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A real-life manual for the identification of ultra-processed food and its use in lifestyle disease prevention

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Abstract: The modern diet, which consists of food produced with high level of industrial processing, is associated with an increased risk of the development of lifestyle diseases. Current nutritional science is, however, focused on chemical composition of food, and not on the type and degree of processing used during the food production. Here, we take a fresh perspective on the relationship between the extent and type of food processing, and evaluate its impact on consumer health. We argue that the preference for consumption of minimally processed foods, and restriction of ultra-processed foods should be an essential part of a healthy lifestyle, disease prevention, and even treatment. We also present a simple, user-friendly consumer guide, which is intended to be used as a practical, ready-to-go identifier of ultra-processed foods.

Keywords: lifestyle diseases; food processing; ultra-processed food; NOVA classification; nutrition

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1. Introduction

Food quality, rather than macronutrient ratios, recently emerged as arguably the most important aspect of healthy eating. However, up to this date, official nutritional guidelines state that the optimal diet should consist of 50-55 % energy intake from carbohydrate sources, 30-35 % from fats, and 15-20 % from proteins. Accordingly, WHO guidelines state that no more than 30 % of total energy intake should come from fat sources, and that intake of saturated fats should not exceed 10 % of total daily caloric intake (WHO healthy diet, https://www.who.int/news-room/fact-sheets/detail/healthy-diet).

Nevertheless, it has been shown repeatedly that positive effects on health can be achieved as well using non-conventional nutritional strategies with dramatically distinct macronutrient composition. Plant-based approaches with its higher saccharide intake [1–3] as well low-carbohydrate diets, rich in protein and fat [4,5] have been repeatedly associated with positive health outcomes. It is clear, therefore, that

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macronutrient composition is not such a crucial factor for achieving and maintaining good health, and food quality is emerging as one of the key aspects of the positive health impact of those diets.

Food quality can be viewed either from the perspective of food safety (e.g. hygienic harmlessness) or from the standpoint of such food's biological value. While sanitary and health harmlessness is certainly indisputable and food processing can be indeed designed to eliminate the risks of microbial contamination, this will not be further discussed here.

Home-cooked meals are generally viewed as healthier than ultra-processed food (UPF). A recent study by Martins *et al* [6] suggests a correlation between parents' cooking skills and UPF consumption in their children. However, a certain level of caution should be maintained. During home culinary processing, *e.g.* cooking, a whole range of physical and chemical changes are induced in the food. Those changes can lead to the formation of potentially dangerous substances, e.g. acrylamide, heterocyclic amines, polycyclic aromatic structures, etc. Hence, the customer has an indisputable role in the resulting quality of his food.

For food products manufactured using a high level of technological processing, unbiased assessment of their biological value is often complicated. Food processing is defined as any physical, chemical, or biological process leading to changes in the food structure and/or composition. Let's consider grain processing as an example. Removal of the grain skin and subsequent grinding of the grain during the production of white flour leads not only to an increase of the glycemic index of the product compared to the original grain but in the end, it affects the hormonal response of the human body to the consumption of such food. Processed saccharides lacking fiber, e.g. due to the disruption of its microstructure, or its complete removal, are predominantly digested in the upper part of the small intestine. This shifts the incretin hormone ratios and subsequently leads to significantly higher postprandial insulin release [7,8].

Changes induced to the food by industrial processing are, however, usually strongly associated with poor health outcomes [9]. Those changes include shifts in nutrient ratios, disruption of food microstructure, depletion of essential nutrients and minerals, nutrient degradation, and replacement of parts of the original food with less biologically valuable ingredients, food additive use, and artificial increase of simple sugar and fat content. For heavily industrially-processed foods, the term "ultra-processed" is now widely-used.

