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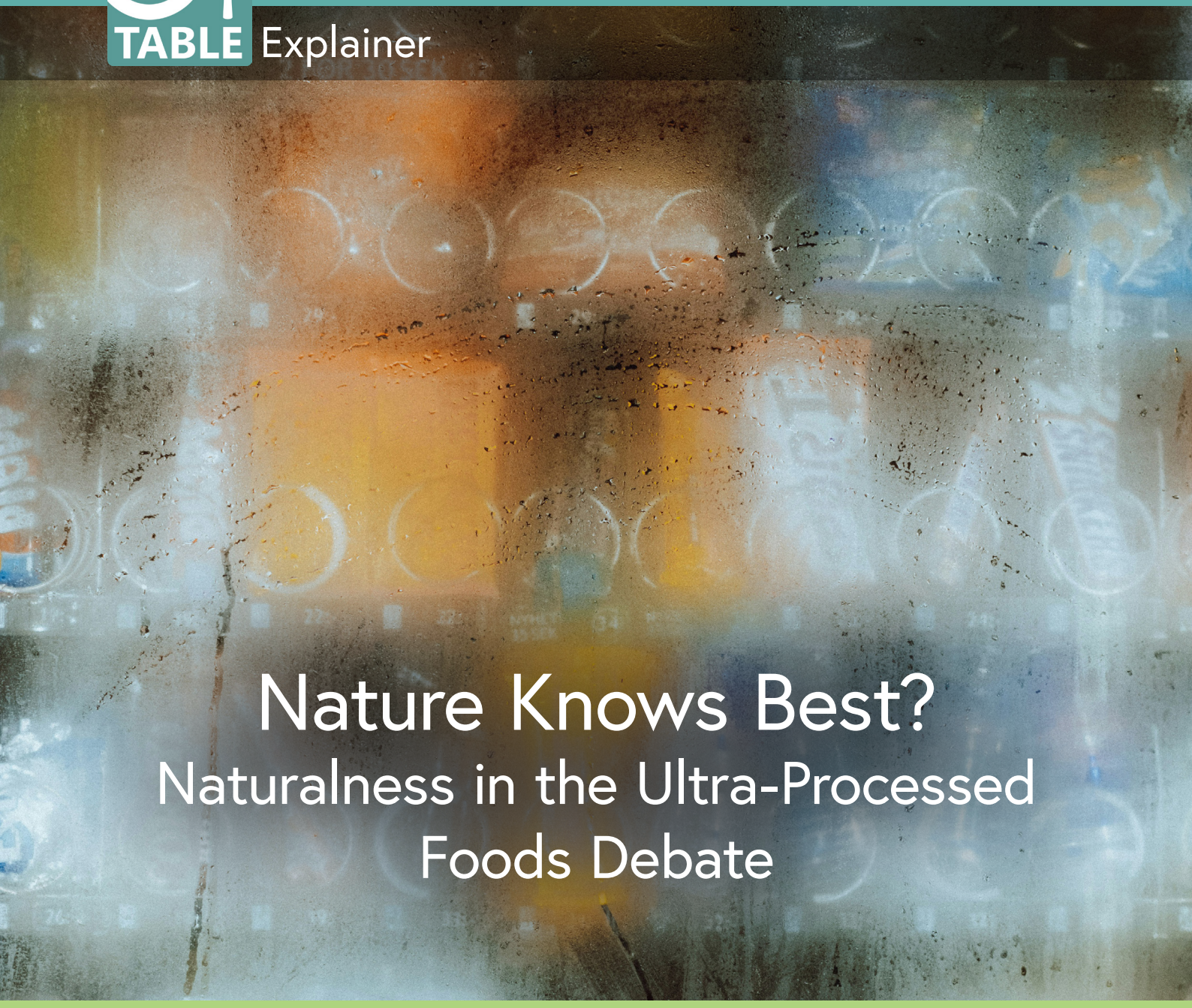

Nature Knows Best?

Naturalness in the Ultra-Processed Foods Debate

June 2024

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TABLE

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Suggested citation

van Hensbergen, H. (2024). Nature Knows Best? Naturalness in the Ultra-Processed Foods Debate. TABLE Explainer. TABLE, University of Oxford, Swedish University of Agricultural Sciences, and Wageningen University and Research. https://www.doi.org/10.56661/f76228c7

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Summary

What can an idea like ultra-processed foods (UPFs), which is so appealing and yet so divisive, tell us about the underlying values, fears, and hopes of those involved in the debate? In this piece, we will explore how debates around UPFs intersect with concerns about naturalness in the food system, where naturalness represents a tangled bundle of other associated values. Firstly, this piece offers a definition of ultra-processed foods and explores how these foods are understood both at the level of food formulation and at the level of the food system. Secondly, the essay explores common conceptions of natural food and looks at how the debate around UPFs relates to a widespread preference for naturalness, sometimes referred to as the "naturalness bias", in food and food systems. In the second half of the piece, three aspects of concerns with UPFs, which are perceived as unnatural, are explored: the question of whether UPFs are bad for us and in what ways; the concern with UPFs as displacing more natural foodstuffs and food systems; and the question of whether UPFs are good or bad for nature and the earth's ecosystems.

Is a more natural food system the answer to our problems? Or does the preference for naturalness, and the dismissal of heavily processed foods, have potentially negative implications for the sustainability of the future food system? Is a better future one that includes the benefits of both natural foods and some heavily processed foods, allowing us to make the most of the earth's limited natural resources, and provide adequate nutrition for all? These are the questions that underlie the debate around ultra-processed foods, but which are rarely drawn into the light.

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1 Defining UPFs

Wrapped in visually appealing packaging, promising a world of flavours and textures, and omnipresent in the supermarkets of rich and middle-income countries; industrially processed foods form an increasingly prominent part of diets across the world. Based on a few cheap ingredients, transformed and combined with complex additives, the production, distribution, and consumption of these foods operates on a massive, international scale. According to some measures, this loose group of foods now account for more than half of overall energy intake in the United States and United Kingdom, and more than a third in France and Australia.[1]

When Brazilian academics first coined the idea of ultra-processed foods (UPFs)[2] in 2009, they sparked a huge debate amongst academics, journalists, and policy professionals on the implications of industrial food processing for human and planetary health. Could they be connected to many of the food system's problems, including malnutrition, obesity, and other non-communicable diseases, as well as major environmental impacts, such as biodiversity loss? Or was the loosely defined category of UPFs unhelpful compared to other methods of categorising food, which focus on foods high in fat, sugar and salt, or processed meat? The concept is highly contested: pinpointing the exact nature of ultra-processed foods has proved evasive. The food industry, food scientists and other commentators caution that ultra-processing is an unhelpful catch-all, encompassing everything from microwaveable burgers to infant formula to sliced brown bread and oat milk.

Despite these concerns over definitions, a growing number of epidemiological studies have shown a relationship between highly processed diets and a suite of negative health outcomes[3] – including, but not limited to, obesity,[4] cardio-metabolic diseases,[5] cancer,[6] inflammatory bowel disease,[7] and depression[8] – and the only controlled trial to date showed that heavily processed diets led to substantially higher calorie consumption and weight gain compared to minimally processed diets that were nutritionally matched.[9] While other studies have nuanced this picture, suggesting the risk is associated with specific UPF subgroups, the idea of UPFs continues to hold sway.[10] With public concern growing, some policy approaches are already targeting UPFs: at least seven countries – Brazil, Ecuador, Peru, Uruguay, Belgium, Maldives, and Israel[11] – as well as individual organisations, such as the American Heart Association,[12] now advise against them in dietary guidelines. In autumn 2023, Colombia became the first country to introduce a comprehensive tax on a large selection of UPFs, which they defined as "industrial formulations manufactured from substances derived from foods or synthesised from organic sources", with an initial 10% tax rate set to increase to 20% by 2025.[13]

So what exactly is a UPF? One general heuristic that often gets used as a shorthand for understanding UPFs is this: you ask if the food in question contains anything you wouldn't find in a home kitchen; an ingredient or additive that requires industrial processes.[14] If the answer is yes, then it's ultra-processed, whether that's a chocolate bar or a vegetable-filled ready meal. UPF isn't just a synonym for fatty, salty, sugary "junk food", but includes heavily processed foods with a variety of nutritional profiles.

In a little more detail, the NOVA classification system, which was developed by the Brazilian team led by nutritionist Carlos Monteiro, groups foods from unprocessed and minimally processed (group 1), through processed culinary ingredients (group 2), to processed foods like canned beans and freshly baked bread (group 3), and finally ultra-processed foods (group 4). UPFs are characterised by complex combinations of ingredients that are themselves already heavily processed, such as high fructose corn syrup, soya protein isolate, and industrial additives.[15] There have been several attempts to classify foods according to degrees of processing with divergent results, but NOVA is the best known; it is the classification referred to in this essay unless otherwise stated.[16]

There are two broad ways of understanding the concept of UPFs from here: they might be parsed into the narrow "ultra-processing formulation" and the wider "ultra-processing regime", as academics Jennifer Lacy-Nichols and Nick Freudenberg have suggested.[17] The narrower conception looks at the question of food composition and processing. For those who understand the concept in this way – often the scientists carrying out studies on the effects of processing on health – the categorisation of UPFs is often viewed as in need of greater refinement. As Kevin Hall, the lead scientist on the controlled trial on ultra-processed diets in 2019 sees it, the concept of UPFs is a "blunt tool", if an illuminating one: the next step is to identify the precise mechanisms by which heavily processed foods affect human health, and narrow the category further.[18] With this better understanding, the blurred boundaries of UPFs could be drawn more clearly, eliminating the possibility of unnecessarily demonising the wrong foods and missing opportunities for exploring avenues towards healthy and sustainable diets. It holds open the possibility that UPFs as a category might become redundant if a better definition is found.

In the broader sense of the "ultra-processing regime", the idea of UPFs is a political and economic conception. Monteiro and others don't just make claims about the extent of processing, but also its purpose. They argue that UPFs are designed by corporations to be highly profitable, because they are based on cheap ingredients transformed into something convenient, long-lasting and "hyper-palatable" for consumers.[19] While all food produced within a corporate food system is designed to generate profit, UPFs are seen as the most extreme example of a system that prioritises corporate profiteering above all else, and disregards public health.[20] In this latter sense, UPFs offer a shorthand for a broader critique of the current food system. For those who have adopted this understanding, including critical academics and public commentators, the looseness of the category is one of its advantages. But this bundling together of values and technical qualities has led to the criticism that UPFs is a "chaotic conception" that creates confusion.[21]

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2 UPFs as a Code for Naturalness

One way of understanding the discussion about ultra-processed foods at both the level of formulation and regime, which will be developed and explored in the following sections of this essay, is to think of it as underpinned by concerns over naturalness in the food system. Nature and naturalness are complex concepts with layers of associated meanings and antitheses: nature vs technology; nature vs culture; natural vs artificial; natural vs synthetic. However tangled, there is no doubt that the idea of nature holds huge power. In relation to food, naturalness is both conceptually vague and often hugely appealing. From brand names like General Mills's Nature Valley to more conspicuous claims of "100% natural", it is ubiquitous. This apparent prevalence is confirmed by statistics: a recent study of US food retail market data found that 16.9 % of all food items purchased carried natural claims on labelling.[22] Moreover, there is an observable preference towards the natural amongst consumers. This is known as the "naturalness bias", and it is observable across cultures.[23] The "naturalness bias" provokes strong positive associations of inherent goodness, environmental benefits, and health.[24]

When applied to food and food formulation, there is no single agreed definition of a natural food, however. On the one hand, there are ingredients of natural origin that can go through different degrees of processing: cacao beans can be transformed into cacao nibs, cacao mass, cacao butter, and cacao powder. On the other hand, there are ingredients of entirely synthetic origin, such as artificial sweeteners like aspartame, saccharin, and sucralose, which can be added to foods. But how we assess the naturalness of any given food product is complex. How does the addition of some synthetic origin additives change the naturalness of the overall product? How do industrial processes affect the naturalness of a food product, if at all? How natural are foods derived from genetically modified crops? How natural is any food derived from crops which have been manipulated by human interference over thousands of years of breeding and selection?

