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Which Are the Links between Excess Ultra-Processed Food Consumption and Food System Sustainability?

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Abstract: Global food systems are no longer sustainable for health, the environment, animal biodiversity and wellbeing, culinary traditions, socioeconomics, or small farmers. The increasing massive consumption of animal foods has been identified as a major determinant of unsustainability. However, today, the increasing consumption of ultra-processed foods (UPFs) worldwide is also questioned. Up today, more than 40 epidemiological studies have shown that excess UPF consumption significantly increase the risks of several chronic diseases and all-cause mortality. Concerning the other dimensions of sustainability, we attempted, based on the collection of scattered data from scientific literature, to build the interrelations between massive UPF consumption and impacts on food systems. For this, we first identified the main ingredients/additives present in UPFs and the agricultural practices involved in their provision to agro-industrials. Overall, UPF production is analyzed regarding its impacts on the environment, biodiversity, animal wellbeing, and cultural and socio-economic dimensions. Our main conclusion is that UPFs are associated with intensive agriculture/livestock and threaten all dimensions of food system sustainability due to the combination of low-cost ingredients at purchase and increased consumption worldwide. However, plant-based UPFs do not produce the highest greenhouse gas emissions (GHGEs) compared to conventional meat and dairy products. In addition, only reducing energy-dense UPF consumption (associated with excess calorie intakes), without substitution, might substantially reduce GHGEs. Therefore, significant improvement in food system sustainability requires urgently encouraging limiting UPF consumption to the benefit of mildly processed foods, preferably seasonal, organic and local products, a recommendation that we formalized in the concept of the 3V-based diet for Végétal (Plant), Vrai (Real foods), Varié (Varied, preferably organic, local and seasonal - when possible).

Keywords: Ultra-processed foods; animal calories; food systems; sustainability; human health

1. Introduction

In theory, sustainable food systems should protect the three dimensions of life on earth, that are human health, animal biodiversity and welfare, and environment. Yet, today, food system sustainability are threatened by excess animal and ultra-processed food (UPF) calories (Figure 1), especially in Western countries, and more and more in emerging countries where animal products and UPFs are external signs of wealth (Fardet & Rock, 2018).

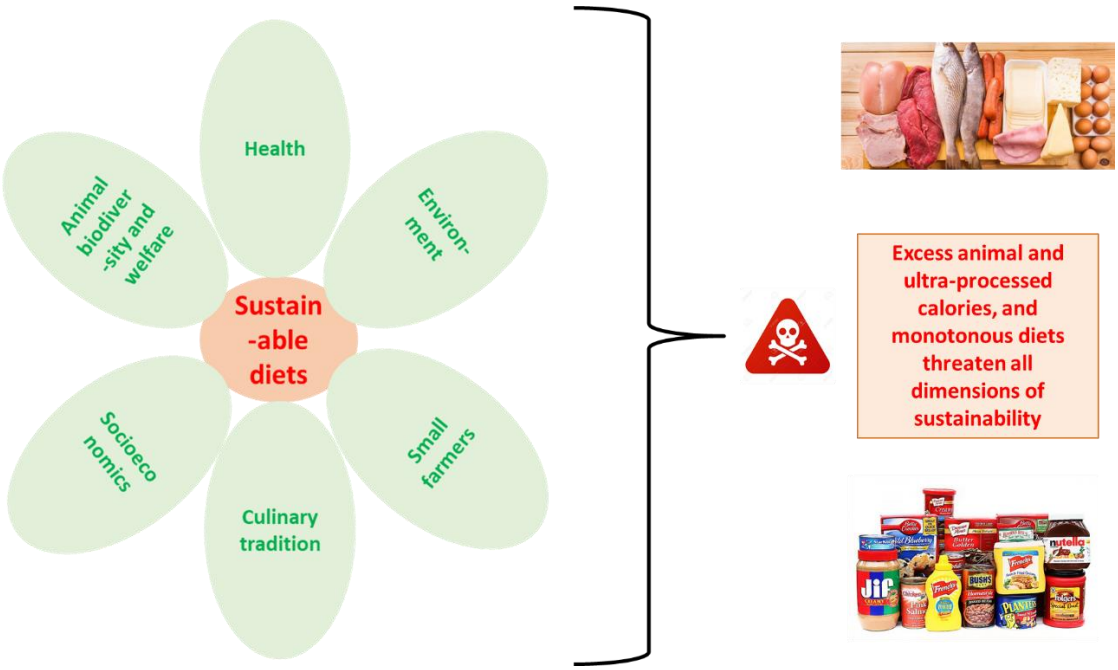
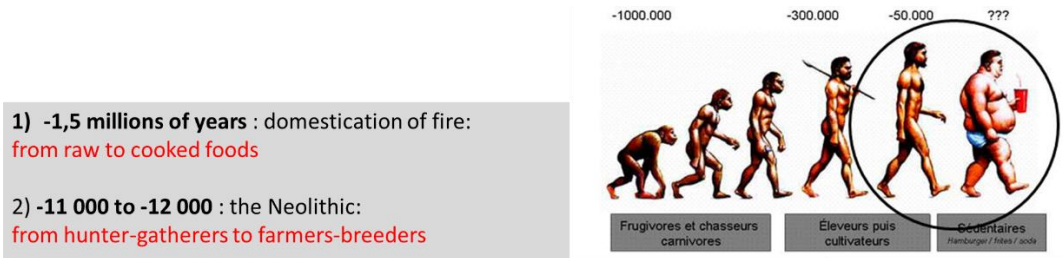


Figure 1. The different dimensions of food systems as threatened by excess animal and ultra-processed calories.