The consumption of ultra-processed foods and beverages had markedly increased in recent decades, in some countries contributing more than 50 % of total caloric intake [10–12]. Several studies have recently connected the consumption of ultra-processed foods with a higher risk of development of lifestyle-associated diseases, including obesity [13–15], hypertension and heart disease [16], lipoprotein profile alteration [17], metabolic syndrome [18], type 2 diabetes [19], possibly cancer [20], and even overall risk of death [21,22]. More recently, obesity, hypertension, and other lifestyle-related diseases have been shown as a high-risk factor for the covid-19 pandemic, and the role of healthy eating and the food industry has been stressed [23,24]

But, for easy and practical on-the-go assessment of the nutritional quality of food, a clear definition of the high-risk, ultra-processed food

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group is missing. Two features with the greatest potential to have a positive health impact are, arguably, (i) easy and reliable identification of ultra-processed foods, which are to be avoided, and (ii) easy identification of foods suitable for safe and healthy home cooking. Additionally, our goal is to draw attention to the potential negative health effects of ultra-processed food consumption. As a result, we present a simple and practical consumer guide to identifying ultra-processed foods in real-life scenarios.

Research objectives

Our aim is to provide a simple guide for identification of ultra-processed food. The guide should be comprehensive enough to be used in real-life scenario by a non-expert in nutrition science, while maintaining the standards set by the current knowledge in the field.

2. Characterization of the NOVA system

2.1. Classification of food according to a level of industrial processing (NOVA)

The NOVA food classification system is based on the evaluation of the extent of industrial food processing and was designed to identify such ultra-processed food groups [25,26]. In table 1, we show the summary of foods and food product classification according to the level of industrial processing, as provided by NOVA [27].

Group 1 consists of food that is processed either minimally, or not at all. As minimal processing, we understand physical processes used to increase the shelf-life of food, e.g., cooling, drying, freezing, and vacuum-packing, or technologically uncomplicated processing of food that aims to facilitate further culinary use, e.g., shredding, filtration, separation. As minimal processing is also considered fermentation and pasteurization. Group 2 summarizes products derived from foods in group 1, typically intended for further use in kitchens, and can be called processed ingredients. Group 3 is designated for processed food. Usually, group 3 are products of a combination of group 1 and 2 products, often with the aim to enhance the sensory qualities of food, and/or its conservation. Group 4 is reserved for ultra-processed food. Such food is produced in a way that cannot be recreated at home, and thus can be called "industrial processing". The goal of such a degree of processing is to produce a meal intended to be consumed directly, after simple re-heating, or after a very easy and short preparation (instant food mixes). Such food products contain additives to mimic some sensory properties of natural food components, e.g., colorants, aromas, texture enhancers, thickeners, and many others. Ultra-processed food usually contains high amounts of salt and sugar. They also typically contain hydrogenated and/or interesterified fats and oils, protein hydrolysates, isolated soy protein, inverted sugar, or high-fructose corn syrup.

2.2. Restrictions and usability of the classification system in practice

The NOVA food classification is, without question, designated for the experts in nutrition science and disease prevention, who can use it as a methodical tool for assessment of scientific analyses and studies [28]. While other classification systems are available, arguably none of them is developed to the level of NOVA. During its existence, the classification system was modified several times to remain a suitable tool for the achievement of stated goals. The system, however, has been criticized before, mainly for its imprecision in the classification of some foods [29,30]. More importantly, it is fairly incomprehensible for a common layperson. Successful classification of some food product into a specific group can be a difficult task, and sometimes, extended knowledge of food production technology is necessary. Additionally, NOVA classification is practically inapplicable for the assessment of meals served in restaurants and canteens, mostly due to the incomplete information (or lack thereof) about the food composition.

In NOVA, the term "food processing" is understood as every physical, chemical, or the biological process involved in any particular phase of the food's lifecycle, until the moment the food is being prepared and consumed [26,27]. NOVA operates under the premise that virtually all processing has a more or less negative effect on human health. While it is important to acknowledge that the extent of processing is indeed a factor with a great impact on the quality of the final food product (meal), the health impact of those changes is, however, often a matter of discussion. We argue that a significant number of those processes can be viewed as non-impact, or even beneficial for human health, but others, currently graded as group 1, can be argued as less healthy than currently perceived.