The fact that there is no universally accepted definition is reflected in differing official guidance on food marketing using the term natural. According to EU legislation from 2008, in order to label food flavourings as natural, "the flavouring components used should be entirely of natural origin."[25] More recently, there has been pressure from MEPs and campaigning groups to offer a better legal definition of the term natural.[26] In the UK, non-binding guidance released in 2008 by the Food Standards Agency (FSA) offered a somewhat vague definition, suggesting that natural means "that the product is comprised of natural ingredients", that is "ingredients produced by nature, not the work of man or interfered with by man", and that "it is misleading to use the term to describe foods or ingredients that employ chemicals to change their composition."[27] This definition is arguably far too vague, since all cultivated crops have been interfered with substantially by human hands. The FSA has not updated guidance on this since 2008. In the US, the US Food and Drug Administration (FDA) and the US Department of Agriculture (USDA) suggest different definitions. The non-binding policy of the FDA states that natural means "nothing artificial or synthetic has been added", though it caveats that the term is not intended to apply to growing methods, such as the use of pesticides.[28] The USDA, which regulates meat and poultry, has a more stringent definition: the product should contain no "artificial ingredients" and be "minimally processed."[29] It is not an indicator of how the animal was raised.[30]

Another way to get at the meaning of the natural when it comes to food is to ask what the public understands a natural food to mean, and it is this conception that is most relevant to the understanding of naturalness or unnaturalness which undergirds the idea of ultra-processed foods. Two decades ago, psychologist Paul Rozin conducted a study on American citizens and found that, when assessing the naturalness of a food, processing and additives were viewed as highly significant.[31] A natural food is often defined by consumers in terms of either an absence of processing or an absence of additives.[32] Participants in Rozin's study believed that the naturalness

of a food decreased as the levels of processing increased, while any additives were perceived as dramatically reducing the naturalness of the food.[33] The idea that even a small amount of additive – regardless of whether it is synthetic or naturally derived – is more influential than other processes has been dubbed the principle of "additivity dominance" and attributed to the idea of contagion or contamination, as well as to the idea that addition rather than subtraction is viewed as involving more processing.[34] At the level of formulation and classification, then, we can see the NOVA system as a way of coding degrees of naturalness, and of formalising this lay understanding of naturalness in relation to processing and additives.

At the level of the regime or food systems scale and critique of the current food system, another set of ideas around naturalness and goodness have been articulated by natural food movements, which have expressed a belief in "the healing power of nature" and in the value of a "return" to a more "natural way of eating and living."[35] Natural food in this context means organic food, grown without pesticides. The natural or organic food movements took off as a counter development to the expansion of factory farming and industrial food processing in the 20th century in Europe and America, gaining pace in the Second World War, and with the countercultural hippie movements in the 1960s and 1970s.[36] Advocates of natural or whole foods and farming in these years didn't just argue for organic agriculture, but often envisaged a return to working the land, a return to traditional food systems, and stronger nature connection in rejection of the industrial society.[37] This movement continues to the present day. Another iteration of the natural food systems vision is that of the "natural farming" movement, which has had particular uptake in the Indian state of Andhra Pradesh since the 1990s.[38] There have been many other natural food movements globally; each with their own ideological distinctiveness, but what they often share is a tendency to equate naturalness with localism and small-scale and subsistence farming. The UPFs discourse at the level of food regime critique might be seen as a novel iteration of these ways of thinking about the problem of food system industrialization, updated for a time when industrial food production is far more deeply entrenched.[39] The pull towards naturalness today might be understood as an impulse to turn back the clock on some of the developments of the globalised food system of the last half century, and to reinstitute greater control and agency over food for individuals and communities.

At the scale of both formulation and regime, the idea that natural is best lurks beneath the UPFs debate. There are several ways this assumption might be contested. Firstly, the line of the natural is drawn arbitrarily. Food scientists are quick to point out that humans have processed food for millennia, and that industrial processes build on historic knowledge.[40] Industrial techniques, such as biomass fermentation to grow meat alternatives and extrusion under high temperatures to produce puffed cereals and snacks, are novel iterations of older processes. Grinding, cutting, salting, smoking, drying, fermenting are all processing techniques that have long been used by humans to make food more palatable, digestible, and durable. There are processes to sterilise food, and to cultivate desirable bacteria; to transform its texture, its flavour, its colour. These processes reach into the deep past. They may even have had a role in making us human. According to evolutionary anthropologist Richard Wrangham's hypothesis, cooking enabled higher energy intake and facilitated the development of bigger brains among early humans.[41] In one view, then, food processing is as natural as it gets.

Critics of the discourse surrounding ultra-processed food might additionally point out that agriculture (as culture) is fundamentally distinct from the natural: it is a transformation of the natural – wild animals and plants – through human designed technologies into something that serves human purposes over many generations. The antitheses of nature and culture, or nature and artifice do not map easily onto narratives about natural food, both in terms of perceived natural whole crop foods and the notion that traditional farming methods are natural. Foods of all kinds are steeped in layers and layers of culture and history, with all the attendant complexity and variety that brings. They aren't reducible, therefore, to simple dichotomies of nature versus culture, natural versus artificial, or even traditional versus industrial.

Not only is the line between natural and its opposite drawn arbitrarily, however, the idea that the natural is inherently best when concerned with matters of human health and wellbeing may simply have no grounding. Psychologist Paul Rozin, who conducted the studies on lay conceptions of natural foods, and colleague Sydney Scott, argue that, when it comes to food, "nature is neither inherently good nor inherently bad for humans", but rather "nature is neutral", and the benefits or disadvantages of any product must be individually assessed without reference to naturalness.[42] The benefits of some industrially processed foods have been significant for human industrial societies: enabling food production to be scaled up significantly, alleviating common vitamin deficiencies through fortification, prolonging shelf-life to reduce waste, and ensuring higher degrees of food safety. These foods have made survival possible in otherwise difficult conditions: as emergency famine foods, as wartime sustenance, as foodstuffs for astronauts.

Photo by Russell Watkins at DFID

Is the concept of UPFs another iteration of common perceptions around naturalness or is there more rigorous utility in it? The following two sections of this essay explore concerns around the loss of naturalness in the food system through the increasing predominance of heavily processed foods in human diets. The first looks at the health impacts of UPF-heavy diets and what the science can tell us so far. It shows that the idea of UPFs as a collective category may be less illuminating than more specific properties of foods that might make them prone to overconsumption, or bad for human health in other ways. The second looks at how UPFs work in a broader food system, and at the idea that that which is natural, healthy and traditional is being substituted by that which is second best and profitable, as explored through the example of infant formula. This section shows how the idea of the natural is bundled up with and sometimes confused with other ideas, such as power and agency.

In the final section, the discussion turns to the potential uses of ultra-processed foods to the advantage of nature, especially in the context of a food system placing excessive stress on the earth's fragile ecosystems. It looks at concerns that UPFs are environmentally damaging, but also at the idea that they can offer important tools for the nutrition transition towards more plant-based diets. It asks whether nature versus technology is the best framework through which to express concerns about the state of the current food system, or whether dismissing the use of advanced food technologies and industrial additives is a possible missed opportunity for nutritious food that doesn't cost the earth.

3 Unnatural Eating? Textures, Flavours, and Additives

What can the science actually tell us, so far, about whether these heavily processed foods are bad for us, and in what ways? Conventional nutrition focuses on foods high in fat, salt, and sugar as the ones to avoid for healthy living. The degree of processing and the number of synthetic additives are not a measure by which the healthfulness of a food is assessed. Scientific studies have now linked UPF-heavy diets with higher energy consumption and individual weight gain, and correlated UPF-heavy diets with increased rates of diet-related disease and mortality.[43] But what are the specific mechanisms by which this might be happening? If it's not about the foods that are high in fat, salt, and sugar, this poses the question of what other aspects of these foods might help explain these patterns. The current science suggests that food texture, food energy density, certain additives, and even combinations of rewarding nutrients that do not occur in less processed foods may all have a part to play in generating adverse effects.

The texture and energy density of heavily processed foods have provoked particular interest and concern, since their effects on eating rates may be important mechanisms by which people end up eating more food before they are able to register satiation.[44] This isn't a novel idea: the link between energy density and higher calorie consumption without any reported increase in fullness has been observed in clinical trials since the 1990s, while more recent trials have focused on the effects of food texture and eating rate for energy intake.[45] Food texture exposure is especially important for the young: it is formative for oral development, early food acceptance, and lifelong eating habits.[46] From the first introduction of complementary foods, children exposed to a wide range of healthy foods with different textures are more likely to develop healthy habits.[47] There is concern that children who grow up on soft textured foods with limited (and often sweet) flavours, such as fruit purees and melt-in-the-mouth cereal snacks may be being shaped into limited ways of eating with lifelong adverse effects.[48]

There are important qualifications to address, however. While soft food texture has been linked convincingly with higher eating rates, this is the same for both minimally processed and heavily processed foods.[49] There is no definitive link between texture and processing, though it may be more common to find soft textures in the UPF category, where foods are mechanically transformed and reconstructed, hence the idea voiced by some critics that they are "pre-chewed."[50] Nonetheless, in respect to the concern around food texture, it might be better to talk about hard and soft foods rather than processing per se.

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The place of sensory-enhancing industrial additives as replacements for conventional sensory-enhancing ingredients like sugar, and their possible role in encouraging consumption, is another area brought to light in discussions of ultra-processed foods. While the justification of non-nutritive sweeteners has been healthier processed foods, studies haven't established links to sustained long-term weight loss.[51] Non-sugar sweeteners from both natural and synthetic sources can be between 200 and 20,000 times sweeter than sugar, even while they maintain very low or no caloric values.[52] The disjunct between sweetness experienced and

the absence of calories may confuse the learned responses and satiety signals of the body.[53] More generally, the prevalence of high degrees of sweetness in these foods may create expectations of sensory experience that can't be matched in less processed foods, making people reliant on ultra-processed foods to satisfy their palates. The implications of this for obesity and diet-related diseases have yet to be fully established, but without clear evidence of weight loss effects as well as evidence of possible increased health risks (these include risks for type 2 diabetes, cardiovascular diseases and mortality; while sucralose and saccharin have been shown to increase blood sugar levels, and aspartame is categorised as a possible cause of cancer) this is certainly a challenge to the supposed benefits of this category of industrially processed additives as tools for reformulation.[54]

Concerns around novel additives relate to other health impacts as well. Take additives in popular commercial cereals. Food dyes such as Red 40 and Yellow 6, which can be found in Kellogg's Froot Loops and General Mills' Lucky Charms, have been linked to hyperactivity in children.[55] Studies on the emulsifiers polysorbate 80 and cellulose gum, the latter of which is used in cereals such as General Mills' Fiber One Original Bran Cereal and Nestlé's Koko Crunch All in One, found alterations to the gut microbiome that led to anxiety-like symptoms in mice.[56]

Photo by Pixel-Shot from AdobeStock

A range of common sweeteners and emulsifiers have been linked to alterations in the gut microbiota, promoting inflammatory bowel disease.[57] These aren't all synthetic, however, but might be viewed as somewhat natural, though heavily processed, such as carrageenan, a common emulsifier derived from seaweed.[58] Alterations to the gut microbiome do not necessarily point to either positive or adverse effects for processed foods, however. A recent study found that xanthan gum – another naturally derived additive – affects the gut microbiome, but it is not known whether this has positive or negative effects.[59] While many industrial and novel additives may be harmless, there is a lack of rigorous testing and precaution which means that negative health effects often aren't understood prior to use in the food system. Regulation of additives is limited and discrepant across countries.