Before this last dramatic nutritional transition, which especially amplified after the second world war, humanity faced three main other nutritional transitions (Figure 2): 1) from raw to cooked foods with the domestication of fire (more than 1,000,000 years ago), 2) from Paleolithic to Neolithic with the replacement of hunter-gatherer by farmer-breeder and the consumption of cereals, dairy products and farmed meat at large scale, and 3) from traditional to industrial foods with the invention of the steam engine, and the first industrial food, i.e., tinned goods in 1795 with canning/appertisation process. The last transition occurred in the 50's after the Second World War and culminated in the 80's with the advent of marketing, big agro-food multinationals and the hyper-technology applied to our foods. This last transition has been largely ignored while it is crucial because it marks the passage of 'real' to 'fake' foods, of 'normally processed' foods to UPFs; which is concomitant with the worldwide explosions of the prevalence of chronic diseases that progressively substituted to infectious and deficiency diseases.



1) **-1,5 millions of years** : domestication of fire:
from raw to cooked foods

2) **-11 000 to -12 000** : the Neolithic:
from hunter-gatherers to farmers-breeders

3) **XVIIIth century** : invention of the steam engine: appearance of the first industrial foods:
from traditional to industrial foods

4) **Years 50-80** :
from processed to ultra-processed: Concomitant with the explosion of chronic disease prevalence and the decline or stagnation of life expectancy in good health (healthy life years)

5) **Today (in progress)** :
Towards sustainable diets that protects both health and the planet

Figure 2. The five nutritional transitions that faced humanity.

In this article, the link between excessive UPF consumption and food system sustainability will be explored - beyond the excess animal-based food consumption. We will then propose a simple, qualitative, scientific and holistic rule to counteract the degradation of food system sustainability. This rule for protecting both human health and planet is based on the observation - in scientific literature - that complex human diets own three main important dimensions: the plant/animal-based food ratio, the degree of processing, and the diversity (Fardet & Rock, 2018, 2020).

2. Ultra-processed Foods and Food System Sustainability

2.1. Definition: How to Identify Them?

Ultra-processed foods have been first defined around the year 2010 by Brazilian epidemiologist *via* the NOVA classification (Monteiro, 2010; Monteiro, 2009), then in 2014 in the Brazilian Dietary Guidelines (Ministry of Health of Brazil, 2014) and through comparison with other classifications (Moubarac et al., 2014). To summarize, UPFs are characterized in their formulation by the addition of cosmetic ingredients and/or additives for primarily industrial use - and having undergone an excessive processing - to mimic, exacerbate, mask or restore sensory properties (aroma, texture, taste and color). It can also be very denaturing technological processes directly applied to original food (extrusion-cooking, puffing, extreme refining ...)". As stated by Monteiro et al.: "*Generally, the practical way to identify if a product is ultra-processed is to check to see if its list of ingredients contains at least one item characteristic of the UPF group, which is to say, either food substances never or rarely used in kitchens, or classes of additives whose function is to make the final product palatable or more appealing ('cosmetic additives').*" (Monteiro et al., 2019). They added: "*Food substances not used in kitchens appear in the beginning or in the middle of the lists of ingredients of UPFs. These include hydrolysed proteins, soya protein isolate, gluten, casein, whey protein, 'mechanically separated meat', fructose, high-fructose corn syrup, 'fruit juice concentrate', invert sugar, maltodextrin, dextrose, lactose, soluble or insoluble fibre, hydrogenated or interesterified oil; and also other sources of protein, carbohydrate or fat which are neither foods from NOVA group 1 or group 3, nor culinary ingredients from NOVA group 2. The presence in the list of ingredients of one or more of these food substances identifies a product as ultra-processed… Cosmetic additives include flavours, flavor enhancers, colours, emulsifiers, emulsifying salts, sweeteners, thickeners, and anti-foaming, bulking, carbonating, foaming, gelling and glazing agents*." (Monteiro et al., 2019).

Say it differently, UPFs are the symbol of the artificialization of our foods through cosmetic ingredients and/or additives, to notably exacerbate organoleptic food properties that are color, aroma, taste and texture (Fardet, 2019; Fardet & Rock, 2019). This is very profitable for three reasons: 1) one can continue to eat the food because pleasure overcome satiety; 2) one redeem the product; 3) and, if children are targeted very young, they can become customers for life, with the dramatic consequence of keeping them away of the more subtle organoleptic properties of real/homemade traditional foods.