One of such questionable entries is the classification of extracted and pasteurized fruit juices into group 1. Extracted fruit juices are usually fiber-depleted. Depletion of fiber has a dramatic effect on the subsequent release of insulin and gastrointestinal peptides [31–33]. Pasteurization of those juices can lead to degradation of some micronutrients, like ascorbate and carotenoids [34], although technologies are developed to minimize these undesirable effects [35]. While some studies seem to be inconclusive about the cumulative effect of fruit juices on fasting glucose and insulin levels [36], it is important to note that the vast majority of relevant RCT are short-term, and usually include further dietary interventions. Furthermore, the inconclusiveness of those meta-analyses can be also caused by the improper selection of studies, e.g. comparing studies using water as a control beverage with those using sweetened beverages as controls.

Other questionable entries are present in groups 2 and 3. Oils, classified as group 2, vary in quality due to the technology used, as cold-pressed oils are usually of better nutritional value than refined oils [37]. Mill products can be made either from whole grain or skinless (white) grain, as described before. Beer, originally classified as group 3, has similar nutritional value as sweetened, coke-like beverages, and due to the high amount of malt sugars, it has a high glycemic index as well. Another food with arguable classification is salted nuts.

3. Nutritional aspects of processed food

Ultra-processed food is often mistakenly labeled as healthy. This can be legally achieved due to artificially decreasing fat content, protein, and micronutrient fortification, and adding fiber. These foods than can be massively marketed and advertised as healthy, while – undoubtedly – the reality is the opposite of that. The products classified by NOVA as group 4 (ultra-processed food) are usually a rich source of food components that are associated with negative health impacts, e.g. salt, sugar, starch, and some fats.

3.1. Trans-unsaturated fats

Arguably, the most problematic in this sense are partially-hydrogenated fats that contain *trans*-unsaturated fatty acids. High consumption of *trans*-unsaturated fats is strongly associated with several health risks, including cardiovascular disease, type 2 diabetes, and even some cancers [38,39].

3.2. Fat-free products

On the other side of the spectrum are low-fat, or even fat-free dairy products, where the fats are removed from the basic ingredient (milk). This leads not only to loss of palatability but more importantly, to the removal of fat-soluble vitamins. Starches and/or other thickeners are then used to upgrade the product consistency, and sugar or artificial sweeteners are added to compensate for the loss of palatability.

3.3. Salt

Recommended daily dose of salt is 5 g/day, and despite inconsistencies in data, increased intake of salt and sodium is widely considered as risky, particularly for people with hypertension [40]. Besides salt used as a seasoning in cooking, the main sources of sodium are salty foods and bakery products classified as group 4. During periods of increased intake of such foods, salt intake may easily surpass 15 g/day.

3.4. Sugars

Overconsumption of simple sugars, especially fructose, is widely considered as a risk factor for the development of many diseases, e.g., non-alcoholic fatty liver disease, type 2 diabetes, hypertension, dyslipidemia, cardiovascular disease, and even some malignant growths [41–45]. Higher levels of industrial processing of foods composed mainly from saccharides, including added sugars, leads to an undesirable increase of the food's glycemic index. This disrupts the natural hormonal responses to the consumption of such food. In particular, the incretin hormones balance and release, and subsequently, the insulin response to the consumption of processed food. This ultimately leads to defects in satiety regulation, and undesirable effects on body fat stores [46]. Additionally, arguments have been made that added sugar, not total caloric value (discussed below), is responsive to the addictive properties of ultra-processed food [47].

3.5. Caloric value

As a result of the excessive content of fats, sugar, and starch discussed above, ultra-processed food usually has abnormally high caloric value, even though it lacks sufficient protein, essential fats, fiber, and micronutrients. Due to this imbalance, they are usually characterized as "empty calories", which further underscores the lack of nutritional value and excess of calories. Besides, due to artificially-enhanced sensory properties and low satiety effects, they are incredibly easy to overconsume [48], and may even be associated with addictive-like behavior [49,50]. If a majority of a person's diet is composed of ultra-processed food, it leads to the development of obesity [51], at least in the predisposed population. Additionally, due to the unfavorable calorie/nutrient ratio of such food, it may in some cases lead to selective malnutrition, even in obese. Populations with higher demand for

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essential nutrients, such as children, pregnant and lactating women, recovering patients, and chronically ill are particularly vulnerable.

