<sub>6</sub>, folate, calcium, magnesium and zinc<sup>(66)</sup>.

Similarly, labelling of some forms of oily fish, especially shelf stable, affordable sources, as PF<sub>n</sub>/UPF<sub>n</sub> might decrease intakes of *n*-3 fatty acids<sup>(102)</sup>.

#### Fortified foods

All foods with added nutrients are UPF<sub>n</sub>. However, data support the positive impact of enrichment and fortification. In the USA their use means that fewer than 12% of the US population fall below the estimated average requirement for thiamin, riboflavin, folate, iron and vitamin B<sub>6</sub><sup>(17,66)</sup>. For thiamin, 49% meet the estimated average requirement without fortificants, but 96% with them; for folate 12% without and 89% with them<sup>(66)</sup>. Avoidance of folate-fortified grains in women the year prior to conception (as part of low carbohydrate or gluten/grain-free diets) was associated with a 30% increased risk of spina bifida and anencephaly in the infants<sup>(103)</sup>. Thus, questionable placement of some foods into various categories and recommending the avoidance of all foods designated as UPF<sub>n</sub> may not be sound dietary advice and may carry risks.

#### Ultra-processed foods, grain foods and body weight

Most grain-based foods are listed as UPF<sub>n</sub>. Many eat too many grain servings, especially grain-based desserts or snacks and most fail to ingest recommended levels of wholegrain and fibre<sup>(80,104–106)</sup>. Excess consumption of grain-based desserts and snacks may be associated with weight. However, avoidance of wholegrain and high-fibre bread and cereals because they are deemed UPF<sub>n</sub>, may not address weight concerns. In the Physicians Health Study, those who ate one or more servings of whole and refined grain cereals daily, compared with those who ate less, were associated with lower risk of increasing BMI over time<sup>(107)</sup>. Adolescents in the European HELENA cohort who were daily RTEC consumers, either whole grain or refined, had an OR of being overweight, 0.43 compared with non-consumers<sup>(108)</sup>. Similar findings have been shown in Australian children and adults<sup>(109,110)</sup>. Designation of RTEC and bread as PF<sub>n</sub>/UPF<sub>n</sub> may decrease wholegrain, fibre and nutrient intakes and may not address the obesity problem<sup>(111)</sup>.



### *Added sugars, flavoured milk, nutrients and obesity*

Flavoured milk and yoghurts are categorised as UPF<sub>n</sub>. However, children consuming flavoured, *v.* unflavoured, milk have higher calcium and nutrient intakes and lower obesity risks<sup>(112,113)</sup>. Initiatives to eliminate flavoured milk in schools made no difference in added sugars consumption. However, there was a significant drop in overall milk and calcium consumption<sup>(114,115)</sup> because flavoured milk drinkers consumed more milk. Avoidance of flavoured milk may do little to address obesity and may reduce nutrient intake<sup>(112,113)</sup>.

### *Ultra-processed foods and other foods*

Designating foods *e.g.* infant formulas, supplemental foods, lactose- and gluten-free foods, as UPF<sub>n</sub> might cause avoidance by those who need these<sup>(116–118)</sup>. Avoidance of any of those foods might do little to address rising rates of obesity and may not improve health.

### **Does the NOVA categorisation meet standards for dietary guidance?**

Nutrition recommendations should follow the Hippocratic oath *primum non nocere* ‘first do no harm.’ Ideally, they should improve food choices and health outcomes and not create a possibility of less healthy choices<sup>(119)</sup>.

Standards for dietary recommendations state that they: (1) are based on valid assumptions and sound science; (2) improve nutrient intakes and public health; (3) have been successfully  $\beta$ -tested with consumers and have outcomes equivalent to vetted recommendations; (4) address the four principles for successful dietary recommendations (Table 5)<sup>(18,19)</sup>.

### **Does the placement of foods in the NOVA categories use valid assumptions and sound science?**

Placement of foods in NOVA categories may not be based on valid assumptions as noted in the previous discussion. Analyses of food intake data showing that PF<sub>n</sub>/UPF<sub>n</sub> provide a large proportion of added sugars demonstrates a tautology<sup>(120)</sup>. (A tautology exists when a conclusion involves circular reasoning and cannot be tested with empirical data.) Since foods with added sugars were designated as PF<sub>n</sub>/UPF<sub>n</sub>, most added sugars would come from these categories<sup>(121)</sup>.

