

Meat alternatives



OVERVIEW

- There is growing interest and investment in meat alternatives that attempt to imitate meat, with plant-based products already available and cultured meat in development.
- The environmental profile of meat alternatives looks promising in some scenarios, but there is little independent evidence on the consequences of large-scale production.
- Long-term studies are needed to assess the health and other implications of eating meat alternatives.
- The proportion of people willing to try plant-based and cultured meat alternatives is increasing. There are calls for accurate and transparent labelling and marketing practices, and for regulatory preparedness.
- It is important to contextualise the role of meat alternatives within our global food system. Meat alternatives might increase food security if production is scaled up, but meat reduction initiatives could have a negative impact on some farming communities. Meat alternatives should be considered within these broader contexts and alongside a range of other potential solutions for achieving food sustainability.

INTRODUCTION

Meat occupies a special position in the diets of many humans.¹ It is often desired and valued culturally and for its taste and nutritional value as an energy-dense and rich source of protein and

vitamins.² Global meat production has tripled over the last four decades,³ due to an increase in the world's population size, affluence, and dietary preferences.⁴

Farming practices vary globally and carry social, cultural, and economic significance. Livestock farming employs millions of people, can deliver some environmental benefits by helping manage habitats for wildlife, allowing carbon storage, and providing landscapes for recreation.⁵ However, most animals farmed for meat worldwide are farmed intensively.⁶ This can result in significant use of freshwater, greenhouse gas emissions, soil degradation, pollution, and loss of biodiversity.⁷ There are longstanding concerns about the welfare of animals in certain farming systems, and some people have fundamental objections to the rearing and killing of animals for food.⁸ Meat production can contribute to public health risks such as the transmission of disease and antibiotic resistance,⁹ and high consumption of processed meat is associated with adverse health conditions.¹⁰ These

problems support an ethical imperative to reduce meat production and consumption. International bodies, experts, and NGOs are calling for people to reduce the amount of meat in their diets, or to stop eating meat altogether.¹¹

There is growing interest in meat alternatives that attempt to closely imitate meat produced from animals. Manufacturers of these kinds of products aim to fulfil people's desire for meat, without the potentially harmful consequences of meat production.¹² This briefing note takes a global view with particular reference to the UK context to consider the possible implications of meat alternatives for animal welfare, the environment, and human health, and their place within broader efforts to promote public health and sustainable food systems.

BOX 1. TYPES OF MEAT ALTERNATIVES

There are two main types of meat alternatives that imitate meat produced from livestock:

- **Plant-based meat alternatives** use a biomimicry approach to create the taste and texture of meat without the use of any animal products, offering people a 'viscerally equivalent' experience to eating meat.¹³
- **Cultured meat alternatives** are grown from the cells of an animal and seek 'biological equivalence' with livestock meat products without the slaughter of animals.¹⁴ These

products are also known as cultivated or cell-based meats.¹⁵

Definitions of what cultured meat 'is' and its status as a meat are still contested and at the heart of debates about how these foodstuffs should be regarded.¹⁶ Whilst cultured meat may be seen by some as meat, these categories are in many ways constructed, historically situated, and political, and may change over time based on the criteria used to define meat.¹⁷

BOX 2. OTHER RESPONSES TO THE IMPACTS OF LIVESTOCK FARMING

There are a range of other approaches to mitigating the impacts of livestock farming that are being explored or promoted, for example:

- **'Plant-forward' diets** which involve the consumption of long-established plant-based alternatives to meat such as jackfruit, soy-based products like tofu and tempeh, and seitan made from wheat, or other meat alternatives like Quorn made from mycoprotein.
- **Alternative sources of protein such as insects** as feed for livestock or insect-based food products, which are a rich source of protein, essential amino acids and other nutrients, and have a much lower carbon, land, and water footprint than meat.
- Initiatives which encourage and promote **reducing waste** across the entire food system.
- **Agroecological farming** methods which combine dimensions of social, technological, economic, and environmental contexts with local ecological knowledge for holistic approaches to sustainable farming and which could reduce GHG emissions, restore soils and biodiversity.¹⁸
- Techniques using **genome-editing in farmed animals** which are being researched and developed in an attempt to produce disease-resistant animals and reduce some of the environmental impacts of meat production, for example, by improving feed conversion ratios.¹⁹

SOCIAL CONTEXTS AND CHANGING BEHAVIOURS

In many societies and cultures, the provision and consumption of meat signals status, hospitality, cultural practice, and religious observance.²⁰ Decisions about the purchase of meat are influenced by many factors including affordability, convenience, marketing activities, personal preferences, and cultural norms.²¹ On average, people in high income countries consume between 80-115 kg of meat per year, compared with 4-32 kg in low and middle-income countries.²²