More generally, UPFs importantly developed worldwide for three main reasons: 1) hyperstandardized and easy-to-access sensory attributes; 2) low cost due to the replacement of real foods by artifices such as aromas; and 3) very practical and keep very long. Finally, agro-food industry has taken over from mothers who, in the old days, cooked at home. Foods at very low cost and time saving have also greatly contributed to increase the offer of UPFs.

2.2. Worldwide Consumption and Sale Growth Rates

Consumption of UPFs is high in Western countries, especially Anglo-Saxon ones with 307 kg/year per capita in USA, followed by Canada (230 kg), Germany 219 kg), Mexico (214 kg), Belgium (210 kg), Australia, Norway and UK (>200 kg/year) (Pan American Health Organization, 2015). Conversely, it is still low in India (7 kg), some African, South-America and Asian countries (<100 kg) (Pan American Health Organization, 2015). However, the growth rate of sales is very huge in emerging countries with 115% increase in sales between 2000 and 2013 for Asian and Pacific regions, 71% in Middle East and Africa, and 73% in Eastern Europe (Pan American Health Organization,

2015). Overall, the world growth is of 44% during this period. Finally, the market share of UPFs is the highest in Asian and Pacific countries with 29.2%.

In France, the consumption of daily ultra-processed calories is almost of 40% (Julia et al., 2018), with 71% of packaged foods in large and medium-sized stores (Frank et al., 2018), and around 27% in organic stores (Desquilbet et al., 2018).

In emerging countries such as India, China, and some South-American countries, these foods progressively substitutes to real foods with increasing prevalence of overweight, obesity, type 2 diabetes and hepatic steatosis (called the "disease of sodas").

2.3. Ultra-processed Foods and Human Health

The issue of UPF consumption and human health has been recently reviewed (Elizabeth et al., 2020; FAO et al., 2019; Fardet & Rock, 2019). Today, more than 45 epidemiological studies have been carried out since the year 2010, and they showed a significant increased risk of overweight, obesity, adiposity, metabolic syndrome, type 2 diabetes, hypertension, hypercholesterolemia, total and breast cancers, cardiovascular diseases, irritable bowel syndrome and functional dyspepsia, asthma and wheezing, frailty, depression and mortality. To establish a causal relationship established by the latter epidemiological studies, current research focuses on additives (alone or in cocktail) featuring ultra-processed products. Another explanation behind this negative health impact can consider first the artificialization of food matrices as primary cause, leading people to consume more calories, salt, sugars, saturated fats and additives than necessary, then affecting the physiology (overweight), before resulting in more severe diseases Indeed, hyper-attractive, hyper-addictive and rapidly eaten foods prompt consumers to consume beyond their real caloric and nutrional needs (Hall et al., 2019). Moreover, to approach causal links, four characteristics of these foods have been identified as being deleterious to health (Figure 3) (Fardet & Rock, 2019):

1) "empty" calories, devoid of protective micronutrients for preventing chronic diseases, *i.e.*, fiber, vitamins, minerals, and antioxidants;

2) hyperglycaemic foods;

3) Poorly satiating foods;

4) the presence of numerous xenobiotics such as neoformed compounds, synthetic additives, ultra-processed ingredients (*e.g.*, invert sugars, glucose-fructose syrup, hydrolyzed protein, hydrogenated oils…), and potential migrating compounds from packaging.

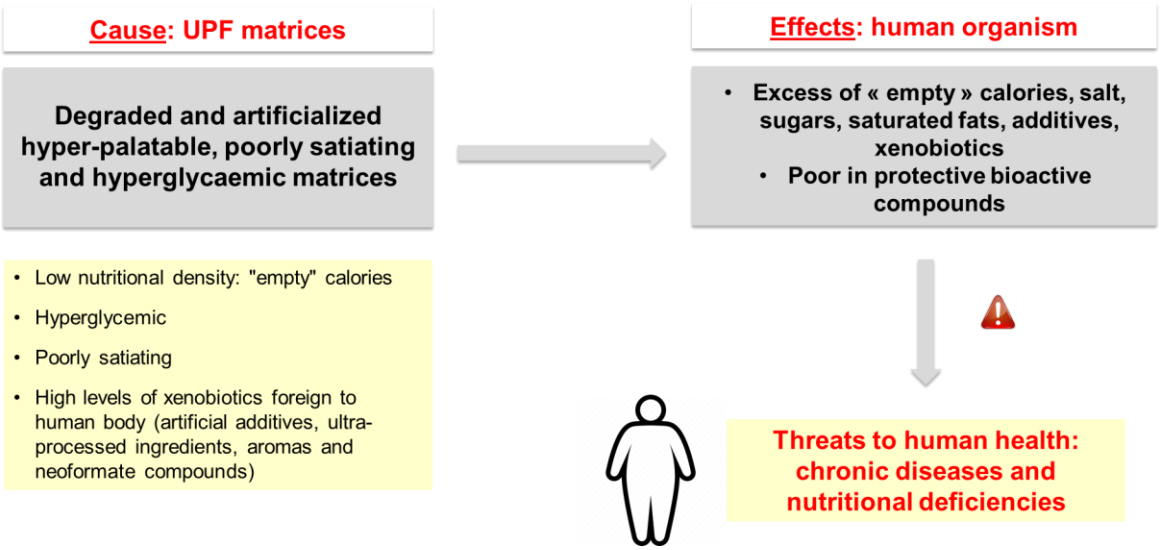


Figure 3. Ultra-processed food characteristics that are deleterious to human health.