3.6. Food additives

Ultra-processed food also usually contains a significant amount of food additives, representing a fairly large number of chemical compounds. These can be classified into several categories, e.g., colorants, aromas, palatability enhancers, emulgators, preservatives, stabilizers, thickeners, and artificial sweeteners. Toxicologically, they are safe in amounts allowed to be used in foods. It is therefore possible to consume them the whole lifetime without any significant health risk. On the other hand, many studies imply that caution should be advised, as various food additives were connected with hyperactivity symptoms [52], modulation of immune cells [53], changes in gut microbiota [54], and other health consequences, particularly in children [55]. Since the use of food additives during food processing is almost inevitable, the list of additives contained in particular products can be — to some level — taken as an indicator of processing degree, and is easy to assess by the consumer as a deciding factor during shopping.

4. Consumer recommendation proposal

For a common customer, patient, or physician, the classification system leads to several important considerations. First and foremost, it is the need for easy and precise identification of ultra-processed foods (group 4), and distinguishing it from others, more beneficial food groups (1-3). The food classified as group 4 does not bring any considerable nutritional benefits, and, as we discussed above, it is even possible to consider its regular consumption as risky for human well-being. We, therefore, propose that its consumption should be avoided entirely. This is, of course, often not possible due to real-life circumstances. It should be stated, however, that ultra-processed food should be avoided as much as possible, and definitely should not be a regular part of a person’s diet.

Even though the group 4 food is defined quite precisely, it is more than probable that a regular customer will face several difficulties with their identification. We, therefore, propose a simple, yet effective manual for the identification of ultra-processed foods, which can be successfully used by every customer (Fig. 1). The decision process illustrated in Fig. 1 provides a fairly comprehensive way to avoid group 4 foods. There may be some disputable cases for which a misplacement can happen; usually, the products from group 3 will be classified as ultra-processed. In such cases, however, we argue that the “misplacement” may be due to a valid reason.

It should be also noted that the proposed scheme does not deal with deep analysis of meat products, the selection of which is considerably wide. Many of those, especially ready-to-cook meals and cheap products containing less valuable ingredients are, however, self-limiting in the context of the scheme. During the selection of those meat products that are not eliminated by the manual, the final selection is a consumer’s decision. Here, we stress the importance of meat percentage, or muscle protein content, respectively.

5. Conclusion

In this work, we present recent findings in the case of the connection between the extent of technological processing of food, and preventable diseases. We propose that preference of minimally processed foods and restriction of ultra-processed food consumption should be an unquestionable part of a healthy lifestyle, disease prevention, and possibly treatment. Avoidance of nutritionally unsuitable food groups should be stressed, as well as the negative effects of ultra-processed food on human health, especially during prolonged consumption of such products. Here, we present an interdisciplinary view on this topic, and, perhaps most importantly, an easy way of practical identification of nutritionally inferior foods – without any additional knowledge of food science necessary.

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Figure 1

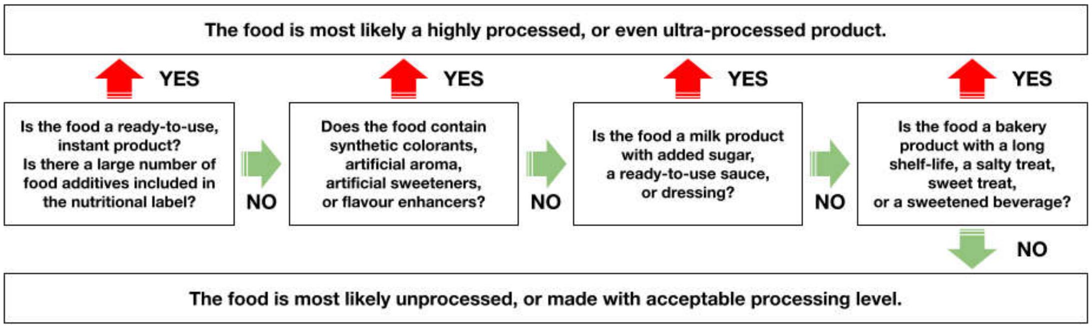

Fig. 1 A consumer manual for identification of ultra-processed food.

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Table 1 — Characterization of food groups according to the NOVA classification system.