Recommendations to avoid foods containing more than five ingredients has an equivocal theoretical basis. Proof that foods with fewer than five ingredients are healthier than those with more is not possible because a food’s nutritional quality depends on the ingredients and their treatment. More ingredients might complete a protein, contribute needed nutrients or act synergistically to improve nutrient absorption<sup>(122)</sup>. Ingredients (including additives) can make food safer, prevent nutrient loss, enable foods for special needs (*e.g.* gluten-free products) or enhance acceptability of needed dietary components

**Table 5.** Principles for successful dietary recommendations.<sup>(5,6)</sup>

Understandable
Actionable
Affordable and safe

Adaptable to many lifestyles and cultures for the long term.

*e.g.* bran<sup>(123–125)</sup>. They also can do the opposite especially if the ingredients are ‘components to limit,’ such as sugar<sup>(103)</sup>. Judging food quality on the number of ingredients, rather on their nutritional contribution, is questionable<sup>(119,120)</sup>.

### **Are NOVA categories understandable and actionable?**

Dietary guidance works when recommendations give consumers clarity about foods to choose. The many disparate definitions and categories (Tables 1–3) are a testament to the lack of agreement. Even within NOVA studies, foods are not uniformly categorised among studies and their placement in categories is not consistent among studies<sup>(1–15,79,82–84,88–90)</sup>.

NOVA guidance requires consumers to have the knowledge of menu planning and skills and ability, time and resources to utilise PCI and MPF<sub>n</sub> to plan menus and prepare meals. However, consumers in many regions have limited skills in these areas<sup>(126–129)</sup>. Elderly and those with mobility or cognitive limitations may find PF<sub>n</sub> and UPF<sub>n</sub> not only helpful but necessary<sup>(130,131)</sup>.

Time, cost and affordability for most consumers are limited, especially for those with children, employed outside the home. Processed foods and labour-saving equipment have decreased the 6+ hours spent daily in 1900 by women on food-related activities<sup>(132,133)</sup>. Almost half of the respondents in a Euromonitor survey said that they do not cook from scratch because of lack of time<sup>(134)</sup>. A 2018 survey of US households showed that only 28% of meals are prepared from scratch<sup>(135)</sup>. These data suggest that the operationalising NOVA would be difficult for many.

Cost of home-prepared foods from MPF<sub>n</sub> may not be lower, especially when time is considered<sup>(136)</sup>. For example, the price of US packaged bread is about \$2 (600 g, ten servings) and lasts up to 5–10 days; classic French baguette, about \$5.00 (360 g, five–six servings) and lasts 1–2 days; and ingredients homemade bread, about \$1–1.50 (450 g and, at \$17/hour, the loaf costs over \$8.00) and lasts 2–5 days depending on the ingredients. If most foods were prepared using PCI and MPF<sub>n</sub>, the time (and cost of time) dedicated to food procurement, preparation and cleaning would be significant.

Dietary recommendations must be affordable for all socioeconomic levels. Calls to avoid PF<sub>n</sub>/UPF<sub>n</sub> may adversely impact food selection, especially for lower-income consumers<sup>(137)</sup>. Studies show that the cost of fresh produce can inhibit the selection of fruit and vegetables<sup>(138–143)</sup>. The United States Department of Agriculture has designed nutritionally-balanced menus

made primarily with PF/UPF for consumers with limited refrigeration, cooking facilities, time and money<sup>(77,144)</sup>.

### Safety

Techniques and equipment for safe food handling are required to use MPF<sub>n</sub>, especially as many outbreaks are linked to these foods<sup>(145–149)</sup>. PF<sub>n</sub> and MPF<sub>n</sub> (without additives and preservatives) may not only have shorter shelf lives but also may pose a greater risk because ‘hurdle’ technologies and additives that inhibit microbial growth and maintain safety are not used<sup>(150)</sup>.

