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# The food system and climate change: are plant-based diets becoming unhealthy and less environmentally sustainable?

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A plant-based diet, which can include small amounts of meat, is the foundation for healthy sustainable diets, which will have co-benefits for health, climate and the environment. Studies show that some of the barriers to making this dietary change and reducing meat consumption are perceptions that plant-based diets are inconvenient, it takes too much time and skills to prepare meals and ingredients are expensive. The food environment is changing and the industry is responding with the exponential increase in the market of highly processed, convenient and cheap plant-based foods. This overcomes some of the barriers, but there is concern about whether they are healthy and environmentally sustainable. Plant-based foods have a halo effect around health and the environment, but many being produced are ultra-processed foods that are high in energy, fat, sugar and salt and have a higher environmental impact than minimally processed plant-based foods. The trend towards eating more highly processed plant-based convenience foods is a concern with regard to both public health and the targets set to reduce greenhouse gas (GHG) emissions. The ‘modern day’ plant-based diet emerging is very different to a more traditional one comprising pulses, vegetables and wholegrain. Studies show that those who are younger and have been a vegetarian for a shorter duration are eating significantly more ultra-processed plant-based foods. While there is a place for convenient, desirable and affordable plant-based food to encourage dietary change, care should be taken that this does not subconsciously set a path which may ultimately be neither healthy nor sustainable.

### **Plant-based diet: Climate change: Ultra-processed food: Health: Food systems**

It is indisputable that global action is needed now to reduce greenhouse gas (GHG) emissions to limit global warming. Targets set in the UN Paris Agreement in 2015<sup>(1)</sup> are for global temperature not to rise more than 2°C above pre-industrial levels, ideally not above 1.5°C, to reduce the impacts of climate change. This is a legally binding treaty on climate change to reduce emissions, agreed by 196 countries at COP 21 in December 2015 (<https://www.cop21paris.org/>). In order to achieve these goals, significant action is needed in all sectors, including changes within the food sector. This means

not only reducing emissions in agriculture and across the food chain but also dietary changes within the population to environmentally sustainable diets. In high-income countries, the main dietary change to reduce GHG emissions is to eat less meat and dairy products, especially from ruminant animals. In 2015, the International Panel on Climate Change report on climate change and land<sup>(2)</sup> highlighted the need to move away from carbon-intense diets (i.e. high in animal products). In the sixth carbon budget report, published in 2020 by the UK Climate Change Committee<sup>(3)</sup>, made

**Abbreviations:** GHG, greenhouse gas; UPF, ultra-processed foods.  
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recommendations that quantified the reduction of meat and dairy required. The goal is to reduce consumption of the most carbon-intensive foods (i.e. beef, lamb and dairy) by at least 20% per capita to plant-based options by 2030 and a further 15% reduction in meat products by 2050. These recommendations could also have potential co-benefits for human health and align dietary recommendation to reduce red meat consumption in line with national and international dietary guidelines for health. In the FAO and WHO joint report on guiding principles for sustainable healthy diet (2019)<sup>(4)</sup>, one of the principles is for consumption of only small amounts of red meat consumption for health and the environment.

The focus on red meat and dairy products is due to the high GHG emissions associated with the production of ruminant livestock. This is higher than emissions from plant-based commodities even accounting for differences in livestock production systems<sup>(5)</sup>. Restricting consumption of red meat (also including pork) has potential co-benefits for human health. The World Cancer Research Fund<sup>(6)</sup> recommends people to eat no more than three portions of red meat per week since high consumption of red and processed meat is associated with an increased risk of cancers, such as colorectal cancer. Current intake of red and processed meat of adults in the UK aged 19–64 years range from 0 to 183 g/d (2.5th and 97.5th percentiles, respectively)<sup>(7)</sup>. Despite a gradual decline in consumption of red meat for many people, this dietary change is unpopular.