Group	Characteristic	Methods and Application	Examples
1	unprocessed minimally processed	Physical processes for increase shelf-life od food, facilitation of further culinary use	Parts of plants/animals, fruit & vegetables (fresh, dried, frozen), mushrooms, nuts, legumes, meat, eggs, milk, pasteurized juices, fresh pasta, spices, white yogurt, coffee, tea, water
2	processed ingredients for direct use in cooking	Group 1-derived products	Salt, sugar, molasses, honey, vegetable oils, butter, lard, starches extracted from plants (flour)
3	processed food	Enhancement od sensoric qualities, conservation	Sterilized fruit, vegetables, and legumes, ham, cheese, salted nuts, salted, smoked meat, fish cans, fresh bread, beer, wine
4	ultra-processed food	Food for direct consumption, high sensoric qualities achieved by additives	Crisps, chocolate, instant products, carbonated and sweetened beverages, crackers, sweets, ready-to-use food mixtures, energy drinks, breakfast cereals, conserved meat products, long-lasting bakery products, ice-cream, alcohol beverages

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Table 2 — Summary of ultra-processed food and examples of their healthier alternatives in specific categories.

Type of food	Examples of ultra-processed food	Examples of suitable alteratives
meat & meat products	canned products, most patés, met product with lower proportion of meat	meat, prime quality ham (at least 16 % by weight of pure muscle protein) Note: ham contains additives belonging to group 4.
fish & fish products	fish sticks, nuggets, surimi sticks, canned fish in ready-made sauces	fish & seafood, prime quality canned fish (in brine/oil)
eggs & mayonnaise	low fat, light mayonnaise	fresh eggs, mayonnaise (full-fat)
milk & dairy	powdered milk, sweetened condensed milk, low-fat and skimmed products	milk, cream, butter, flavoured butter, dairy products with no added sugar
fermented dairy products	sweetened dairy, products with thickeners (starch) and colourings, skimmed products	dairy products without added sugars
cottage/cream cheese	products with thickeners and added sugars	plain cottage cheese
cheese	processed cheese	plain cheese
frozen cream products	ice cream, frozen desserts with added vegetable oil, water-based desserts with added sugars	products made from milk and cream, sorbet Note: the additive content may be problematic
fats & oils	hydrogenated fats, shortening fat, margarine	gently extracted vegetable oils and fats (e.g. cold-pressed olive oil), virgin oils, lard
legumes & vegetables	processed, pre-cooked products	legumes, vegetables, canned legumes, canned vegetables
soy products	soy beverages, soy granulate	fermented soy products, fermented soy sauce
tea products	instant tea	tea leafs, bagged tea
coffee products	instant coffee	coffee beans, fresh ground coffee
spices	mixtures with flavour enhancers, soy sauce made from acid-hydrolyzed protein	herbs, mixtures without additives
Type of food	**Examples of ultra-processed food**	**Examples of suitable alteratives**
instant products	soup, sauce, broth, ready-to-use mixtures, toppings, creams, ice cream	–

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dressing	almost all	home-made dressing
processed fruit and vegetables	Products with added sugar and additives	products without added sugar and additives
mushrooms	instant products with additives	fresh or dried mushrooms
potato products	dried mashed potatoes, crisps, french fries and pre-fried products	–
milled ceral products and breads	with added sugar and additives, muesli with added sugar	milled products made from basic ingredients (flour, salt, levain)
pasta	filled, pre-cooked, instant, cous cous	fresh or dried pasta
pastry	various products (biscuits, extruded and puffed products, fried products etc.)	–
sweeteners	inverted sugar syrup	–
cocoa and sugar mixtures	cocoa mixtures with suger (powdered chocolate drink, sweetened cocoa)	–
chocolate and chocolate products	most products (milk chocolate, white chocolate, candies)	dark chocolate with high percentage of cocoa
non-alcoholic beverages and concentrate	nectar, lemonade, flavored mineral water, beverages with added sugar	beverages with natural flavours and without added sugar, juiced fruit and vegetables
instant product	soup, sauce, broth, ready-to-use mixtures, toppings, creams, ice cream	–
dressing	almost all store-bought products	home-made dressing