Although the global demand for meat is on the rise, 14% of people in Britain now identify as flexitarian²³ – meat-eaters reducing their meat consumption –

and 70% of buyers of plant-based meat alternatives are meat-eaters.²⁴ Furthermore, an increasing number of people are opting for vegetarian and vegan diets.²⁵ However, only 4% of the UK population are vegan or vegetarian.²⁶

Efforts to encourage a reduction in meat consumption have so far resulted in relatively small changes in meat eating habits.²⁷ Rather than trying to change people's meat-eating behaviour, manufacturers of meat alternatives are seeking to change how meat is produced, representing a paradigm-shift in strategies.

PLANT-BASED MEAT ALTERNATIVES

MARKET TRENDS

New products have helped boost the plant-based meat alternatives sector. In the European market, meat substitutes have seen a growth rate of 450% between 2013 and 2017,²⁸ capturing 1% of the total meat market.²⁹ Global investments in the plant-based meat industry exceeded US\$1 billion between 2017-2018. Investors include venture capitalists, as well as those in the traditional meat industry, such as Tyson Foods, America's largest meat producer, which has also launched its own plant-based products.³⁰

Recent products that have been introduced into the market include the Beyond Burger, which is sold in over 25,000 food outlets worldwide and can be found in the meat section of some UK supermarkets, and the Impossible Burger, which is served in more than 10,000 food outlets in the US. In October 2019, it was reported that Impossible Foods has applied for authorisation of the use of an ingredient, soy leghemoglobin, which would enable its products to be sold in the EU.³¹

METHODS OF PRODUCTION

New plant-based meat alternatives are using novel ingredients and innovative processes to create products with a higher degree of meat mimicry.³² Beyond Burger's key ingredients are pea protein isolate, canola oil and refined coconut oil. The Impossible Burger uses soy protein isolate and soy leghemoglobin, which contains 'heme', an iron-rich molecule. Impossible's leghemoglobin is manufactured by genetically engineered yeast and

gives the burger the colour, aroma, and flavour of meat.

Creating realistic cuts of meat or fish, rather than processed products such as burgers, remains a challenge. However, 3D-printing techniques to produce plant-based meat alternatives are being developed. Using a new scaffolding technique, meat-alternative products can be 3D-printed from vegetable proteins to resemble the fibrous texture of meat.³³

IMPLICATIONS FOR THE ENVIRONMENT

Estimates of the environmental impact and sustainability of large-scale production of plant-based meat alternatives vary according to the assumptions of different lifecycle assessments,³⁴ and further independent evidence is needed. Lifecycle assessments comparing plant-based meat alternative products to conventional meat products find that plant-based meat uses 72-99% less water, 47-99% less land, emits 30-90% fewer greenhouse gases and causes 51-91% less aquatic nutrient pollution.³⁵

Other research, however, suggests that some plant-based meat alternatives can produce similar levels of emissions as some unprocessed or minimally processed animal-sourced products.³⁶ Environmental sustainability might be limited by the energy required for protein processing and transformation of raw materials.³⁷ Plant ingredients can also pose environmental risks.³⁸ Intensive crop monoculture can drive deforestation and climate

change, as with the example of soy production in South America.³⁹

IMPLICATIONS FOR HEALTH

In contrast to most meat products, the Beyond Burger and Impossible Burger provide fibre and contain no cholesterol.⁴⁰ However, these and similar products are highly processed and incorporate purified plant protein rather than whole foods, contain similar levels of calories and saturated fat as beef burgers, and have much higher levels of sodium and iron.⁴¹ Nutrition experts have cautioned

against extrapolating the health benefits of eating minimally processed fruits, vegetables, whole grains and nuts to plant-based meat alternatives.⁴²

The health effects of soy leghemoglobin and other ingredients not previously consumed by humans have not been established.⁴³ There are calls for rigorous, independent studies to assess the overall long-term health implications of plant-based meat alternatives, so that people can make informed food choices based on considerations of health, as well as animal welfare and environmental impact.⁴⁴

CULTURED MEAT

MARKET TRENDS

There has been an investment of over US\$100 million in the cultured meat industry since 2015.⁴⁵ The technology is in an early rapid development phase and faces challenges of scalability and affordability for mass markets. A prototype of a cultured beef burger, funded by Google co-founder Sergey Brin, was announced in 2013.

Cultured meat research was initially led by biomedical scientists in universities, but has more recently moved into the space of entrepreneurship.⁴⁶ Start-ups are being funded by venture capitalists, biotech companies like Merck, and large companies in the livestock industry, including Tyson Foods and Cargill. This shift has seen an increase in intellectual property activity to secure patents. Non-profit organisations such as The Good Food Institute and New Harvest are also funding research and driving investment into cultured meat alternatives.