A move away from diets high in meat will need interventions in both the demand and supply side of the food system, which is challenging because of the barriers people cite, not least that they enjoy eating meat. Personal health is the main reason people give for reducing meat consumption, but others report concerns about the potential negative impacts on their health, such as insufficient protein or micronutrients in their diets<sup>(8,9)</sup>. A lack of protein is highly unlikely when switching to a plant-based diet. Other perceived barriers are the inconvenience, time and skills needed to prepare plant-based meals, difficulty of obtaining information and the fact that raw ingredients tend to be expensive<sup>(10)</sup>. Popular plant-based foods are those that mimic meat products, such as burgers, sausages or mince, which can minimise the changes people have to make to their meals and do not require new cooking skills. Using raw ingredients, such as pulses or lentils that can change familiar meal formats, may present more of a challenge when meat is typically the focal point of a meal. Using plant-based food that mimics meat can also help to overcome social feelings of inclusion since people can have the same meal as others but just have a plant-based alternative (e.g. burgers and sausages). This combined with a lifestyle, culture and desire for convenience food is driving a rapidly growing market of cheap, convenience plant-based foods. It, however, cannot be assumed that just because they are plant-based they will all be healthy or have a low environmental impact.

#### Alternatives to animal-based products

The first step in reducing meat consumption for many people is to move away from eating red meat to eating

poultry, which is associated with lower GHG emissions since poultry do not produce methane. The industrial process for rearing non-ruminant animals is heavily dependent on feed, such as soya, with negative environmental consequences, e.g. land use and biodiversity. Seafood is another substitute people make for meat, but emissions associated with seafood, especially intensively farmed fish, are similar to poultry and pigs<sup>(5)</sup>. Limiting fish consumption to reduce GHG emissions would conflict with dietary advice (i.e. Eatwell Guide) to eat at least two portions of fish weekly<sup>(11)</sup>. Other alternatives are plant-based foods, such as pulses, nuts, grains and vegetables, which when minimally processed are healthy (e.g. low in fat and high in fibre and micronutrients) as well as having lower GHG emissions. However, as described above these foods can be viewed by some as inconvenient, time consuming to prepare and expensive.

#### *Synthetic meat alternatives*

Novel meat alternatives that look and taste like conventional meat are being developed, which could satisfy the pleasure people experience from eating meat. Significant investments are being made in cultured meat produced *in vitro* (e.g. synthetic or lab grown). This process uses engineering techniques to grow cell cultures from animal tissues to recreate the structure of animal muscle tissue<sup>(12)</sup>. Rather than rearing and slaughtering animals, this technology is thought to be more environmentally sustainable (e.g. lower GHG emissions and virtually no dependency on land) and more ethical than conventional livestock production. This is based on small-scale production but if scaled up to a level to potentially replace most of the conventional livestock production, it is unknown what the environmental impact would be. Lynch and Pierrehumbert<sup>(13)</sup> modelled a number of scenarios comparing theoretical future production systems for cultured meat with different conventional beef production systems. They found that not all the cultured meat production scenarios were more environmentally sustainable than conventional livestock systems because of the significant amount of energy required. However, as the authors acknowledge the environmental impact was based on energy production today and did not consider the future supply of energy, which may come from more renewable sources. The technology is still in its infancy and currently most processes are economically unviable; they would also need to be passed by food safety regulatory bodies. In 2020, Singapore gave regulatory approval for cultured meat, which was first sold in a Singapore restaurant in the form of 'chicken nuggets'<sup>(14)</sup>. While there are still unknowns about the environmental impacts of scaling up production, the safety, potential nutritional benefits and consumer acceptance, these may well be part of the solution to reduce the production of livestock. Having a product that mimics the taste and texture of meat may not reduce the enjoyment people associated with eating meat.