This cocktail, when regularly and highly consumed, makes the bed of metabolic deregulations (weight gain, insulino-resistance, metabolic syndrome and hepatic steatosis), leading to more serious

and/or fatal chronic diseases such as NASH, type 2 diabetes, cardiovascular diseases and some cancers.

2.4. Ultra-processed Foods and Animal Well-being and Biodiversity

Due to interrelated low cost and massive consumption through the economy of scale, animal calories from UPFs come from intensive livestock where animals are raised in extreme conditions, not always respectful of their fundamental needs and wellbeing, and therefore are associated with animal suffering.

In France, 82% of animals are raising intensively, notably the chicken, rabbits and pigs (more than 90%), while cattle is only 15% (Amis de la Terre Europe (Friends of the Earth Europe), 2015).

In the 1960s to 1970s, people began to pay attention to the animal welfare in intensive breeding, after livestock and poultry husbandry changed from extensive range to intensive animal husbandry (Weary & Fraser, 1999). According to Li et al. "*animals' living environment, quality of life and behavior need are far from satisfied, and animal welfare haven't been improved fundamentally*" (page 284) (Li et al., 2015). In intensive livestock and poultry breeding, animal welfare is not guaranteed, affecting the quality of the animal products (Li et al., 2015). For example, sows in intensive pig farms are often confined in cages (sow stalls) that are a little bigger than their body (Caulfield & Cambridge, 2008).

Behind this situation, there is the idea of refusing to sanction change unless supported by scientific evidence (Caulfield & Cambridge, 2008). Yet, "*the criteria for assessing welfare should not be restricted to consideration of scientific evidence alone, but should be widened to encompass moral and ethical considerations*" (page 446) (Caulfield & Cambridge, 2008). As stated by the AVMA (American Veterinary Medical Association) Task Force, more science is not going to resolve the issue (Caulfield & Cambridge, 2008). Since the management of farm animals must take into account their physiological, social and behavioral needs, organic systems are probably a relevant solution for optimal welfare (Gade, 2002).

For example, by 1999 on can find some description of the potential causes of suffering for turkey broilers in intensive conditions: 1) genetic selection of fast growing strains has increased locomotory problems, and made natural mating impossible; 2) high stocking densities have several drawbacks such as poor air quality, cannibalism and impairment of the gait of the birds; 3) A range of different photoperiods are used in practice, and have many consequences for welfare; 4) transport and slaughter are further causes of poor animal welfare (Martrenchar, 1999).

More science has been developed to improve animal farming in these intensive conditions. However, one can also consider that animal welfare is more an ethical issue than a scientific one: it is easy to know whether animals are suffering or not. The idea behind more science may well be to always move back the time for the adoption of more restrictive measures for breeders, which many do not wish…

2.5. Ultra-processed Foods and Environment: Pollution, Deforestation, Greenhouse Gaz Emissions…

Excess UPF consumption is threatening environment through mainly pollution, deforestation, greenhouse gas emissions. These are over packaged foods, especially sodas, leading to plastic pollution in oceans, or the deforestation for providing more soy for animal feeding and cheapest animal calories, notably in Western Europe. As stated in the 2014 Brazilian Dietary Guidelines: "*The need for cheap oils, sugar and other raw materials for UPFs creates monocultures and farms producing for export and not for local consumption. Intensive farming of raw materials is dependent on pesticides and intensive use of fertilizers and water. The manufacture and distribution of most UPFs involves long transport routes, and thus excess use of non-renewable energy and water, and emission of pollutants. This all results in environmental degradation and pollution, loss of biodiversity, and draining and loss of water, energy and other natural resources. Production and consumption also cause creation of vast amounts of waste and garbage, dumped in disgusting and dangerous landfill sites. Overall, UPFs are a serious threat to the sustained survival of the planet*" (Ministry of Health of Brazil, 2014).

Today, it is also more profitable to sell the isolated ingredients of the foods than the original complex raw food. A few foods, cultivated in intensive conditions, are then cracked in many isolated

ingredients and nutrients, and are recombined worldwide into the form of UPFs. They are mainly soy, pea, wheat, maize, rice, potatoes, milk, eggs and meats. It is easy to guess that this is largely more energy-consuming than the original raw food locally produced and consumed.

2.6. Ultra-processed Foods and Socioeconomics

In theory, sustainable socioeconomics corresponds to food systems that allow all the actors of the agro-food value chain to decently live from their work; but also to supply to everyone foods of high quality whatever one's level of salary or education, and to preserve social life. With UPFs, this dimension of sustainability is not achieved. The poorest and less educated are the highest consumers of UPFs, which are very cheap calories. In USA, UPFs are almost 62% less expensive than un/minimally-processed fresh foods (Gupta et al., 2019).