In the US, industry has been granted the power to determine which of its own novel substances it deems safe, resulting in over 98% of the 766 additives introduced since 2000 skipping any review by the Food and Drug Administration.[60]

The next area of concern is that "some foods may be designed in ways that create hyper-palatability".[61] This is the idea that certain combinations of nutrients – fat and sugar, say – are particularly appealing to the human gut in ways that go beyond their conscious sensory appeal, and cut directly to the signals between the gut and brain that encourage consumption.[62] Particular combinations (which don't tend to occur naturally in whole foods) of fat and sodium; fat and carbohydrates; fat and sugars; and carbohydrates and sodium may create reward signals that bypass the conscious operation of desire or self-control, and trigger subconscious mechanisms that may encourage higher levels of consumption. The phenomenon of sensory-specific satiety, which was identified in the 1980s, describes the decline in liking or desire for a particular food as more of it is eaten.[63] Tera Fazzino and colleagues, who have attempted to create a rigorous definition of hyper-palatability, suggest the combinations of palatable ingredients might evoke a weakened sensory-specific satiety response.[64] If further work confirms and refines the concept of "hyper-palatability" these aspects of heavily processed foods might contribute to a case for understanding them as addictive, or quasi-addictive. The idea of food addiction is highly controversial, but there are now a substantial number of studies showing behavioural and biological changes in response to palatable processed foods.[65] It is worth noting, however, that very few studies have looked at whether whole or natural foods have addictive-like qualities, so the link to processing could be more effectively established with further investigations.[66]

Energy density, food texture, nutritional profile, sensory characteristics, and industrial additives are all possible mechanisms by which industrially processed foods affect human health and encourage overconsumption. Collectively, these different mechanisms pose a challenge to a conventional focus on nutrients and suggest several avenues for further research. They have raised the possibility that human appetites, consumption patterns, and health are being affected in ways conventional nutrition science can't explain. They do not amount to a clear narrative about UPFs collectively, however, which remains a loose category of foods, though they do suggest that many characteristics typical of UPFs could contribute to adverse health effects.

UPFs are some of the most widely available, cheap, and accessible foods; they are often the staples that provide people with the energy they need to live, as well as key nutrients through fortification of bread, milk powder, and other basic foods. Whole foods and minimally processed options are frequently more expensive and less accessible to the lowest income groups in industrial societies. Without major structural transformations, the avoidance of UPFs may not be feasible for all social groups. If studies on energy density, food texture, additives, and hyperpalatability can identify clear mechanisms for overconsumption and other negative health effects, this would create opportunities for reformulation to create better processed foods. Explorations could include creating harder to eat food textures and exploring food odours to promote healthy choices.[67] Strong incentives for innovation and strict regulation against negative aspects of these foods would make it more likely that such foods could have a positive impact on the current obesogenic environment.

The above changes would potentially satisfy those who see UPFs as a problem exclusively in terms of food formulation. However, for those who see UPFs in a broader sense as an "emergent property of today's commercialised and commodified food system" (as one British parliamentarian put it recently), reformulation is not likely to be an appealing route forward.[68] The problem still comes back to the conviction that the corporations involved in developing these foods are pursuing overconsumption as part of a project to turn humans into profitable dependents, or as Chris van Tulleken puts it, "ultra-processed people."[69] The concern is that companies, which are always driven by the profit motive, would not want to reformulate to make their food less addictive or hyper-palatable. In this view, UPFs are part of an ongoing project to replace subsistence farming, local food economies, and natural, whole and traditional foods with globally produced ultra-profitable ultra-processed foods. The idea that the real problem with UPFs is that they displace the natural for that which is profitable, as part of a wider pattern of deepening corporate control of the food system is addressed in the next section.

4 Naturalness Displaced? Corporate Power and Infant Formula

For those who articulate a critique of UPFs from the perspective of a wider ultra-processed regime, the concern is with how multinational corporations have intervened to displace natural and traditional foods in favour of those which are commercially viable and profitable, with, at best, a glancing regard for the interests of public health. UPFs form part of a wider story about food systems in the last half century: the growing power of corporations, the diminishing significance of subsistence economies, the changing shape of culinary cultures, and convergence on a "global standard" food supply and diet.[70] If these developments are framed in terms of a move away from the natural, however, this story runs the risk of conflating ideas of power, agency, and naturalness in ways which miss out on the benefits offered by advanced technologies and create a false narrative of a natural past that has never existed.

This section will explore these questions with special reference to infant formula, an unusual UPF that gets at the crux of some of the concerns around the replacement of the natural and traditional. It can tell us a lot about how science can be useful, how corporate power can be manipulative, how the natural becomes something reified in the rejection of corporate influence, and what the limitations are of this reification.

Formula is a UPF made up of proteins derived from animal milk, fats from vegetable oils, and a range of added vitamins and minerals. It is nutritious and currently used to feed millions of babies across the world. For those who can, the World Health Organization (WHO) recommends exclusive breastfeeding for the first six months, but where breastfeeding is either not possible or desired, commercial milk formula provides the only recommended alternative to human breast milk for newborn babies.[71] Science tells us that natural (human breast milk) is best, but technology, where necessary, is an adequate second best. Nonetheless, there is a consensus amongst the scientific and international communities that breastfeeding rates are too low: formula is being used in its place.[72]

Powdered baby formula. Photo by Africa Studio from AdobeStock

Logically, infant formula ought to be a hard sell. Breastfeeding, a natural practice of mammals, provides all the necessary nutrients infants need. It is free; a gift of nature.[73] For humans, it benefits both breastfeeding parents and babies, providing communication between immune systems, releasing hormones that develop mother-baby bonding, and stimulating sleep. The environmental impacts of breastfeeding, moreover, are lower than those of substitutes, since it requires no packaging, generates no waste, and doesn't require the production of cow milk (though breastfeeding carers do need to eat more).[74] Epidemiological studies correlate nursing practices to reduced likelihood of obesity, better education outcomes for children, and protection against breast cancer for those who lactate.[75]

Yet, despite these facts, the use of formula has become widespread since the middle of the 20th century, while less than half of babies are breastfed exclusively up to six months.[76] From workplace demands to breastfeeding issues, there are a whole range of social, economic, cultural, political, and health factors which influence the high rates of bottle feeding.[77] But, primarily, critics of the rise and rise of formula milk blame corporate marketing. They see a "predatory" industry taking advantage of parental anxieties about natural aspects of child development, such as disrupted sleep and crying, targeting health workers, making false scientific claims, obstructing access to impartial information on breastfeeding, and influencing regulatory standards for formula.[78] Despite attempts at regulation, there has been limited compliance with the WHO's voluntary International Code of Marketing of Breast-milk Substitutes since it was introduced in 1981, particularly in the Global South.[79]

These concerns, acute as they are in the case of infant formula, apply more widely to how critics think about UPFs. In the broader shift in dietary patterns away from local, traditional and natural diets and subsistence food regimes towards heavily processed diets, they point to assertive marketing tactics by industry. This is especially when it comes to reaching the world's poorest people, dubbed "bottom of the pyramid" consumers, who live in areas of low incomes and limited infrastructure. Nestlé's now famous Amazon boat is just one example; another travels the rivers of Bangladesh to reach remote communities with Nestlé products; and there are Maggi brand "cooking caravans" travelling around Cameroon, Côte d'Ivoire, and Nigeria to sell products and offer cooking and food education.[80] Corporate strategists argue this is a "win-win" situation, allowing consumers to benefit from nutritious and affordable food, but critics view this as a tool for achieving market dominance and dictating a wholesale dietary shift from natural and traditional to ultra-processed diets.[81] Critical academics see new commodities displacing traditional food habits, disrupting local subsistence economics, and transforming people into "aspiring consumers" within a capitalist system as globalization becomes ever more pervasive and entrenched.[82] The process of displacement is thought to erode local food knowledge and skills, and heavily processed foods become the most affordable source of nutrition, further solidifying the power of food corporations to dictate the content of people's diets on a global scale.

Where the widespread use of formula has been seen as a problem there has been a tendency to set up a dichotomy between the natural and the technological, where each stands for a collection of other ideas and values: natural means breast milk, health, resistance, empowerment. Technology means formula, ill health, corporate manipulation, subjugation. Historian Tehila Sasson offers a good example in the 1970s scandal over Nestlé's marketing of formula to mothers in the Global South. Activists in the Global North framed this in terms of "baby killer" formula vs. the naturalness and goodness of breastfeeding as a weapon of resistance. Yet this dichotomy contained its own contradictions of power and inequality: activists ran the risk, Sasson argues, of essentializing Southern women as natural mothers unprepared for a changing world and creating a double standard, since formula was already widely used in the Global North.[83] Naturalness arguments are often double edged in this way.

Another issue with the argument for naturalness in the food system is that it runs the risk of creating a false narrative of a natural past that never really existed. In the case of infant feeding, alternative feeding practices aren't a novel phenomenon. Throughout history, when mother-infant nursing hasn't been possible or desirable, humans have relied on alternatives such as wet nursing and artificial feeding.[84] Depending on the time and place,

breast milk replacements might have meant a mixture of cows' milk and boiled wheat kernels (as recommended in ancient Egypt);[85] a blend of walnut, cornmeal and water (as used by the Wabanaki Nations in North America according to 18th century colonists' diaries);[86] or the porridge, bread, milk, and broth-based substances known as gruel, pap, and panada (early modern Europe).[87] These alternatives were less than ideal: animal milk could be unsafe, there was a risk of underfeeding, and they were associated with increased infant mortality, especially when conditions were compounded by poverty.[88] In the 19th century, processes such as milk pasteurisation, bottle sterilization, as well as the invention of commercial milk formula, made these alternatives to breastfeeding safer and more nutritious.

Since then, the recipe for infant formula has improved with the discovery of vitamins and minerals in the early 20th century, and more recently with efforts to fine tune the balance of proteins, lactose, enzymes, and lipids, and even attempts to mimic the immunity benefits of breast milk in order to "humanize" the product further.[89] These efforts of food scientists to improve milk formula seems anathema to the discourse that views heavily processed and technologically advanced food substances in wholly negative terms. Certainly, knowledge of food science can be used for good or ill – infant formula in China was found to have been doctored with the chemical melamine to improve nitrogen content and give the appearance of higher protein levels, causing damage to infants' kidneys – but when kept within adequate boundaries, it can offer significant benefits to humans, especially where more natural alternatives, such as breastfeeding, aren't available.[90]

For industry sceptics of the ultra-processing idea, formula hits at the core of why ultra-processing is an unhelpful terminology, disconnected from more realistic hopes for the food system and more reliable markers of healthfulness and nutrition. The tension is well-illustrated in the fact that Colombia's new law, which has introduced new taxes on ultra-processed foods, makes an exception for infant formula (as well as for several foods with cultural importance such as dulce de leche and butifarra sausage).[91] While consumer discussions have viewed UPFs as a way to categorise "good" and "bad" foods, another way of understanding the argument around UPFs which is pulled into relief with this example, is to see that the critique is less about the content of individual foods themselves than the ways in which they operate in the food system: displacing the natural for that which is second best. Today, a complex set of socio-economic conditions – from workplace policies to lack of healthcare support to prohibitive social norms – create barriers to breastfeeding.[92] As a result of both these barriers and powerful commercial marketing, infant formula occupies a more significant role in infant feeding practices. In this case, formula is technically nutritious, but it is often solving a problem – low breastfeeding rates – that requires more structural changes to fix, and reflects the broader point about the negative effects of dramatic power imbalances in the food system.

The case of infant formula is an extreme but illustrative one: it shows the dangers both of cleaving too closely to ideas of a natural past, and of the risks involved in novel technologies developed and marketed for the pursuit of profit. But the question of UPFs isn't just about their impact on human health, it is also a question of dietary impacts on planetary health. Is there a place for UPFs for eating within the limits of ecosystem capacities? Are plant-based UPFs a useful tool in the protein transition, or are the global supply chains and heavy processing practices of UPFs another reason to be deeply sceptical?