#### *Processed plant-based foods*

A survey of 2400 adults in 2021 reported that in the UK approximately 31% of meat eaters and 52% flexitarians

(i.e. a diet of mostly plant-based food with only a small amount of animal products) ate plant-based meat substitutes, such as sausages, burgers and mince, at least once a month, compared with 19 and 46 %, respectively, in the USA<sup>(15)</sup>. The main reason was their belief that plant-based meat is healthier and less damaging to the environment than meat. There are an increasing number of industrially processed plant-based foods on the market, including textured vegetable foods (e.g. vegetarian sausages or burgers) and textured soya-based meat replacement (e.g. mince). An Australian study comparing plant-based alternatives with the equivalent meat product for burgers, sausages, mince, chicken and seafood found<sup>(16)</sup> that while many were overall nutritionally better than the meat equivalents, many of the processed plant-based alternatives were high in sodium.

In the past few years, there has also been an exponential increase in the availability of plant-based convenience foods, with retailers and fast-food chains launching many new ready-to-eat products and ready-to-heat plant-based meals. The influx of many of the new plant-based processed foods, especially in the fast foods market, coincided with prominent international campaigns such as Veganuary, a movement encouraging people to follow a vegan diet for the month of January<sup>(17)</sup>. Many of these new foods would be classed as ultra-processed foods (UPF), according to the NOVA food classification system<sup>(18)</sup> based on the degree of industrial processing. Processing is classified into four categories; unprocessed and minimally processed (e.g. fruit, milk, eggs), processed culinary ingredients (e.g. oils, butter, sugar), processed foods (e.g. canned vegetables, bacon, bread) and UPF, which is typically combined with many processed foods plus additives (e.g. biscuits, confectionery, pre-prepared meals and snacks)<sup>(18)</sup>. Some degree of processing is necessary to make food edible and safe, such as cooking meats, milling grain but there is concern about the association between negative health outcomes and the degree to which a food is processed. Whether this can be explained by the poor nutritional quality of ingredients used in UPF or by the effect of high levels of processing is still debated<sup>(19)</sup>.

#### *Ultra-processed plant-based foods and health*

Many studies have linked the consumption of UPF with negative health outcomes. A recent systematic review of the association between UPF consumption and health outcomes, by Elizabeth *et al.*<sup>(20)</sup>, reports that of the forty-three studies reviewed, thirty-seven found an association with at least one adverse health outcome (e.g. overweight, obesity, cancer, type II diabetes, CVD, depression). A 10-year prospective study from the French NutriNet-Santé cohort between 2009 and 2019 showed that high consumption of UPF was associated with an increase in BMI and risk of being overweight and obesity, even after adjusting for differences in energy intake<sup>(21)</sup>. Hall *et al.*<sup>(22)</sup> conducted a randomised controlled trial using a cross-over design to examine the effects of an ultra-processed *v.* an unprocessed diet.

Twenty weight-stable adults were randomly assigned to either the ultra-processed diet or unprocessed diet for 2 weeks immediately followed by the alternative diet for 2 weeks. Where possible the meals were matched in energy, protein, total fat, carbohydrates, total sugar, fibre and sodium, but the ultra-processed meals had a higher proportion of added sugar and saturated fat. Participants were told to eat as much or as little of the meals as desired. Energy intake on average was about 2092 kJ/d (500 kcal/d) greater on the ultra-processed diet. Body weight and body fat increased on this diet and decreased on the unprocessed diet. While not all the foods in these studies were plant-based foods, consumption of ultra-processed plant-based foods, high in energy, fat, sugar and salt, could have the same negative health outcomes.

There is often a halo effect around plant-based food and diets, where they are perceived as being 'healthy' regardless of their nutrient profile. Traditionally plant-based diets comprise minimally processed food such as fruit, vegetables, pulses, nuts and wholegrains. However, plant-based diets today appear to be changing with the increasing availability of convenient and affordable industrially ultra-processed plant-based foods, which fit many modern lifestyles. A cross-section study of a cohort of 21 212 adults in France found that 33.0, 32.5, 37.0 and 39.5 % of energy intake came from UPF in diets of meat-eaters, pescovegetarians, vegetarians and vegans, respectively<sup>(23)</sup>. The appeal of UPF is not just their convenience, but they are also attractive, highly palatable and cheap, and typically energy dense and high in fat, added sugar or salt<sup>(24)</sup>. For example, many UPF contain palm oil and palm kernels that are high in saturated fats. A study of eight middle- and high-income countries found that while the mean energy contribution of UPF ranged from 15.9 % in Colombia to 56.7 % in the UK, a positive association between the consumption of UPF and saturated fat was seen in all countries<sup>(25)</sup>.