Concerning the agri-food value chain, in France for example, upon 100 euros the farmer only get 6% while mass retail and industry takes the highest share. This disproportion does not allow farmers to make a decent living, resulting in a continuous decrease of the number of farmers and increased suicide level.

Due to their very low price and high attractiveness, it is observed that UPFs substitute to local and traditional foods, especially in emerging and developing countries, threatening small farmers, who are then obliged 'to put the key under the door' and to move to urban areas feeding the slums. For example, in Africa, it has been observed that the importation of chicken wings destroys local companies (Amis de la Terre Europe (Friends of the Earth Europe), 2015). Indeed, the processing of slaughtering by-products into animal feed is prohibited for European poultry companies, but allowed to cheaply export them to the developing countries. This is only one example among others, *e.g.*, excess milk in Europe first dried and then exported to Africa where it is sold cheaper than local milk.

As reported by Johnston et al. the reason lies in the fact that "current government subsidies to farmers in the United States and parts of Europe enable developed countries to produce large quantities of cheap staple and UPFs at 40–60% below the cost of local production of similar goods in developing markets (Action Aid, 2002) ". In turn, these less healthy foods as imports are considerably less expensive than the locally produced foods, distorting local markets and depressing demand for the more expensive, locally produced, and often times healthier food options (Affairs, 2011) " (Johnston et al., 2014).

As written in 2005 in the journal Revue Tiers Monde: "How many countries have paid a heavy price for having sacrificed, if not more, their peasants on the pretext of providing sufficient basis for industrial development by imposing leonine terms of exchange on peasants without impelling the modernization of their agriculture? How many countries are experiencing stagnation, a social regression, even a break in their social cohesion, for having simultaneously precipitated this modernization of their agriculture, expelled the poorest and least protected peasants, finally surrounded the cities of shantytowns where they are crammed together, forced to sell their labor power for misery income in informal activities of strict survival?" (Unknown, 2005).

Finally, as stated in the Brazilian Dietary Guidelines: "Ultra-processed foods are formulated and packaged to be ready-to-consume without any preparation. This makes meals and sharing of food at table unnecessary. Ultra-processed foods can be consumed anytime, anywhere, often when being entertained or when working, walking in a street, driving, or talking on a phone. These are mostly isolated situations, which are disguised by advertisements suggesting that such products promote social interaction, which they do not" (Ministry of Health of Brazil, 2014).

2.7. Ultra-processed Foods, Culture and Culinary Traditions

As stated in the Brazilian Dietary Guidelines: "Brands, packages, labels, and the contents of UPFs tend to be identical throughout the world. A type of soft drink made by one giant manufacturer is essentially the same the world over. Types of burger made by various manufacturers are much the same everywhere. Leading brands are promoted often using the same entertainers, models, music and slogans everywhere, including on television, the internet and social media. They are

disseminated by means of intensive and aggressive advertising campaigns, including the launching of hundreds of new products every year, which leads to a false sense of diversity. Because of these campaigns, genuine food cultures come to be regarded as uninteresting. All this pushes a sense especially to children and young people that the culture and identity of their own country, region, ethnicity and tradition including food culture and patterns, are boring. Young people especially are being induced by major manufacturers, in effect acting in concert, to have a false sense of belonging in a superior, modern, high cost and expense consumer culture" (Ministry of Health of Brazil, 2014).

If food standardization obviously allows a strict and efficient toxicological and hygienic control, conversely, such standardized foods are mainly ultra-processed and unhealthy foods: food safety has somewhat replaced food diversity, and substitutes to more healthy foods. In Western and emerging countries, the populations no longer die from food toxics but from chronic diseases, and they suffer from deficiencies because empty calories from UPFs do not supply enough protective micronutrients (Cornwell et al., 2018; Fardet et al., 2017; Gupta et al., 2019; Louzada et al., 2015; Luiten et al., 2016; PAHO & WHO, 2019; Rauber et al., 2018).

Food standardization is also accompanied by standardized tastes worldwide (Alpha, 2007; Fumey, 2007). Consequently, vacationers and travelers may well prefer buying UPF abroad with no risk to dislike the product than testing a local dish with the risk not to like it while paying it. The same is true for children, with standardized taste when very young, and who reject later real foods with subtler tastes. One can also observe that in most countries where the increase of standard of living translates into the decline of traditional foods consumption, *i.e.*, there is a shift towards a certain homogenization of the way of eating, towards the offer of agro-food industries of more animal and UPF calories often considered by national policies as a demand, and by populations as outward sign of wealth.

3. The 3V's Rule for Protecting Food System Sustainability

3.1. Too Much Animal Calories

Beyond excess ultra-processed calories, excess animal calories has been consistently associated with increased risks of some leading chronic diseases such as colon cancer/adenoma (Aune et al., 2013) and cardiovascular diseases (Chen et al., 2013; Micha, Wallace & Mozaffarian, 2010), notably leading French authorities to propose limiting animal-based foods in national recommendations (ANSES, 2019; Nutractiv & Ligeriaa Pays de la Loire, 2018); but also with increased greenhouse gas emissions (Tilman & Clark, 2014; Willett et al., 2019), potentially leading to global warming as regularly pointing out and published by the Intergovernmental Panel on Climate Change (IPCC). Presently, there is no need to demonstrate that meat-rich diet is no more sustainable (Wageningen University, 2019).