5 Nature Spared? UPFs and Planetary Health

When the concept of UPFs was first developed in the late 2000s, the concern was not with environmental impacts but with health. Increasingly, however, approaches to healthy diets have also come to tackle questions of sustainability, where there may be both overlaps and trade-offs.[93] Looking at UPFs from this perspective presents both possibilities and concerns. Do these foods, understood as an "emergent property" of the current industrial food system, exemplify some of the worst environmental stresses created by that system, through their encouragement of overconsumption, their use of processed animal products, and their reliance on high levels of processing, packaging, mono-cropping, and extensive global supply chains? Or could UPFs be a key tool in mitigating food system environmental impacts by supporting a transition to more sustainable plant-based diets? Since many of the plant-based alternatives to animal products are considered UPFs, what role might these foods play in nutritionally adequate diets which help to limit human impacts on the earth's ecosystems more broadly, through constraining the land required for food production? In order to better understand the place of ultra-processed foods in future diets, it's important to take account of both health and environmental questions, and to take full account of the potential advantages and disadvantages of plant-based processed foods.

The particular contribution of UPFs to the ecosystem impacts of the global food system – the primary driver of biodiversity loss and contributor of between a quarter and third of the world's greenhouse gas emissions[94] – have only been assessed by a handful of studies.[95] [96] [97] The consistent results of these studies have been that one of the main mechanisms by which diets heavy in UPFs contribute to greater environmental impacts is through higher energy intake.[98] For populations eating beyond the requirements for sustenance, additional foods could be seen as "discretionary" foods, meaning their related environmental impacts are superfluous or unnecessary.[99] Another key factor influencing the impacts of UPFs is the levels of animal products in these diets. One study conducted on the Brazilian diet showed that across degrees of processing "meat subgroups contributed disproportionately" to both water and carbon footprints, while a French study concluded that a reduction in red and processed meat remained the "main lever" for improving the environmental sustainability of diets while benefiting human health.[100]

There is one fairly simple story to be told here: processed animal products and higher energy consumption are the two factors linking UPFs to higher environmental impacts. As ever, however, there is more complexity here than meets the eye. It is important to recognise that researchers are only now conceptualising the best ways to approach the assessment of ultra-processed foods and their specific environmental impacts – including monoculture-linked biodiversity loss, pollution from packaging, energy use from processing, and the impacts of global supply chains.[101] More research and data is needed in this area before the utility of the UPFs concept can be fully assessed. More work needs to be done, moreover, to understand the links between the prevalence of cheaper processed meats and meat intake, and further explorations of the relationship between energy intake and the particular properties of industrially processed foods, like hyper-palatability, need to be undertaken.

While the environmental impacts of UPFs is an ongoing discussion, the comparative impacts of animal products in diets are well-established. One recent UK study found that vegan diets were associated with less than half the impact of high meat consumption diets, while there were even substantial differences of at least 30% between low and high meat eaters on several major indicators, including global greenhouse gas emissions, land use, and eutrophication.[102] It is widely agreed that a dietary transition towards more plant-based diets could have an enormous positive impact on the environmental pressures created by the food system, including freeing up large swathes of land currently devoted to animal husbandry and feed crops.[103] Different visions of plant-based futures or "legume dreams" reflect differing values around naturalness and technology*.[104] When it comes to the food itself, the world of possibilities include unprocessed and minimally processed foods that have long been used as meat alternatives, such as pulses, mushrooms, jackfruit, and tofu, but also heavily processed alternatives, including plant-based milks and products that mimic processed meat and fish.[105]

**For more about plant-based futures, see our podcast project* Meat: The Four Futures

Processing can ensure that novel plant foods have sensory appeal and contain adequate vitamins through fortification. They can be made to taste and look similar to their processed animal product counterparts, encouraging uptake amongst consumers. The processing techniques that make this possible may be relatively novel, but they build on traditional processes. Fermentation, one of the most long-standing human culinary technologies, has been an important tool for the development of industrial plant-based proteins. Traditional fermentation uses microbial digestion to create products like yoghurt and alcohol, and can also be used to change the flavour and texture of plant-based animal product alternatives. Biomass fermentation, which has been used in food production since the 1980s, uses microbes to grow large quantities of proteins in bioreactors. Quorn is made this way, using the fungus Fusarium venenatum. Precision fermentation, meanwhile, uses yeasts, fungi, mycelium, or microalgae to create specialist ingredients with specific sensory properties, such as the meat-like taste of precision fermented soy.[106]

Fortification is another technique used in processing to improve the quality and nutritional content of industrially produced plant-based foods. It has had some remarkable successes: synthetic folic acid fortification, for example, has been adopted by over seventy governments globally for cereals and flours since the 1990s, and studies have shown that they have prevented brain and spine birth defects.[107] Fortification can ensure that cheap staples based on a few common crops provide key nutrients that might otherwise be missed. But it has been criticised as a reductionist and technocratic approach to healthy and sustainable diets, which fails to address the structural factors of inequality and poverty. It's seen as a "nutritional fix", as critical nutritionist Aya Kimura has called it, which means that, while some people have access to diverse nutritious foods, others are reduced to reliance on the fortification of cheap staples as the only safety net against serious deficiencies.[108] Some are also sceptical of fortification's potential to create a false "health halo" effect around otherwise unhealthy foods.[109] If fortification can be viewed as an inadequate technocratic tool, however, it may nonetheless be an indispensable one: offering essential routes to nutritional security in a world that is simultaneously environmentally degraded and deeply unequal, where access to a diversity of whole foods isn't widely guaranteed.

KFC advert on a bus shelter in Wales. Photo by Jaggery from Geograph

As novel technologies, ultra-processed plant foods play into the existing political and economic dynamics of meat production in complex ways. On the one hand, there are organisations with interests in meat production that are devoted to generating scepticism and concern around plant-based meats, such as the National Cattlemen's Beef Association and the Centre for Consumer Freedom (originally set up by Philip Morris to fight tobacco legislation, but now devoted to tackling plant-based meats).[110] The discourse of UPFs has aided these groups in creating aversion and disgust around these new foods. On the other hand, both plant-based meat alternatives and cellular agriculture have been met with enthusiasm from major meat companies, where an opportunity for product diversification presents itself. All of the global top ten meat producers are invested in, or actively pursuing, projects in this space.[111] This has led to comparisons with Big Oil, and criticisms of greenwashing from journalists and advocacy groups.[112] It's clear that ultra-processed animal product alternatives can slot easily into the existing conditions of the corporate food system. This may, in and of itself, make some advocates for plant-based diets shy away from more technologically advanced products in favour of more natural pathways.[113] Corporate control of this novel space isn't inevitable, however, and there are other possibilities. The open source cellular agriculture research institute New Harvest and project Shojinmeat point towards a greater dispersal of power, where smaller groups and individuals are able to work with these technologies. In different political circumstances, moreover,

there could be a much larger role for states and public institutions to test, develop, and harness novel culinary technologies.[114]

Scientific technologies are only neutral in a vacuum: once they are put to work in the world, they reflect the power structures and inequalities of the world in which they operate. If natural foods are seen to lend themselves to more dispersed power and local foodways, this isn't an inevitable connection, and where concerns surrounding power dynamics motivate the rejection of technologically advanced foods, there is a danger of elision. If the discourse surrounding UPFs, especially in its wider "ultra-processing regime" sense, has had a role to play in creating a sense of fear and repulsion around these technologies, there is a risk that their potential utility as tools for the creation of realistically affordable, nutritious, and palatable food in an environmentally degraded world won't be realised. It is clear that in comparative terms, the environmental impacts of plant-based alternatives are dramatically less than equivalent animal-based products. While there is still much to understand about the overall environmental impacts of industrially produced alternatives to animal foods, especially in the case of developing products such as lab-grown meat, it would be a mistake to close this path forwards out of fears of perceived unnaturalness.[115]

Conclusion

The debate surrounding ultra-processed foods over recent years reflects both tensions within the concept and its interpretation, as well as broader differences in the values and beliefs people bring to debates around food, health, and sustainability. Understood more narrowly, the idea of UPFs has offered a useful correction to the notion that "junk food" is sufficient to describe the nature of obesogenic dietary patterns, and has set researchers a useful challenge: to determine precisely which mechanisms make some foods healthier than others. But in its wider sense, UPFs can be viewed as a sign for a set of beliefs about the food system, what is good and what is bad in it, that can be boiled down to a stand-off between nature and technology, where each stands for a tangled bundle of other associated values.

The widespread appeal of naturalness is undeniable. Intuitive associations with goodness and healthfulness run deep, whether or not there is always the evidence to support them. When critics express concern about ultra-processed foods and a preference for natural, wholesome foods, moreover, they may also be expressing other loosely connected critiques and preferences: against corporate consolidation and globalised supply chains, and in favour of autonomy, community, locality, and tradition in the food system. If the value of natural foods is also grounded in these other ideas, however, we might see its value as somewhat circular. Perhaps it's because there is such an extreme power imbalance in the food system, that naturalness has become the keystone concept around which these other ideas and values organise themselves.

When the concept of ultra-processed foods is used as a stand-in for these issues, however, it has the potential to be simultaneously too all-encompassing and too limited. It is too broad if a preference for dispersed power and autonomy is translated uncritically into an aversion towards technologies which might otherwise be useful for ensuring healthy and sustainable food systems. It is too narrow, on the other hand, when it squeezes a host of concerns about the state of the food system into the singular idea of processing, which might distract from other significant issues and dynamics in both production and distribution.

Between the extremes of a technological experimentalism that is unfettered and reckless with human lives and a wholesale traditionalism that harks back to an ideal past that never truly existed, there is a large swathe of creative space. Instead of ceding that room, those working on interdisciplinary efforts to forge a future food system that is equitable, healthy, and sustainable should be seizing it. Explorations of where shared values truly lie, and which technologies – from the most historical to the most novel – can be useful, and to what ends, are all necessary. This is an opportunity to embrace novelty and preserve tradition, wherever those serve the values and ambitions of those involved in forging better food systems for the future.