#### *Ultra-processed plant-based foods and climate change*

The potential negative environmental impact of UPF has been overshadowed by the focus on meat and dairy and is often missing in discussions about sustainable diets and climate change<sup>(26,27)</sup>. This is understandable given that the majority of GHG emissions occur in the agricultural production of commodities, in particular livestock and needs to be the major focus, but industrial processing also generates a level of GHG emissions. Processing food commodities has a number of important roles, such as increasing storage life and food safety, but concern about the environmental impact of UPF is starting to come to light. There is clearly the additional energy used in the industrial processing of food, but also the environmental issues associated with the agricultural systems used to produce common ingredients found in many UPF, such as palm oil, sugar, maize syrup and additives<sup>(28)</sup>. The intensive production of these monocultures is a major cause of biodiversity loss as well as the high requirement for inputs such as fertilizer and pesticides<sup>(29)</sup>.



Milk analogues made from plants such as soya, coconut, almonds, oats or rice are becoming more popular as alternatives to dairy milk. As with many meat alternatives, these would be classed as an UPF because of the degree of processing and added ingredients, such as sugar, salt, oil, thickening and stabilising agents. A study in the USA assessing plant-based beverages showed that 69% of plant-based milks had added salt, especially milks derived from nuts (>93% of almond and cashew nut milks)<sup>(30)</sup>. Fifty-four per cent had added sugar, most frequently in soya milk (>85%). While most of these ingredients are associated with lower GHG emissions than dairy milk, there are other environmental issues with the ingredients of some of the alternatives, in particular, nuts, coconuts and rice. Nuts, especially almonds, tend to be grown in water-scarce areas of the world and therefore increasing demand is causing depletion of water in already water-stressed areas<sup>(31)</sup>. Similarly, as the demand for coconut milk increases so does the commercialisation of the cultivation of coconut. Concerns about biodiversity loss and deforestation from palm oil plantations have received a lot of attention but the increase in coconut monoculture plantations is of equal concern in terms of land use, biodiversity loss and substantial use of fertilisers<sup>(32)</sup>. Finally, it should be recognised that the growth of rice generates significant amounts of the potent GHG methane<sup>(5)</sup>. While these alternatives to dairy products will have lower GHG emissions, potential unintended consequences for both the environment and health have to be explored.

The amount of packaging used for processed convenience foods is another environmental concern. The total contribution of packaging to GHG emissions within the food system (about 5%) is small relative to agriculture<sup>(33)</sup> but the type of packing is important, with the excessive use of plastics causing pollution on land and in global waters. However, packaging cannot be totally eliminated as it plays an important role in food safety (e.g. reducing the risk of pathogens) and increasing the storage life of food thus reducing food waste. Something other than plastic is, however, needed to preserve food but have less environmental damage.

Finding plant-based alternatives for meat and dairy that meet expectations, desires and fit within modern lifestyles is a complex issue. When the production of any of these alternatives is scaled up to meet population demand, new agricultural practices, land management and diversification to minimise the environmental damage will have to be an integral part of the solution.

### **Traditional v. modern day vegetarians and vegans**

A recent survey conducted on behalf of the British Nutrition Foundation in 2020 found that 41% of adults in the UK surveyed thought a plant-based diet was a vegan diet, 20% a vegetarian diet and 8% did not know what it meant<sup>(34)</sup>. This raises questions about how the public interpret messaging about plant-based diets.