On the contrary, high consumption of plant-based foods (*i.e.*, fruits and vegetables, wholegrain cereals, nuts and seeds, legumes, and tubers) have been consistently associated with reduced risks of chronic diseases and metabolic deregulations (Fardet & Boirie, 2014; Qian et al., 2019; Yokoyama et al., 2017).

For the future, the plant/animal ratio therefore appears as an important dimension for defining sustainable diet for health and environment.

3.2. The 3V Rule Basis

3.2.1.15. % Maximum Animal Calories

Several institutions have defined a sustainable diet for the future, taking into consideration human health and environment (Stolze et al., 2019; Karlsson et al., 2017; Le Mouël et al., 2018; Solagro, 2019; Willett et al., 2019; WWF France, 2019). The recommended servings or grams of animal products reach a median of 16.4% daily animal calories. Then, when considering traditional protective diets worldwide (*i.e.*, Okinawan (Willcox et al., 2014), Mediterranean (Martinez-Lacoba et al., 2018), and Nordic/Baltic (Meltzer et al., 2019) diets), and also *a posteriori* scientific protective diets (i.e., DASH

(Mohsenpour et al., 2019), prudent (Enas et al., 2003), anti-inflammatory (Tolkien et al., 2019), and vegetarian (Parker & Vadiveloo, 2019) diets), the recommended servings or grams of animal products reach a median minimum of 11.3% daily animal calories. Both foresight and actual protective diets therefore converge towards ≈15% daily animal calories.

In comparison, the daily average nationally recommended animal calories from 37 countries is 21.9% (Scherer et al., 2019), with French PNNS (Programme National Nutrition Santé) corresponding to ≈40% animal calories.

3.2.2. 15% Maximum Ultra-processed Calories

For defining the maximum daily ultra-processed calories, we selected epidemiological studies investigating association between overweight/obesity risk and consumption of UPFs (Canella et al., 2014; Canhada et al., 2019; Juul et al., 2018; Louzada et al., 2015; Mendonca et al., 2016; Nardocci et al., 2019) for two reasons: 1) this is the most studied health outcome with UPFs, and 2) overweight/obesity is the first step to more serious - even fatal - diseases, such as some cancers and cardiovascular diseases (Fardet & Boirie, 2013). On average, the median UPF caloric threshold for which obesity risk begins to increase is 21.5%, and the precautionary minimum UPF caloric threshold is 14.1%, from which a +≈29% increased risk of overweight/obesity was observed in two studies (Canhada et al., 2019; Louzada et al., 2015).

3.2.3. Varied, If Possible Organic, Local and Seasonal

In addition to the plant/animal ratio and the degree of food processing, a third and basic dimension can be added to a diet. Indeed, to meet all nutritional needs, it is important to eat "varied" among plant- and animal-based foods, and among the different food groups, *i.e.*, fruits and vegetables, whole grain cereals, legumes, tubers, nuts and seeds, algae, white and red meats, insects, seafood, dairy products, egg-based products, and offal.

This is not only important for human organism metabolism but also for environment, because eating "varied" stimulate planetary biodiversity, polyculture, genetic biodiversity, and food system resilience, especially towards forthcoming climatic changes.

Further environmental impacts (e.g., greenhouse gas emissions and pesticides) and xenobiotic consumption may be also reduced when trying to consume organic, local and/or seasonal.

3.3. The 3 Rules Are Interconnected

The above-mentioned 3V rule is therefore based on three interconnected fundamental dimensions to define the health and sustainability potential of a diet (**Figure 4**). They are qualitative, and easy to appropriate for large public without high level of knowledge in nutritional and food sciences. However, if one dimension is lacking as developed below, the diet is no more protective against human health and planet as a whole.

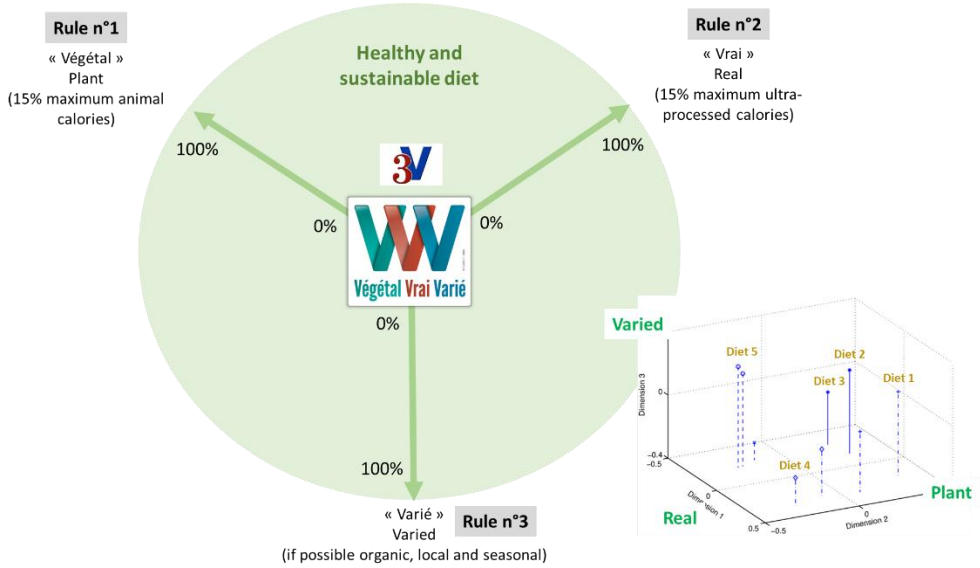


Figure 4. The interconnectedness of the 3V rule.