Endnotes

1. According to the NOVA classification system, see Martini, D., Godos, J., Bonaccio, M., Vitaglione, P., & Grosso, G. (2021). Ultra-Processed Foods and Nutritional Dietary Profile: A Meta-Analysis of Nationally Representative Samples. *Nutrients, 13*(10), 3390. https://doi.org/10.3390/nu13103390

2. Monteiro, C. (2009). Nutrition and health. The issue is not food, nor nutrients, so much as processing. *Public Health Nutrition, 12*(5), 729-731. https://doi.org/10.1017/S1368980009005291; Fraanje, W. & Garnett, T. (2019). What is ultra-processed food? And why do people disagree about its utility as a concept? Food Climate Research Network, University of Oxford. https://doi.org/10.56661/ca3e86f2

3. Lane M. M., Gamage E., Du S., Ashtree D. N., McGuinness A. J., Gauci S., Baker, P., Lawrence, M., Rebholz, C. M., Srour, B., Touvier, M., Jacka, F. N., O'Neill, A., Segasby, T. & Marx, W. Ultra-processed food exposure and adverse health outcomes: umbrella review of epidemiological meta-analyses BMJ 2024; 384 :e077310, https://doi.org.10.1136/bmj-2023-077310; Chen, X., Zhang, Z., Yang, H., Qiu, P., Wang, H., Wang, F., Zhao, Q., Fang, J., & Nie, J. (2020). Consumption of ultra-processed foods and health outcomes: a systematic review of epidemiological studies. *Nutrition journal, 19*(1), 86. https://doi.org/10.1186/s12937-020-00604-1; Elizabeth, L., Machado, P., Zinöcker, M., Baker, P., & Lawrence, M. (2020). Ultra-Processed Foods and Health Outcomes: A Narrative Review. *Nutrients, 12*(7), 1955. https://doi.org/10.3390/nu12071955; Lane, M. M., Davis, J. A., Beattie, S., Gómez-Donoso, C., Loughman, A., O'Neil, A., Jacka, F., Berk, M., Page, R., Marx, W., & Rocks, T. (2021). Ultraprocessed food and chronic noncommunicable diseases: A systematic review and meta-analysis of 43 observational studies. *Obesity reviews : an official journal of the International Association for the Study of Obesity, 22*(3), e13146. https://doi.org/10.1111/obr.13146

4. Silva, F. M., Giatti, L., de Figueiredo, R. C., Molina, M. D. C. B., de Oliveira Cardoso, L., Duncan, B. B., & Barreto, S. M. (2018). Consumption of ultra-processed food and obesity: cross sectional results from the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) cohort (2008-2010). *Public health nutrition, 21*(12), 2271–2279. https://doi.org/10.1017/S1368980018000861

5. Levy, R. B., Rauber, F., Chang, K., Louzada, M. L. D. C., Monteiro, C. A., Millett, C., & Vamos, E. P. (2021). Ultra-processed food consumption and type 2 diabetes incidence: A prospective cohort study. *Clinical nutrition, 40*(5), 3608–3614. https://doi.org/10.1016/j.clnu.2020.12.018; Juul, F., Deierlein, A. L., Vaidean, G., Quatromoni, P. A., & Parekh, N. (2022). Ultra-processed Foods and Cardiometabolic Health Outcomes: from Evidence to Practice. *Current atherosclerosis reports, 24*(11), 849–860. https://doi.org/10.1007/s11883-022-01061-3

6. Chang, K., Gunter, M. J., Rauber, F., Levy, R. B., Huybrechts, I., Kliemann, N., Millett, C., & Vamos, E. P. (2023). Ultra-processed food consumption, cancer risk and cancer mortality: a large-scale prospective analysis within the UK Biobank. *EClinicalMedicine, 56*, 101840. https://doi.org/10.1016/j.eclinm.2023.101840; Isaksen, I. M., & Dankel, S. N. (2023). Ultra-processed food consumption and cancer risk: A systematic review and meta-analysis. *Clinical nutrition, 42*(6), 919–928. https://doi.org/10.1016/j.clnu.2023.03.018

7. Narula, N., Chang, N. H., Mohammad, D., Wong, E. C. L., Ananthakrishnan, A. N., Chan, S. S. M., Carbonnel, F., & Meyer, A. (2023). Food Processing and Risk of Inflammatory Bowel Disease: A Systematic Review and Meta-Analysis. *Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association*, S1542-3565(23)00071-X. Advance online publication. https://doi.org/10.1016/j.cgh.2023.01.012

8. Godos, J., Bonaccio, M., Al-Qahtani, W. H., Marx, W., Lane, M. M., Leggio, G. M., & Grosso, G. (2023). Ultra-Processed Food Consumption and Depressive Symptoms in a Mediterranean Cohort. *Nutrients, 15*(3), 504. https://doi.org/10.3390/nu15030504

9. Hall, K. D., Ayuketah, A., Brychta, R., Cai, H., Cassimatis, T., Chen, K. Y., Chung, S. T., Costa, E., Courville, A., Darcey, V., Fletcher, L. A., Forde, C. G., Gharib, A. M., Guo, J., Howard, R., Joseph, P. V., McGehee, S., Ouwerkerk, R., Raisinger, K., Rozga, I., … Zhou, M. (2019). Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell metabolism, 30*(1), 67–77.e3. https://doi.org/10.1016/j.cmet.2019.05.008

10. Cordova, R., Viallon, V., Fontvieille, E., Peruchet-Noray, L., Jansana, A., Wagner, K.-H., Kyrø, C., Tjønneland, A., Katzke, V., Bajracharya, R., Schulze, M. B., Masala, G., Sieri, S., Panico, S., Ricceri, F., Tumino, R., Boer, J. M. A., Verschuren, W. M. M., van der Schouw, Y., Jakszyn, P., Redondo-Sánchez, D., Amiano, P., Huerta, J. M., Guevara, M., Borné, Y., Sonstedt, E., Tsilidis, K. K., Millett, C., Heath, A. K., Aglago, E. K., Aune, D., Gunter, M. J., Ferrari, P., Huybrechts, I., & Freisling, H. (2023). Consumption of ultra-processed foods and risk of multimorbidity of cancer and cardiometabolic diseases: a multinational cohort study. *The Lancet Regional Health Europe, 35*, 100771. https://doi.org/10.1016/j.lanepe.2023.100771

11. Koios, D., Machado, P., & Lacy-Nichols, J. (2022). Representations of Ultra-Processed Foods: A Global Analysis of How Dietary Guidelines Refer to Levels of Food Processing. *International journal of health policy and management, 11*(11), 2588–2599. https://doi.org/10.34172/ijhpm.2022.6443

12. Lichtenstein, A. H., Appel, L. J., Vadiveloo, M., Hu, F. B., Kris-Etherton, P. M., Rebholz, C. M., Sacks, F. M., Thorndike, A. N., Van Horn, L., & Wylie-Rosett, J. (2021). 2021 Dietary Guidance to Improve Cardiovascular Health: A Scientific Statement From the American Heart Association. *Circulation, 144*(23), e472–e487. https://doi.org/10.1161/CIR.0000000000001031

13. El Congreso de Colombia (2022). Ley 2277. Colombia, https://acmineria.com.co/sitio/wp-content/uploads/2023/05/LEY-2277-DE-13-DE-DICIEMBRE-DE-2022.pdf

14. van Tulleken, C. (2023). Ultra-processed people: Why do we all eat stuff that isn't food… and why can't we stop?. Cornerstone Press.

15. Monteiro, C. A., Levy, R. B., Claro, R. M., Castro, I. R., & Cannon, G. (2010). A new classification of foods based on the extent and purpose of their processing. *Cadernos de saude publica, 26*(11), 2039–2049. https://doi.org/10.1590/s0102-311x2010001100005

16. Other attempts to bring processing into wider classifications of foods include the Food Compass, work at UNC Chapel Hill, and Siga, see: Mozaffarian, D., El-Abbadi, N. H., O'Hearn, M., Erndt-Marino, J., Masters, W. A., Jacques, P., Shi, P., Blumberg, J. B., & Micha, R. (2021). Food Compass is a nutrient profiling system using expanded characteristics for assessing healthfulness of foods. *Nature food, 2*(10), 809–818. https://doi.org/10.1038/s43016-021-00381-y; Poti, J. M., Mendez, M. A., Ng, S. W., & Popkin, B. M. (2015). Is the degree of food processing and convenience linked with the nutritional quality of foods purchased by US households?. *The American journal of clinical nutrition, 101*(6), 1251–1262. https://doi.org/10.3945/ajcn.114.100925; Davidou, S., Christodoulou, A., Fardet, A., Frank, K. (2020). The holistico-reductionist Siga classification according to the degree of food processing: an evaluation of ultra-processed foods in French supermarkets. *Food & Function, 11* (3), 2026-2039. https://doi.org/10.1039/C9FO02271F

17. Lacy-Nichols, J., & Freudenberg, N. (2022). Opportunities and limitations of the ultra-processed food framing. *Nature food, 3*(12), 975–977. https://doi.org/10.1038/s43016-022-00670-0

18. Center for Food as Medicine. (2023). Ultra-Processed Foods: Center for Food as Medicine Panel Discussion. Youtube. https://www.youtube.com/watch?v=2dZMjhhjIyA

19. Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L. G., & Jaime, P. C. (2019). Ultra-processed foods: what they are and how to identify them. *Public health nutrition, 22*(5), 936–941. https://doi.org/10.1017/S1368980018003762

20. Fraanje, W. & Garnett, T. (2019). What is ultra-processed food? And why do people disagree about its utility as a concept? *Food Climate Research Network*, https://www.doi.org/10.56661/ca3e86f2

21. Sadler, C. R., Grassby, T., Hart, K., Raats, M., Sokolović, M., & Timotijevic, L. (2021). Processed food classification: Conceptualisation and challenges. *Trends in Food Science & Technology, 112,* 149-162. https://doi.org/10.1016/j.tifs.2021.02.059; Sadler, C. R., Grassby, T., Hart, K., Raats, M. M., Sokolović, M., & Timotijevic, L. (2022). "Even We Are Confused": A Thematic Analysis of Professionals' Perceptions of Processed Foods and Challenges for Communication. *Frontiers in nutrition, 9,* 826162. https://doi.org/10.3389/fnut.2022.826162

22. Kuchler, F., Sweitzer, M., & Chelius, C. (2023). *The prevalence of the "natural" claim on food product packaging* (Report No. EB-35). U.S. Department of Agriculture, Economic Research Service. https://doi.org/10.32747/2023.8023700.ers

23. Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations, and the contrast between foods and medicines. *Appetite, 43*(2), 147–154. https://doi.org/10.1016/j.appet.2004.03.005; Román, S., Sánchez-Siles, L. M., & Siegrist, M. (2017). The importance of food naturalness for consumers: Results of a systematic review. *Trends in Food Science & Technology, 67,* 44–57. https://doi.org/10.1016/j.tifs.2017.06.010; Ji, L. J., Lappas, C. M., Wang, X. Q., & Meier, B. P. (2023). The Naturalness Bias Influences Drug and Vaccine Decisions across Cultures. *Medical decision making : an international journal of the Society for Medical Decision Making, 43*(2), 252–262. https://doi.org/10.1177/0272989X221140803

24. Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations, and the contrast between foods and medicines. *Appetite, 43*(2), 147–154. https://doi.org/10.1016/j.appet.2004.03.005; Román, S., Sánchez-Siles, L. M., & Siegrist, M. (2017). The importance of food naturalness for consumers: Results of a systematic review. *Trends in Food Science & Technology, 67,* 44–57. https://doi.org/10.1016/j.tifs.2017.06.010; Ji, L. J., Lappas, C. M., Wang, X. Q., & Meier, B. P. (2023). The Naturalness Bias Influences Drug and Vaccine Decisions across Cultures. *Medical decision making : an international journal of the Society for Medical Decision Making, 43*(2), 252–262. https://doi.org/10.1177/0272989X221140803; Meier, B.P., Dillard, A.J., & Lappas, C.M. (2019). Naturally better? A review of the natural-is-better bias. *Social and Personality Psychology Compass, 13/8,* e12494. https://doi.org/10.1111/spc3.12494

25. Regulation 1334/2008. *Regulation (EC) No 1334/2008 of the European Parliament and of the Council of 16 December 2008 on flavourings and certain food ingredients with flavouring properties for use in and on foods and amending Council Regulation (EEC) No 1601/91, Regulations (EC) No 2232/96 and (EC) No 110/2008 and Directive 2000/13/EC.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008R1334-20240205

26. Southey, F. (2021). Defining 'natural' in food: Commission pressed to fill 'considerable gap' in labelling framework. *Food Navigator.* https://www.foodnavigator.com/Article/2021/02/17/Defining-natural-in-food-Europe-pressed-to-fill-considerable-gap-in-labelling-framework

27. Food Standards Agency. (2008). Criteria for the Use of the Terms Fresh, Pure, Natural Etc in Food Labelling. https://www.food.gov.uk/sites/default/files/media/document/markcritguidance.pdf

28. FDA. (2018). Use of the Term Natural on Food Labelling. https://www.fda.gov/food/food-labeling-nutrition/use-term-natural-food-labeling

29. USDA Food Safety and Inspection Service. (2015). Meat and Poultry Labelling Terms. https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety-basics/meat-and-poultry-labeling-terms

30. Kuchler, F., Sweitzer, M., & Chelius, C. (2023). *The prevalence of the "natural" claim on food product packaging* (Report No. EB-35). U.S. Department of Agriculture, Economic Research Service. https://doi.org/10.32747/2023.8023700.ers

31. Rozin, P. (2005). The meaning of "natural": process more important than content. *Psychological science, 16*(8), 652–658. https://doi.org/10.1111/j.1467-9280.2005.01589.x

32. Scott, S. E., & Rozin, P. (2017). Are additives unnatural? Generality and mechanisms of additivity dominance. *Judgement and Decision Making, 12*(6), 572–583. https://doi.org/10.1017/S1930297500006707

33. Rozin, P. (2005). The meaning of "natural": process more important than content. *Psychological science, 16*(8), 652–658. https://doi.org/10.1111/j.1467-9280.2005.01589.x

34. Scott, S. E., & Rozin, P. (2017). Are additives unnatural? Generality and mechanisms of additivity dominance. *Judgement and Decision Making, 12*(6), 572–583. https://doi.org/10.1017/S1930297500006707

35. Shurtleff, W. & Aoyagi, A. (2020). History of the natural and organic foods movement (1942–2020): Extensively annotated bibliography and sourcebook. SoyInfo Center. https://www.soyinfocenter.com/pdf/224/NaFo.pdf

36. Vogt, G. (2007). Origins of organic farming. In W. Lockeretz. (ed.) Organic farming: An international history. (pp. 9-29). CABI. https://ebookcentral.proquest.com/lib/oxford/detail.action?docID=315091; O' Sullivan, R. (2015). *American organic: A cultural history of farming, gardening, shopping, and eating*. University of Kansas Press.