Vegetarianism has a long history associated with religion and culture, but more commonly today reasons to

adopt a vegetarian or vegan diet include improvement in health, reduction in environmental damage and concern for animal welfare<sup>(35)</sup>. 'Traditional' vegetarian (excluding meat and fish) or vegan (excluding all animal-based foods) diets are typically high in unprocessed or minimally processed foods, such as fruit, vegetables, wholegrain and pulses. However, with the increasing availability of plant-based processed convenience foods, there are some interesting changes, which could be described as 'modern day' vegetarian or vegan diets, including more convenience and highly processed foods.

### *Traditional diets*

Studies show that 'traditional' vegetarians tend to be more health conscious than meat-eaters. A meta-analysis of 98 cross-sectional studies of both vegetarian and vegan diets found they were associated with a lower relative risk of chronic disease (e.g. BMI, lipid variables and fasting glucose) than meat-based diets<sup>(36)</sup>. It is widely recognised that some caution is needed in the interpretation of the results since vegetarians and vegans traditionally tend to have healthier lifestyles, such as lower levels of smoking, higher levels of physical activity and lower BMI than meat eaters, which also reduce the risks of chronic disease. Evidence from large prospective cohort studies, which can overcome some of the effects of these confounders, tend to show fewer differences in all cause-mortality than cross-sectional studies, but some significant health benefits of these diets are still observed<sup>(37)</sup>. In these studies, the diets of vegetarians and vegans tend to be lower in total fat and saturated fats, with higher intakes of legumes, nuts, fibre and vegetable oils, and lower energy intakes. This is consistent with the proposed EAT-Lancet diet for a healthy and sustainable diet<sup>(38)</sup>. As part of the EAT-Lancet diet, it is suggested to include 50 g of nuts daily, which if scaled up to meet population demand across the world will place intense pressure in already water-scarce areas.

### *Modern day diets*

Increasing concern about climate change has stimulated international campaigns, such as Veganuary, promoting vegan diets. Veganuary describes veganism as a life of 'lentils, chickpeas and dairy-free cheese'<sup>(17)</sup>. However, with changing food environments and the increase in processed convenience foods, 'modern day' vegetarian and vegan diets can differ greatly from traditional vegetarian and vegan diets. A survey published in 2020 found those who had adopted a vegetarian diet more recently were more likely to eat processed plant-based foods<sup>(34)</sup> and younger people (18–24 years) were more likely to eat processed meat and dairy plant-based alternatives (e.g. meat-free sausages, burgers, plant-based milks and ready meals). A similar pattern was found in a cohort study in France where those who had been vegetarian for a shorter duration and those who had commenced these diets at a younger age had a higher consumption of ultra-processed plant-based foods<sup>(39)</sup>. This suggests that with many of the plant-based alternatives available today, people are opting for dietary changes that are



more convenience based without dramatic change to their meals and diet. While it is encouraging to see a reduction in animal-based foods, which fits with many modern lifestyles, but as described above, not all plant-based alternatives are as healthy as assumed and can have a quite significant environmental impact.

### Conclusions

Reduction of meat and dairy foods and a move to a more plant-based diet will have co-benefits for health, climate and the environment, assuming that the diet does not comprise large quantities of processed foods. There is a current trend towards eating more highly processed plant-based convenience foods, which is a concern with regard to both public health and achieving the targets of reducing GHG emissions. Plant-based foods can have a halo effect in terms of health and climate change, that dietary changes to any plant-based diet will benefit health and the environment. Evidence does suggest that with the increasing availability of plant-based convenience foods, there is a slow shift towards eating a more plant-based diet. This further suggests a willingness to eat less meat if it is attractive, convenient and accessible. The challenge is how to ensure that dietary changes to reduce meat consumption will improve health and it does not become the vehicle for high fat, sugar and salt foods, which could also create more environmental damage. Innovation plays an important part in achieving sustainable diets but care should be taken that this does not subconsciously set a path that may ultimately be neither healthy nor sustainable. A shift to diets to help reduce global warming and other environmental damage is urgently needed but any changes must be addressed in parallel with moves towards healthy diets.

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