3.3.1. Animal/Vrai/Varié

Although we eat real and varied foods, if our main daily calorie basis is animal products rather than plant-based ones, then deleterious impacts can be seen for health and environment.

This is yet the case for the Inuits diet, mainly based on animal products. However, this is a niche population that has specifically evolved for thousands of years with its particular environment, and with a specific genetic background. Compared to the whole Canadian population, their life expectancy is around 10 years less. This is therefore important to point out that a 3V rule-based diet is for the general worldwide population that has reached today near 7.7 billion people, and that extrapolating Inuit's diet to world population is not possible today.

3.3.2. Végétal/Ultra-Processed/Varié

It is also possible to follow rules 1 and 3, *i.e.*, Plant food-based & Varied, but not the second rule for "Real" foods, *i.e.*, limiting UPFs. For example, some vegetarians and vegans may consume many ultra-processed plant-based products offered by agro-food industry, *e.g.*, meat substitutes. In this case, as shown in a longitudinal study, the risk of coronary heart diseases is quite similar to those consuming high level of animal calories (Satija et al., 2017). Besides, when consuming many UPFs, the third dimension "Varied" has less interest because UPFs are "empty" calories that can lead to nutritional deficiencies, called "hidden hunger".

3.3.3. Végétal/Vrai/Monotonous

Finally, as observed in some Sub-Saharian African and South-Asian countries, it is not sufficient to eat many plant-based and minimally processed foods, but also "Varied" ones. Indeed, often, their diet tend to be monotonous, mainly based on the same cereal and/or legumes, leading to potential nutritional deficiencies. For example, in Laos, white refined glutinous rice is more than 50% of daily calories, with potential deficiencies in vitamin A.

4. The Regionalization of Healthy Diets: Declining the 3V's Rule According to Local Specificity

The last concept we want to develop is that of the « regionalization of the healthy 3V rule-based diet ». These rules are very generic, allowing their declination according to specificities of regions worldwide, depending on pedo-climatic, agronomic, urbanization, social, and/or culinary traditions.

The 15% maximum animal calories may vary according to culinary traditions, with insects in Asia, dairy products in Western countries, fish and seafood in coastal regions, cheese and red meat in mountain regions, etc. The same is true for main plant sources: fruit, vegetable, grains and nuts

may be adapted to local climate, and culinary traditions. Such a regionalization is necessary to avoid dogmatic protective diets, and to vary food sources.

4.1. The case of France

The case of France is interesting because we are used to daily consume up to 40% of animal calories, (ANSES, 2017), and up to 40% of ultra-processed calories (Julia et al., 2018). A question arises: "by what to replace the +25% excess animal and ultra-processed calories?"

Probably the most sustainable solution is the increase of offer, and then a replacement by wholegrain cereals, legumes, and nuts and seeds, being all under-consumed below 14 g/day (Fardet & Rock, 2018). In addition, they are sustainable crops, especially legumes, and are rich in complex carbohydrates, proteins, and lipids, respectively. They concentrate both a high energy and nutritional density, and a high level of fiber.

The challenge here is to tend towards this flexitarian diet in which animal calories accompanied plant calories, not the contrary.

5. Conclusions

5.1. UPF and Food System Sustainability

In this presentation, we intended to answer to the following issue: "are UPFs linked to food system sustainability regarding, beyond human health, the degradation of the other five dimensions of the food system as shown on Figure 1?" First, UPFs, encompassing other designations such as junk, discretionary, non-core, or sometimes street foods, is an updated concept that explains why it was difficult to obtain specific information about their potential associations with the different dimensions of food systems worldwide (Figure 1). Nevertheless, on Figure 5, in reference to Figure 1 and based on the gathered data, we built the potential links between excess UPF consumption and the alteration of the different dimensions of the food system sustainability.