37. Shurtleff, W. & Aoyagi, A. (2020). History of the natural and organic foods movement (1942–2020): Extensively annotated bibliography and sourcebook. SoyInfo Center. https://www.soyinfocenter.com/pdf/224/NaFo.pdf; O' Sullivan, R. (2015). *American organic: A cultural history of farming, gardening, shopping, and eating*. University of Kansas Press.

38. Duddigan, S., Shaw, L. J., Sizmur, T., Gogu, D., Hussain, Z., Jirra, K., Kaliki, H., Sanka, R., Sohail, M., Soma, R., Thallam, V., Vattikuti, H., & Collins, C. D. (2023). Natural farming improves crop yield in SE India when compared to conventional or organic systems by enhancing soil quality. *Agronomy for sustainable development, 43*(2), 31. https://doi.org/10.1007/s13593-023-00884-x

39. Monteiro, C. A., & Cannon, G. (2012). The impact of transnational "big food" companies on the South: a view from Brazil. *PLoS medicine, 9*(7), e1001252. https://doi.org/10.1371/journal.pmed.1001252

40. Kelly, A. (2019). Demonising processed food undermines our trust in science. *The Conversation*, https://theconversation.com/demonising-processed-food-undermines-our-trust-in-science-128442; Fitzgerald, M. (2023). It is time to appreciate the value of processed foods. *Trends in Food Science & Technology, 134*, 222-229. https://doi.org/10.1016/j.tifs.2023.03.001

41. Wrangham, R. (2009). Catching Fire: How cooking made us human. *Profile Books*.

42. Scott, S.E. & Rozin, P. Actually, natural is neutral. *Nat Hum Behav 4*, 989–990 (2020). https://doi.org/10.1038/s41562-020-0891-0

43. Hall, K. D., Ayuketah, A., Brychta, R., Cai, H., Cassimatis, T., Chen, K. Y., Chung, S. T., Costa, E., Courville, A., Darcey, V., Fletcher, L. A., Forde, C. G., Gharib, A. M., Guo, J., Howard, R., Joseph, P. V., McGehee, S., Ouwerkerk, R., Raisinger, K., Rozga, I., … Zhou, M. (2019). Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell metabolism, 30*(1), 67–77.e3. https://doi.org/10.1016/j.cmet.2019.05.008; Lane M. M., Gamage E., Du S., Ashtree D. N., McGuinness A. J., Gauci S., Baker, P., Lawrence, M., Rebholz, C. M., Srour, B., Touvier, M., Jacka, F. N., O'Neill, A., Segasby, T. & Marx, W. Ultra-processed food exposure and adverse health outcomes: umbrella review

of epidemiological meta-analyses BMJ 2024; 384 :e077310, https://doi.org.10.1136/bmj-2023-077310; Chen, X., Zhang, Z., Yang, H., Qiu, P., Wang, H., Wang, F., Zhao, Q., Fang, J., & Nie, J. (2020). Consumption of ultra-processed foods and health outcomes: a systematic review of epidemiological studies. *Nutrition journal, 19*(1), 86. https://doi.org/10.1186/s12937-020-00604-1; Elizabeth, L., Machado, P., Zinöcker, M., Baker, P., & Lawrence, M. (2020). Ultra-Processed Foods and Health Outcomes: A Narrative Review. Nutrients, 12(7), 1955. https://doi.org/10.3390/nu12071955; Lane, M. M., Davis, J. A., Beattie, S., Gómez-Donoso, C., Loughman, A., O'Neil, A., Jacka, F., Berk, M., Page, R., Marx, W., & Rocks, T. (2021). Ultraprocessed food and chronic noncommunicable diseases: A systematic review and meta-analysis of 43 observational studies. *Obesity reviews : an official journal of the International Association for the Study of Obesity, 22*(3), e13146. https://doi.org/10.1111/obr.13146

44. Forde, C. G., Mars, M., & de Graaf, K. (2020). Ultra-Processing or Oral Processing? A Role for Energy Density and Eating Rate in Moderating Energy Intake from Processed Foods. *Current developments in nutrition, 4*(3), nzaa019. https://doi.org/10.1093/cdn/nzaa019; Lasschuijt, M., Camps, G., Mars, M., Siebelink, E., de Graaf, K., & Bolhuis, D. (2023). Speed limits: the effects of industrial food processing and food texture on daily energy intake and eating behaviour in healthy adults. *European journal of nutrition, 62*(7), 2949–2962. https://doi.org/10.1007/s00394-023-03202-z

45. Bell, E. A., Castellanos, V. H., Pelkman, C. L., Thorwart, M. L., & Rolls, B. J. (1998). Energy density of foods affects energy intake in normal-weight women. *The American journal of clinical nutrition, 67*(3), 412–420. https://doi.org/10.1093/ajcn/67.3.412; Teo, P. S., Lim, A. J., Goh, A. T., Janani, R., Choy, J. Y. M., McCrickerd, K., & Forde, C. G. (2022). Texture-based differences in eating rate influence energy intake for minimally processed and ultra-processed meals. *The American journal of clinical nutrition, 116*(1), 244–254. https://doi.org/10.1093/ajcn/nqac068; Lasschuijt, M., Camps, G., Mars, M., Siebelink, E., de Graaf, K., & Bolhuis, D. (2023). Speed limits: the effects of industrial food processing and food texture on daily energy intake and eating behaviour in healthy adults. *European journal of nutrition, 62*(7), 2949–2962. https://doi.org/10.1007/s00394-023-03202-z

46. Mennella J. A. (2014). Ontogeny of taste preferences: basic biology and implications for health. *The American journal of clinical nutrition, 99*(3), 704S–11S. https://doi.org/10.3945/ajcn.113.067694; Tournier, C., & Forde, C. G. (2023). Food oral processing and eating behavior from infancy to childhood: evidence on the role of food texture in the development of healthy eating behavior. *Critical reviews in food science and nutrition*, 1–14. https://doi.org/10.1080/10408398.2023.2214227

47. Tournier, C., & Forde, C. G. (2023). Food oral processing and eating behavior from infancy to childhood: evidence on the role of food texture in the development of healthy eating behavior. *Critical reviews in food science and nutrition,* 1–14. https://doi.org/10.1080/10408398.2023.2214227

48. Childs, R. & Sibson, V. (2023). Ultra-processed foods (UPF) in the diets of infants and young children in the UK. First Steps Nutrition Trust. https://www.firststepsnutrition.org/upfs-marketed-for-infants-and-young-children

49. Teo, P. S., Lim, A. J., Goh, A. T., R, J., Choy, J. Y. M., McCrickerd, K., & Forde, C. G. (2022). Texture-based differences in eating rate influence energy intake for minimally processed and ultra-processed meals. *The American journal of clinical nutrition, 116*(1), 244–254. https://doi.org/10.1093/ajcn/nqac068; Lasschuijt, M., Camps, G., Mars, M., Siebelink, E., de Graaf, K., & Bolhuis, D. (2023). Speed limits: the effects of industrial food processing and food texture on daily energy intake and eating behaviour in healthy adults. *European journal of nutrition, 62*(7), 2949–2962. https://doi.org/10.1007/s00394-023-03202-z

50. van Tulleken, C. (2023). Ultra-processed people: Why do we all eat stuff that isn't food… and why can't we stop?. Cornerstone Press.

51. World Health Organization. 2023. Use of non-sugar sweeteners: WHO guideline. https://www.who.int/publications/i/item/9789240073616

52. U. S. Food and Drug Administration. (2023). Aspartame and Other Sweeteners in Food. https://www.fda.gov/food/food-additives-petitions/aspartame-and-other-sweeteners-food#:~:text=Sucralose%20is%20about%20600%20times,under%20certain%20conditions%20of%20use

53. Swithers S. E. (2013). Artificial sweeteners produce the counterintuitive effect of inducing metabolic derangements. *Trends in endocrinology and metabolism: TEM, 24*(9), 431–441. https://doi.org/10.1016/j.tem.2013.05.005; Wang, Q. P., Lin, Y. Q., Zhang, L., Wilson, Y. A., Oyston, L. J., Cotterell, J., Qi, Y., Khuong, T. M., Bakhshi, N., Planchenault, Y., Browman, D. T., Lau, M. T., Cole, T. A., Wong, A. C., Simpson, S. J., Cole, A. R., Penninger, J. M., Herzog, H., & Neely, G. G. (2016). Sucralose Promotes Food Intake through NPY and a Neuronal Fasting Response. *Cell metabolism, 24*(1), 75–90. https://doi.org/10.1016/j.cmet.2016.06.010; Small, D. M., & DiFeliceantonio, A. G. (2019). Processed foods and food reward. Science, 363(6425), 346–347. https://doi.org/10.1126/science.aav0556

54. World Health Organization. 2023. Use of non-sugar sweeteners: WHO guideline. https://www.who.int/publications/i/item/9789240073616; Suez, J., Cohen, Y., Valdés-Mas, R., Mor, U., Dori-Bachash, M., Federici, S., Zmora, N., Leshem, A., Heinemann, M., Linevsky, R., Zur, M., Ben-Zeev Brik, R., Bukimer, A., Eliyahu-Miller, S., Metz, A., Fischbein, R., Sharov, O., Malitsky, S., Itkin, M., Stettner, N., … Elinav, E. (2022). Personalized microbiome-driven effects of non-nutritive sweeteners on human glucose tolerance. *Cell, 185*(18), 3307–3328.e19. https://doi.org/10.1016/j.cell.2022.07.016; Riboli, E., Beland, F. A., Lachenmeier, D. W., Marques, M. M., Phillips, D. H., Schernhammer, E., Afghan, A., Assunção, R., Caderni, G., Corton, J. C., de Aragão Umbuzeiro, G., de Jong, D., Deschasaux-Tanguy, M., Hodge, A., Ishihara, J., Levy, D. D., Mandrioli, D., McCullough, M. L., McNaughton, S. A., Morita, T., … Madia, F. (2023). Carcinogenicity of aspartame, methyleugenol, and isoeugenol. *The Lancet. Oncology, 24*(8), 848–850. https://doi.org/10.1016/S1470-2045(23)00341-8

55. McCann, D., Barrett, A., Cooper, A., Crumpler, D., Dalen, L., Grimshaw, K., Kitchin, E., Lok, K., Porteous, L., Prince, E., Sonuga-Barke, E., Warner, J. O., & Stevenson, J. (2007). Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: a randomised, double-blinded, placebo-controlled trial. *Lancet, 370*(9598), 1560–1567. https://doi.org/10.1016/S0140-6736(07)61306-3