Infant formulas are designated as UPF<sub>n</sub>. While breastfeeding is optimal, safe options are needed where this is not possible. Home-prepared formulas not only carry risks of nutritional imbalances, they have documented food safety risks<sup>(151,152)</sup>.

### Is NOVA adaptable for the long term?

Long-term food availability must address many issues including food waste. Food processing in developing countries has reduced losses by nearly 50%. Commercial processors have channels for waste not available to consumers<sup>(153,154)</sup>. Studies in Europe document lower food waste with frozen foods than fresh or ambient equivalents<sup>(62,63)</sup>.

Additives and ingredients, such as fat or sugar, extend shelf life and potentially decrease food cost and waste. Thus, diets constructed primarily of PCI and MPF<sub>n</sub> may not be the best ways to address food supply issues.

### Will use of NOVA result in better diet quality?

No studies show that consumers can use NOVA to match energy intake with energy needs and can replace foods with added sugar and fat with those that are recommended. Modelling studies replacing current products with those reformulated to meet lowered sugar and other values showed the only meaningful reduction in added sugars occurred if sugar-sweetened beverage consumption decreased<sup>(155)</sup>. Advice to decrease consumption of nutrient-poor foods,<sup>(156)</sup> rather than foods labelled as PF<sub>n</sub>/UPF<sub>n</sub>, may be clearer and have fewer unintended consequences.

Studies are needed demonstrating that home-prepared foods from MPF<sub>n</sub> and PCI will improve diets and lower energy intake. Recipes from popular UK cooking programmes were shown to be neither lower in sugar and energy contributed, nor higher in nutrients than RTE versions from the supermarket.<sup>(157)</sup> The nutrient contribution of the ingredients mattered, not where and by whom the food is prepared.

### Conclusion

Consumers fail to meet recommended intakes for nutrients and food groups<sup>(158,159)</sup>. Unhealthy diet patterns with excess energy intake, meat, salt, sugar, saturated

fat and nutrient-poor foods are common and contribute to obesity and chronic disease<sup>(119,160–164)</sup>.

NOVA proponents suggest that replacement of PF<sub>n</sub>/UPF<sub>n</sub> with MPF<sub>n</sub> will improve diets and decrease disease risks<sup>(165)</sup>.

NOVA definitions are non-traditional and lack congruence with legal or food science ones. Further, many divergent definitions on the web and popular press could muddle consumer understanding about which foods to avoid as PF<sub>n</sub>/UPF<sub>n</sub>. Further, the NOVA categories are different from the IFIC ones. With IFIC, all categories had foods ‘to limit’ and ‘to encourage’. In NOVA foods designated as PF<sub>n</sub>/UPF<sub>n</sub> are to be limited despite their nutrient contribution.

Analyses of food intake databases using NOVA do show that diets high in UPF<sub>n</sub> have lower nutrient density and more added sugars, but studies also show that not all foods in these categories are poor nutritional choices. Studies with the IFIC categorisation suggest that there are nutritious choices from all levels of processing. Diets such as DASH and MyPlate, constructed with the right mix of foods from all categories, can be nutritious.

No studies or  $\beta$ -testing show that consumers can operationalise NOVA’s definitions and categories to choose nutrient-rich foods, to eschew foods of low nutritional quality and improve diets and health outcomes. Further, there are significant concerns about NOVA’s actionability and practicality for various lifestyles, skill sets and resource availability. Studies comparing NOVA implementation with vetted plans such as DASH or MyPLATE are needed to show that nutrient intakes and health outcomes are at least equivalent to those from plans that promote the right balance of foods from all levels of processing<sup>(2,72–76,166–169)</sup>.

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Julie Miller Jones is a scientific advisor to the Grains Food Foundation, The Healthy Grains Institute (Canada), Quaker Oats Advisory Board, and the Campbell Soup Company Plant and Health Advisory Board. She has written papers of given speeches for *Centro Internacional de Mejoramiento de Maíz y Trigo CIMMYT* (International Maize and Wheat Improvement Center, Mexico), Cranberry Institute, and Tate and Lyle.

### Authorship

The author had sole responsibility for all aspects of preparation of this paper.

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