METHODS OF PRODUCTION

Cultured meat has been inspired by techniques used to reconstruct human muscle tissue from cells.⁴⁷ Stem cells or cells sourced from animals are put in a growth medium and then placed on a scaffold to recreate the structure of meat.⁴⁸ The process is housed within a closed bioreactor to provide sterility and an optimal environment for cells to be cultured. Organ printing and nanotechnology combined with tissue engineering techniques may provide further possibilities for creating cultured meat that has the characteristics of conventional meat.

Researchers in this field face several technical hurdles related to scaling up production, efficiency

of the process, and recreating the texture of meat. There are concerns about the use of certain cell types such as non-human embryonic stem cells, which have unlimited regenerative potential and could accumulate genetic mutations over time.⁴⁹

IMPLICATIONS FOR ANIMAL WELFARE AND THE ENVIRONMENT

Developers of cultured meat aim to eliminate the need to farm and slaughter animals for meat altogether. However, currently some animal products are still required in research, such as cells and fetal bovine serum. The latter is not viable for commercial production. Researchers are developing an artificial growth medium that would eliminate the need for fetal bovine serum.⁵⁰

Lifecycle assessments predict that cultured meat production would use substantially less water, land, and produce less waste than conventionally produced meat.⁵¹ Projections of greenhouse gas emissions for cultured meat are scenario-dependent,⁵² with some estimates suggesting that it could emit 78-96% fewer greenhouse gases.⁵³ Others have raised concerns that the energy requirement of the cultured meat process, according to some assessments, could have a greater and longer-term global warming potential than cattle production,⁵⁴ unless renewable energy is used.⁵⁵ The true environmental benefits and costs of cultured meat will only become known once it is in production.⁵⁶

The Good Food Institute believes that cultured meat could reduce the environmental impacts of food production to help meet sustainability goals.⁵⁷ This is premised on the assumption that meat alternatives will lead to a 'substitution effect', replacing

conventional meat, and not an ‘addition effect’ whereby meat alternatives increase global meat production and consumption.⁵⁸

IMPLICATIONS FOR HEALTH

Cultured meat has a similar composition to meat from livestock, but the closely controlled process of production may enable a greater degree of design of the taste and nutritional components.⁵⁹ The process might eliminate risks of zoonotic infection posed by livestock farming and could remove the need for veterinary antibiotics in closed systems of production, thus reducing the impact

of industrialised meat production systems on antimicrobial resistance.⁶⁰ Currently, antibiotics are used by a number of researchers in initial cell culturing.

The potential for contamination and bacterial growth at different stages of the culturing process might carry health risks, as might the addition of growth factors and additives, such as hormones, which are used in some conventional meat production outside the EU.⁶¹ The Food Ethics Council has highlighted the need for research to assess the health risks associated with cultured meat.⁶²

BOX 3. REGULATORY CHALLENGES

Concerns have been expressed about the lack of regulatory preparedness for meat alternatives.⁶³ Meat alternatives will require regulatory frameworks that ensure the safety and transparency of products. Different elements of cultured meat that might require regulation include cell sourcing, safety of ingesting novel materials, protocols for preventing and monitoring contamination, requirements for managing waste, and certifying and inspecting production facilities.⁶⁴

In the UK, meat alternatives are expected to be regulated by the Food Standards Agency under the EU Novel Foods Regulation, unless they contain genetically modified organisms or additives that mean they fall under additional regulatory regimes within the European Food Safety Authority.⁶⁵ The implications of the UK’s exit from the European Union for regulation in this area are currently uncertain. Timely and affordable regulatory processes that facilitate an open culture for supporting innovation are being called for.⁶⁶

BOX 4. PUBLIC OPINION

Although an increasing number of people are willing to try meat alternatives,⁶⁷ the proportion of people who would substitute conventional meat with these products is still low.⁶⁸ Public opinion varies by location: research in China and India indicates a higher public acceptance of meat alternatives compared with the US.⁶⁹

Consumers of plant-based meat alternatives comprise a high percentage of meat-eaters and those from higher-income households.⁷⁰ Although the sustainability of plant-based products can persuade people to try meat alternatives, the appearance and taste of these products are stronger determinants of regular consumption.⁷¹

Framing cultured meat as integral to sustainability with wider societal benefits can influence people to try it even if they perceive few personal

benefits.⁷² Yet, some people have expressed concerns about the affordability, taste, safety, and personal health risks of cultured meat.⁷³ Feelings of disgust have also been reported with people perceiving cultured meat as ‘unnatural’.⁷⁴

People’s hopes and fears about food more generally are captured in the Food Standard Agency’s report, *Our Food Future*.⁷⁵ The report states that people are concerned about a loss of social connection with food and food waste, and tend to be in favour of small scale, local production.⁷⁶ Some feel that food is a class issue with healthy food becoming an unaffordable luxury. There are concerns about large profit-driven food businesses, and people want more transparency and traceability through clear labelling. People expect the Government to protect public and global interests in healthier and more sustainable food choices.