56. Holder, M. K., Peters, N. V., Whylings, J., Fields, C. T., Gewirtz, A. T., Chassaing, B., & de Vries, G. J. (2019). Dietary emulsifiers consumption alters anxiety-like and social-related behaviors in mice in a sex-dependent manner. *Scientific reports, 9*(1), 172. https://doi.org/10.1038/s41598-018-36890-3

57. Raoul, P., Cintoni, M., Palombaro, M., Basso, L., Rinninella, E., Gasbarrini, A., & Mele, M. C. (2022). Food Additives, a Key Environmental Factor in the Development of IBD through Gut Dysbiosis. *Microorganisms, 10*(1), 167. https://doi.org/10.3390/microorganisms10010167

58. Guo, J., Shang, X., Chen, P., & Huang, X. (2023). How does carrageenan cause colitis? A review. *Carbohydrate polymers, 302*, 120374. https://doi.org/10.1016/j.carbpol.2022.120374

59. Ostrowski, M.P., La Rosa, S.L., Kunath, B.J., Robertson, A., Pereira, G., Hage, L. H., Varghese, N. J., Qiu, L., Yao, T., Flint, G., Li, J., McDonald, S. P., Buttner, D., Pudlo, N. A., Schnizlein, M. K., Young, V. B., Brumer, H., Schmidt, T. M., Terrapon, N., Lombard, V., Henrissat, B., Hamaker, B., Eloe-Fadrosh, E. A., Tipathi, A., Pope, P. B. & Martens, E. C. (2022). Mechanistic insights into consumption of the food additive xanthan gum by the human gut microbiota. *Nature Microbiology 7*, 556–569. https://doi.org/10.1038/s41564-022-01093-0

60. According to analysis from the US non-profit the Environmental Working Group: https://www.ewg.org/news-insights/news/2022/04/ewg-analysis-almost-all-new-food-chemicals-greenlighted-industry-not-fda

61. Fazzino, T. L., Rohde, K., & Sullivan, D. K. (2019). Hyper-Palatable Foods: Development of a Quantitative Definition and Application to the US Food System Database. Obesity (*Silver Spring, Md.*), 27(11), 1761–1768. https://doi.org/10.1002/oby.22639; DiFeliceantonio, A. G., Coppin, G., Rigoux, L., Edwin Thanarajah, S., Dagher, A., Tittgemeyer, M., & Small, D. M. (2018). Supra-Additive Effects of Combining Fat and Carbohydrate on Food Reward. *Cell Metabolism., 28*(1), 33–44.e3. https://doi.org/10.1016/j.cmet.2018.05.018; Small, D. M., & DiFeliceantonio, A. G. (2019). Processed foods and food reward. *Science, 363*(6425), 346–347. https://doi.org/10.1126/science.aav0556

62. Fazzino, T. L., Rohde, K., & Sullivan, D. K. (2019). Hyper-Palatable Foods: Development of a Quantitative Definition and Application to the US Food System Database. Obesity (*Silver Spring, Md.*), 27(11), 1761–1768. https://doi.org/10.1002/oby.22639; DiFeliceantonio, A. G., Coppin, G., Rigoux, L., Edwin Thanarajah, S., Dagher, A., Tittgemeyer, M., & Small, D. M. (2018). Supra-Additive Effects of Combining Fat and Carbohydrate on Food Reward. *Cell Metabolism., 28*(1), 33–44.e3. https://doi.org/10.1016/j.cmet.2018.05.018; Small, D. M., & DiFeliceantonio, A. G. (2019). Processed foods and food reward. *Science, 363*(6425), 346–347. https://doi.org/10.1126/science.aav0556

63. Rolls, B. J., Rolls, E. T., Rowe, E. A., & Sweeney, K. (1981). Sensory specific satiety in man. *Physiology & behavior, 27*(1), 137–142. https://doi.org/10.1016/0031-9384(81)90310-3

64. Fazzino, T. L., Rohde, K., & Sullivan, D. K. (2019). Hyper-Palatable Foods: Development of a Quantitative Definition and Application to the US Food System Database. *Obesity* (*Silver Spring, Md.*), 27(11), 1761–1768. https://doi.org/10.1002/oby.22639

65. Gordon, E. L., Ariel-Donges, A. H., Bauman, V., & Merlo, L. J. (2018). What Is the Evidence for "Food Addiction?" A Systematic Review. *Nutrients, 10*(4), 477. https://doi.org/10.3390/nu10040477

66. Gordon, E. L., Ariel-Donges, A. H., Bauman, V., & Merlo, L. J. (2018). What Is the Evidence for "Food Addiction?" A Systematic Review. *Nutrients, 10*(4), 477. https://doi.org/10.3390/nu10040477

67. https://restructureproject.org

68. Hansard, HC Deb, 21 June 2023, vol 734, cols. 384-400. https://hansard.parliament.uk/commons/2023-06-21/debates/E86A4BD8-C101-4C7E-B893-8AB8FB248270/Ultra-ProcessedFood#main-content

69. van Tulleken, C. (2023). Ultra-processed people: Why do we all eat stuff that isn't food… and why can't we stop?. Cornerstone Press; Moss, M. (2021). Hooked: Food, free will, and how the food giants exploit our addictions. Random House.

70. Khoury, C. K., Bjorkman, A. D., Dempewolf, H., Ramirez-Villegas, J., Guarino, L., Jarvis, A., Rieseberg, L. H., & Struik, P. C. (2014). Increasing homogeneity in global food supplies and the implications for food security. *Proceedings of the National Academy of Sciences of the United States of America, 111*(11), 4001–4006. https://doi.org/10.1073/pnas.1313490111

71. World Health Organization. (2021). Fact sheet: Infant and young child feeding. *World Health Organization*, https://www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding

72. World Health Organization & United Nations Children's Fund (‍ UNICEF)‍ . (2022). Global breastfeeding scorecard 2022: protecting breastfeeding through further investments and policy actions. https://iris.who.int/bitstream/handle/10665/365140/WHO-HEP-NFS-22.6-eng.pdf?sequence=1 Hernández-Cordero, S. & Pérez-Escamilla, R. (2022). What will it take to increase breastfeeding?. *Maternal & child nutrition, 18 Suppl 3*(Suppl 3), e13371. https://doi.org/10.1111/mcn.13371

73. Rollins, N. C., Bhandari, N., Hajeebhoy, N., Horton, S., Lutter, C. K., Martines, J. C., Piwoz, E. G., Richter, L. M., & Victora, C. G. (2016). Why invest, and what it will take to improve breastfeeding practices?. *Lancet, 387*(10017), 491–504. https://doi.org/10.1016/S0140-6736(15)01044-2

74. Karlsson, J. O., Garnett, T., Rollins, N. C., & Röös, E. (2019). The carbon footprint of breastmilk substitutes in comparison with breastfeeding. *Journal of cleaner production, 222*, 436–445. https://doi.org/10.1016/j.jclepro.2019.03.043; Andresen, E. C., Hjelkrem, A.-G. R., Bakken, A. K., & Andersen, L. F. (2022). Environmental Impact of Feeding with Infant Formula in Comparison with Breastfeeding. *International Journal of Environmental Research and Public Health, 19*(11), 6397. https://doi.org/10.3390/ijerph19116397

75. Victora, C. G., Bahl, R., Barros, A. J., França, G. V., Horton, S., Krasevec, J., Murch, S., Sankar, M. J., Walker, N., & Rollins, N. C. (2016). Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet, 387*(10017), 475–490. https://doi.org/10.1016/S0140-6736(15)01024-7

76. World Health Organization. (2021). Fact sheet: Infant and young child feeding. *World Health Organization*, https://www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding

77. Pérez-Escamilla, R., Tomori, C., Hernández-Cordero, S., Baker, P., Barros, A. J. D., Bégin, F., Chapman, D. J., Grummer-Strawn, L. M., McCoy, D., Menon, P., Ribeiro Neves, P. A., Piwoz, E., Rollins, N., Victora, C. G., & Richter, L. (2023). Breastfeeding: crucially important, but increasingly challenged in a market-driven world. *Lancet, 401*(10375), 472–485. https://doi.org/10.1016/S0140-6736(22)01932-8

78. The Lancet. (2023). Unveiling the predatory tactics of the formula milk industry. *Lancet, 401*(10375), 409. https://doi.org/10.1016/S0140-6736(23)00118-6; Rollins, N., Piwoz, E., Baker, P., Kingston, G., Mabaso, K. M., McCoy, D., Ribeiro Neves, P. A., Pérez-Escamilla, R., Richter, L., Russ, K., Sen, G., Tomori, C., Victora, C. G., Zambrano, P., & Hastings, G. (2023). Marketing of commercial milk formula: a system to capture parents, communities, science, and policy. *Lancet, 401*(10375), 486–502. https://doi.org/10.1016/S0140-6736(22)01931-6; Save the Children. (2018). Don't push it: Why the formula milk industry must clean up its act. *Save the Children,* https://www.savethechildren.org.uk/content/dam/gb/reports/health/dont-push-it.pdf

79. World Health Organization. (2022). How the marketing of formula milk influences our decisions on infant feeding. *World Health Organization*, https://iris.who.int/bitstream/handle/10665/352098/9789240044609-eng.pdf?sequence=1; Koletzko, B., & Shamir, R. (2006). Standards for infant formula milk. *BMJ* (*Clinical research ed.*), *332*(7542), 621–622. https://doi.org/10.1136/bmj.332.7542.621

80. Nordhagen, S. & Demmler, K. M. (2023). How do food companies try to reach lower-income consumers, and do they succeed? Insights from a systematic review. *Global Food Security, 37*, 100699. https://doi.org/10.1016/j.gfs.2023.100699; Payaud, M. A. Marketing Strategies at the Bottom of the Pyramid: Examples From Nestlé, Danone, and Procter & Gamble. *Global Business and Organizational Excellence, 33*(2), 51–63. https://doi.org/10.1002/joe.21533

81. Prahalad, C. K. (2004). *The fortune at the bottom of the pyramid: Eradicating poverty through profits.* Wharton School Publishing.