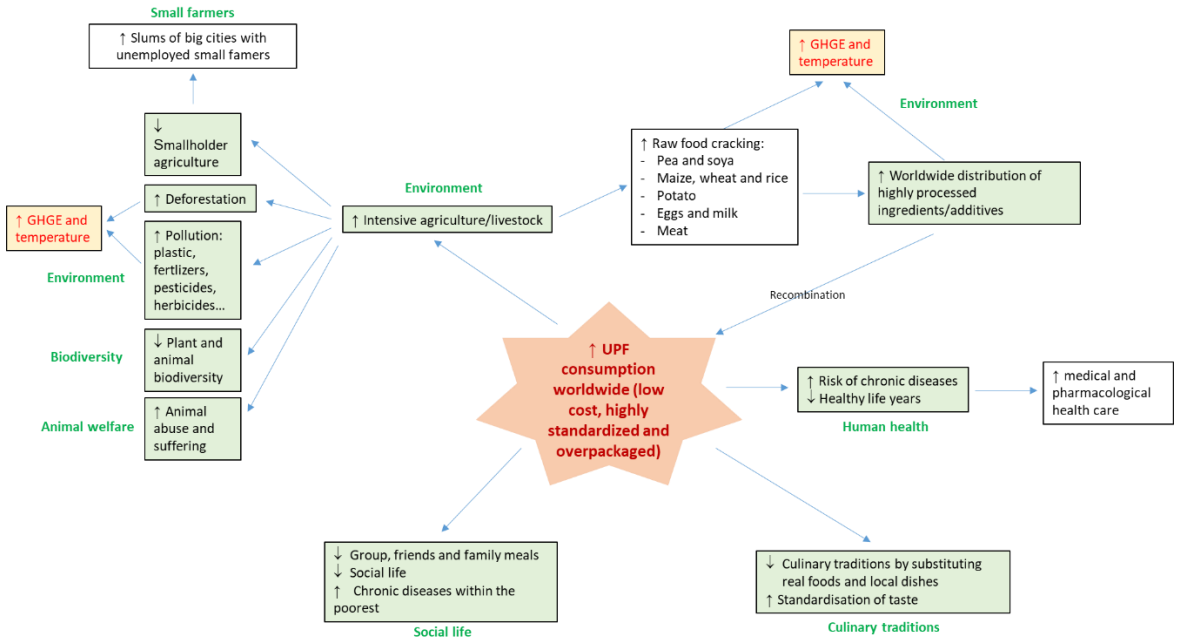


Figure 5. A summary of the impact of increased UPF consumption on food system sustainability.

More generally, by combining both the low cost at purchase and increased consumption worldwide, most of these products appear potentially associated with intensive agriculture/livestock, a loss of culinary traditions, the progressive disappearance of small farmers/peasants, increased animal suffering, a loss of biodiversity, and social inequalities (Figure 5).

Although present studies suggest that UPFs do not necessarily produce the highest GHGEs, within a context of overconsumption of animal calories, their contribution to GHGEs could be importantly reduced without negative health effects. It should also be recognized that some non-UPFs may be produced at low cost and/or environmental impact [128] while being highly consumed worldwide, e.g., refined sugars, oils and cereals, but to the detriment of health outcomes (e.g., obesity or type 2 diabetes). However, the contribution of some non-UPF food (e.g., palm oil, banana, avocado …) to the degradation of food system sustainability is already well recognized, notably through intensive monocultures with large amounts of inputs and loss of biodiversity.

5.2. The 3V's rule proposal

This holistic integrated and scientific-sound 3V's rule is well adapted to large public because the science-society interface is first holistic and qualitative. These rules also get rid of the single-nutrient approach with no mention of nutrients. Adopting these rules allows, without having to worry about them, to meet all DRI (Dietary Recommended Intakes), and other nutritional needs, with low level of salt (< 5 g/day), saturated fats (< 10% daily calories), added sugars (≤ 10% daily calories), and a low omega 6/omega 3 ratio (< 5).

The 3V's rule can be compared to Russian dolls, with the more global and holistic the target for public recommendation the more sustainable it is, encompassing on long term numerous dimensions of food system sustainability. Thus, the 3V's rule is the biggest Russian doll, embarking with them all the system. However, if your public target is a small Russian doll, only a few dimensions will be embarked. For example, if we recommend "less sugars", the animal wellbeing is not taken into consideration, nor the degree of processing, etc.

By tending towards the 3V's rule, one act locally through a way of consuming with global impact. Another issue is also the international/local food ratio. Which percentages to reach? Probably the international food share is today too high, and no more adapted to environment protection. We suggest that increasing consumption of local foods can be safe, even for insuring food security.

Perspectives

If agriculture is considered to produce too many GHGEs, future evaluations from farm to fork should further analyze the level of contribution of UPF processing, packaging, and transport. Similarly, when analyzing the associations between food groups and GHGEs, it is important to discriminate the degree of processing of each of the foods included in those groups. Meanwhile, the available data appear sufficient to extend the application of the precautionary principle (applied to human health [132]) and to urgently implement policy regulations for agro-industrials to include nutritional and environmental criteria with regard to processed foods and policy incentives for consumers to shift from UPFs to real raw and mildly processed foods, preferably seasonal, organic and local products.

As perspectives, an interesting study could be to select a population of people very far from the 3V's rule (high in animal and ultra-processed calories, monotonous diet), and measuring the impacts on health and food system sustainability when tending towards the 3V's rule.

Other foresight studies could consist in calculating, for several countries worldwide, the adequacy to the 3V rule to identify relevant levers to improve food system sustainability.

Finally, behind the 3V's rule there is a huge amount of scientific data converging towards this protective generic diet. We therefore propose that such a diet could be a relevant basis for future recommendations, but also to communication to large public, together with emphasis on school education.

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