FURTHER ETHICAL ISSUES

PUBLIC HEALTH CONSIDERATIONS

The long-term health effects of consuming meat alternatives have not been established and it is not yet known how people will incorporate these foods into their diets. These products are usually highly processed and the use of novel ingredients and new production processes might carry health risks that are hard to predict.⁷⁷ Terms used by manufacturers to describe meat alternatives that promote their environmental and animal welfare benefits, such as 'clean', 'green' and 'slaughter-free', might mean people overlook the health implications of these products. However, there are questions around whether it is appropriate or fair to hold meat alternatives to higher standards of healthiness than conventional meat, given their potential positive environmental and animal welfare profiles, and how moral trade-offs of this kind could be addressed.

Reports suggest that people are not buying meat alternatives to entirely replace animal products. There is the possibility that the availability of meat alternatives might increase people's overall consumption of meat and meat-like products, which could have health implications.⁷⁸ It is unclear how this outcome would be managed or controlled to prevent an exacerbation of the challenges of meat production and consumption.

MARKETING AND LABELLING

There are ongoing disagreements over the use of the term meat, and terms associated with meat, in labelling for non-meat products.⁷⁹ There are questions about whether meat alternatives can be sold alongside meat in shops, and whether cultured meat products should be labelled according to their method of production.⁸⁰ These questions reflect ambiguities which may be inevitable as part of a process of the changing meanings of meat.⁸¹

There have been calls to ensure that labelling and marketing is accurate and transparent so that people are not misled or confused.⁸² People might have concerns about the ingredients used during manufacture and the presence or use of genetically modified organisms. A Chatham House report calls for further research to explore public attitudes on meat alternatives and how they ought to be labelled.⁸³

THE PLACE OF MEAT ALTERNATIVES IN SUSTAINABLE FOOD SYSTEMS

Taking a holistic food systems approach to addressing the challenges of meat production and consumption involves consideration of health, social, economic, political, animal welfare and environmental domains.⁸⁴ Food systems are global and highly complex, and interact with a range of ethical issues such as climate change, food justice, and fair distribution of resources within local and country-specific contexts.⁸⁵

Technologically driven food reform promises a range of benefits, though solutions ought to be implemented with due consideration to those whose livelihoods and homes could be impacted. One billion people, mostly from low-income countries, depend on livestock for their livelihoods, and are likely to be affected by meat reduction policies and the development of meat alternatives in high-income countries.⁸⁶ There are food justice concerns about meat alternatives being part of a corporate food agenda with small number of multinational food companies having a monopoly over meat production, which could reinforce the gap between poorer and richer nations and decrease local self-sufficiency.⁸⁷

Currently, meat alternatives are relatively expensive food items. In the future, however, they could offer greater food security if production is scaled up and they become cheaper than conventional meat. However, some would argue that promoting cheaper, healthier plant-based diets should be the focus.

The development of meat alternatives is a technological approach to reducing the adverse effects of meat production and consumption.⁸⁸ Other approaches, which must not be overlooked, include improving global livestock practices, educational interventions and enacting behavioural change to reduce food waste and meat consumption, increasing the nutritional value of food, increasing the consumption of minimally processed plant-based proteins, and solutions addressing fair distribution of food resources for people across the world.⁸⁹

CONCLUSIONS

Rather than trying to alter people's meat-eating behaviour, manufacturers are changing how alternatives to meat are produced. This represents a paradigm-shift in strategies to address the ethical issues associated with meat production.

The sustainability profiles of meat alternatives look promising in some scenarios. But energy-intensive processes could reduce sustainability goals, and there is little independent evidence on the effects of production. Long-term studies are needed to assess the health implications of eating meat alternatives, some of which are highly processed. However, it might not be appropriate or fair to

hold them to higher standards of healthiness than conventional meat, given their potential positive environmental and animal welfare profiles.

Concerns have been expressed about a lack of regulatory preparedness for meat alternatives more broadly, and there are calls for accurate and transparent labelling and marketing practices.

The potential for meat alternatives to contribute to sustainable food systems should be considered within broader contexts and alongside a range of other potential solutions for achieving food sustainability.

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