82. Errington, F., Fujikura, T., & Gewertz, D. (2012). Instant noodles as an antifriction device: making the BOP with PPP in PNG. *American anthropologist, 114*(1), 19–31. https://doi.org/10.1111/j.1548-1433.2011.01394.x

83. Sasson, T. (2016). Milking the Third World? Humanitarianism, Capitalism, and the Moral Economy of the Nestlé Boycott. *The American Historical Review, 121*(4), 1196–1224. http://www.jstor.org/stable/43955957

84. Stevens, E. E., Patrick, T. E., & Pickler, R. (2009). A history of infant feeding. *The Journal of perinatal education, 18*(2), 32–39. https://doi.org/10.1624/105812409X426314. Wet nursing has had many ebbs and flows in social status. Further reading worth exploring, with regard to wet nursing, race, and slavery, see Roth C. (2018). Black Nurse, White Milk: Breastfeeding, Slavery, and Abolition in 19th-Century Brazil. *Journal of human lactation : official journal of International Lactation Consultant Association, 34*(4), 804–809. https://doi.org/10.1177/0890334418794670; West, E., & Knight, R.J. (2017). Mothers' Milk: Slavery, Wet-Nursing, and Black and White Women in the Antebellum South. *Journal of Southern History 83*(1), 37-68. https://doi.org/10.1353/soh.2017.0001

85. Peringer, A. (2021). The history of baby bottles. Alimentarium. https://www.alimentarium.org/en/story/history-baby-bottles

86. Cevasco, C. (2020). "Look'd Like Milk": Colonialism and Infant Feeding in the English Atlantic World. *Journal of Early American History, 10*(2-3), 147-178. https://doi.org/10.1163/18770703-10020009

87. Obladen, M. (2014). Pap, Gruel, and Panada: Early Approaches to Artificial Infant Feeding. *Neonatology, 105*(4), 267–274. https://doi.org/10.1159/000357935

88. Levenstein, H. (1983). "Best for Babies" or "Preventable Infanticide"? The Controversy over Artificial Feeding of Infants in America, 1880-1920. *The Journal of American History, 70*(1), 75–94. https://doi.org/10.2307/1890522

89. Ahern, G. J., Hennessy, A. A., Ryan, C. A., Ross, R. P., & Stanton, C. (2019). Advances in Infant Formula Science. *Annual review of food science and technology, 10*, 75–102. https://doi.org/10.1146/annurev-food-081318-104308

90. Gossner, C. M., Schlundt, J., Ben Embarek, P., Hird, S., Lo-Fo-Wong, D., Beltran, J. J., Teoh, K. N. & Tritscher, A. (2009). The melamine incident: implications for international food and feed safety. *Environmental health perspectives, 117*(12), 1803–1808. https://doi.org/10.1289/ehp.0900949

91. El Congreso de Colombia (2022). Ley 2277. Colombia, https://acmineria.com.co/sitio/wp-content/uploads/2023/05/LEY-2277-DE-13-DE-DICIEMBRE-DE-2022.pdf

92. Rollins, N. C., Bhandari, N., Hajeebhoy, N., Horton, S., Lutter, C. K., Martines, J. C., Piwoz, E. G., Richter, L. M., & Victora, C. G. (2016). Why invest, and what it will take to improve breastfeeding practices?. *Lancet, 387*(10017), 491–504. https://doi.org/10.1016/S0140-6736(15)01044-2; Tomori, C., Hernández-Cordero, S., Busath, N., Menon, P., & Pérez-Escamilla, R. (2022). What works to protect, promote and support breastfeeding on a large scale: A review of reviews. *Maternal & Child Nutrition, 18*(S3), e13344. https://doi.org/10.1111/mcn.13344

93. FAO and WHO. (2019). Sustainable healthy diets: Guiding Principles. *FAO and WHO.* https://iris.who.int/bitstream/handle/10665/329409/9789241516648-eng.pdf?sequence=1

94. Benton, T. G., Bieg, C., Harwatt, H., Pudasaini, R., & Wellesley, L. (2021). Food system impacts on biodiversity loss: Three levers for food system transformation in support of nature. Chatham House.; Poore, J. & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science, 360*(6392), 987–992, https://doi.org/10.1126/science.aaq0216; Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Liep, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food, 2*, 198–209, https://doi.org/10.1038/s43016-021-00225-9

95. da Silva, J. T., Garzillo, J. M. F., Rauber, F., Kluczkovski, A., Rivera, X. S., da Cruz, G. L., Frankowska, A., Martins, C. A., da Costa Louzada, M. L., Monteiro, C. A., Reynolds, C., Bridle, S., & Levy, R. B. (2021). Greenhouse gas emissions, water footprint, and ecological footprint of food purchases according to their degree of processing in Brazilian metropolitan areas: a time-series study from 1987 to 2018. *The Lancet. Planetary health, 5*(11), e775–e785. https://doi.org/10.1016/S2542-5196(21)00254-0

96. Garzillo, J. M. F., Poli, V. F. S., Leite, F. H. M., Steele, E. M., Machado, P. P., Louzada, M. L. D. C., Levy, R. B., & Monteiro, C. A. (2022). Ultra-processed food intake and diet carbon and water footprints: a national study in Brazil. *Revista de saude publica, 56*, 6. https://doi.org/10.11606/s1518-8787.2022056004551

97. Vellinga, R. E., van Bakel, M., Biesbroek, S., Toxopeus, I. B., de Valk, E., Hollander, A., van 't Veer, P., & Temme, E. H. M. (2022). Evaluation of foods, drinks and diets in the Netherlands according to the degree of processing for nutritional quality, environmental impact and food costs. *BMC Public Health, 22*(1), 877. https://doi.org/10.1186/s12889-022-13282-x

98. da Silva, J. T., Garzillo, J. M. F., Rauber, F., Kluczkovski, A., Rivera, X. S., da Cruz, G. L., Frankowska, A., Martins, C. A., da Costa Louzada, M. L., Monteiro, C. A., Reynolds, C., Bridle, S., & Levy, R. B. (2021). Greenhouse gas emissions, water footprint, and ecological footprint of food purchases according to their degree of processing in Brazilian metropolitan areas: a time-series study from 1987 to 2018. *The Lancet. Planetary health, 5*(11), e775–e785. https://doi.org/10.1016/S2542-5196(21)00254-0; Garzillo, J. M. F., Poli, V. F. S., Leite, F. H. M., Steele, E. M., Machado, P. P., Louzada, M. L. D. C., Levy, R. B., & Monteiro, C. A. (2022). Ultra-processed food intake and diet carbon and water footprints: a national study in Brazil. *Revista de saude publica, 56*, 6. https://doi.org/10.11606/s1518-8787.2022056004551; Vellinga, R. E., van Bakel, M., Biesbroek, S., Toxopeus, I. B., de Valk, E., Hollander, A., van 't Veer, P., & Temme, E. H. M. (2022). Evaluation of foods, drinks and diets in the Netherlands according to the degree of processing for nutritional quality, environmental impact and food costs. *BMC Public Health, 22*(1), 877. https://doi.org/10.1186/s12889-022-13282-x

99. Hadjikakou, M. (2017). Trimming the excess: environmental impacts of discretionary food consumption in Australia. *Ecological Economics 131* 119–128. https://doi.org/10.1016/j.ecolecon.2016.08.006; Seferidi, P., Scrinis, G., Huybrechts, I., Woods, J., Vineis, P., & Millett, C. (2020). The neglected environmental impacts of ultra-processed foods. *The Lancet. Planetary health, 4*(10), e437–e438. https://doi.org/10.1016/S2542-5196(20)30177-7

100. Garzillo, J. M. F., Poli, V. F. S., Leite, F. H. M., Steele, E. M., Machado, P. P., Louzada, M. L. D. C., Levy, R. B., & Monteiro, C. A. (2022). Ultra-processed food intake and diet carbon and water footprints: a national study in Brazil. *Revista de saude publica, 56*, 6. https://doi.org/10.11606/s1518-8787.2022056004551; Kesse-Guyot, E., Allès, B., Brunin, J., Fouillet, H., Dussiot, A., Berthy, F., Perraud, E., Hercberg, S., Julia, C., Mariotti, F., Deschasaux-Tanguy, M., Srour, B., Lairon, D., Pointereau, P., Baudry, J., & Touvier, M. (2023). Environmental impacts along the value chain from the consumption of ultra-processed foods. *Nature Sustainability, 6* 192–202. https://doi.org/10.1038/s41893-022-01013-4

101. Anastasiou, K., Baker, P., Hadjikakou, M., Hendrie, G.A., & Lawrence, M. (2022). A conceptual framework for understanding the environmental impacts of ultra-processed foods and implications for sustainable food systems. *Journal of Cleaner Production, 368*, https://doi.org/10.1016/j.jclepro.2022.133155; Anastasiou, K., Baker, P., Hendrie, G. A., Hadjikakou, M., Boylan, S., Chaudhary, A., Clark, M., DeClerck, F. A. J., Fanzo, J., Fardet, A., Leite, F. H. M., Mason-D'Croz, D., Percival, R., Reynolds, C., & Lawrence, M. (2023). Conceptualising the drivers of ultra-processed food production and consumption and their environmental impacts: A group model-building exercise. *Global Food Security, 37,* 100688. https://doi.org/10.1016/j.gfs.2023.100688; Leite, F. H. M., Khandpur, N., Andrade, G. C., Anastasiou, K., Baker, P., Lawrence, M., & Monteiro, C. A. (2022). Ultra-processed foods should be central to global food systems dialogue and action on biodiversity. *BMJ global health, 7*(3), e008269. https://doi.org/10.1136/bmjgh-2021-008269

102. Scarborough, P., Clark, M., Cobiac, L., Papier, K., Knuppel, A., Lynch, J., Harrington, R., Key, T., & Springmann, M. (2023). Vegans, vegetarians, fish-eater and meat-eater in the UK show discrepant environmental impacts. *Nature Food 4* 565–574. https://doi.org/10.1038/s43016-023-00795-w

103. Ritchie, H. (2021). If the world adopted a plant-based diet we would reduce global agricultural land use from 4 to 1 billion hectares. *Our World in Data*. https://ourworldindata.org/land-use-diets

104. Cusworth, G., Garnett, T., & Lorimer, J. (2021). Legume dreams: The contested futures of sustainable plant-based food systems in Europe. *Global environmental change : human and policy dimensions, 69,* 102321. https://doi.org/10.1016/j.gloenvcha.2021.102321

105. Lagally, C., Clayton, E. R., & Specht, L. (2017). Plant-based Meat Mind Maps: An Exploration of Options, Ideas, and Industry. *The Good Food Institute*.

106. Specht, L. (2024). The science of fermentation. Good Food Institute. https://gfi.org/science/the-science-of-fermentation/

107. Martinez, H., Pachón, H., Kancherla, V., & Oakley, G. P. (2021). Food Fortification With Folic Acid for Prevention of Spina Bifida and Anencephaly: The Need for a Paradigm Shift in Evidence Evaluation for Policy-Making. *American journal of epidemiology, 190*(10), 1972–1976. https://doi.org/10.1093/aje/kwab061

108. Kimura, A. H. (2013). Hidden Hunger: Gender and the Politics of Smarter Foods. Cornell University Press.

109. Kroker-Lobos, M. F., Mazariegos, M., Guamuch, M., & Ramirez-Zea, M. (2022). Ultraprocessed Products as Food Fortification Alternatives: A Critical Appraisal from Latin America. *Nutrients, 14*(7), 1413. https://doi.org/10.3390/nu14071413

110. Woodall, C. (2020). Fake Meat Claims. NCBA. https://www.ncba.org/ncba-news/news-releases/news/details/26008/fake-meat-claims; Consumer Freedom. (2019). What's in Plant-Based Meat. Youtube. https://www.youtube.com/watch?v=0qFa-E6yw1g

111. ETC Group. (2022). Food Barons: Crisis Profiteering, Digitalization and Shifting Power. ETC Group, https://www.etcgroup.org/files/files/food-barons-2022-full_sectors-final_16_sept.pdf

112. Makalintal, B. (2020). Big Meat Is Selling Veggie Burgers—But It's Still Destroying the Environment. Vice, https://www.vice.com/en/article/pkynky/big-meat-is-selling-veggie-burgers-but-its-not-because-they-care-about-you

113. Anderson, M., Clapp, J., Guttal, S., Paskal, A. & Monsalve Suárez, S. (2023). Who's Tipping the Scales? The growing influence of corporations on the governance of food systems, and how to counter it. IPES-Food. http://www.ipes-food.org/_img/upload/files/tippingthescales.pdf

114. Holmes, D., Humbird, D., Dutkiewicz, J., Tejeda-Saldana, Y., Duffy, B. & Datar, I. (2022). Cultured meat needs a race to mission not a race to market. *Nature Food 3,* 785–787. https://doi.org/10.1038/s43016-022-00586-9; Dutkiewicz, J. (2019). Socialize Lab Meat. Jacobin, https://jacobin.com/2019/08/lab-meat-socialism-green-new-deal

115. Howard, P. (2022). The Politics of Protein: Examining claims about livestock, fish, 'alternative proteins', and sustainability. IPES-Food, https://www.ipes-food.org/_img/upload/files/PoliticsOfProtein.pdf; Cresswell, J. (2023). Plant-Based Food Companies Face Critics: Environmental Advocates. The New York Times, https://www.nytimes.com/2021/10/15/business/beyond-meat-impossible-emissions.html