

Alternative proteins: How good are they for people and the planet?

The authors of a recently published UK Food Standards Agency report, *Alternative Proteins for Human Consumption*, discuss the potential contribution of innovative alternative protein sources to public health, climate change mitigation and broader sustainability goals.

“Plant-based meat alternatives are generally highly processed”

THE GLOBAL food system is a remarkable achievement of human endeavour, but is still failing to provide for the world's poorest. On top of this, it is facing the critical challenge of meeting the needs of humanity within current planetary constraints.

A novel food revolution, particularly in sources of proteins, is seen by many as key to supplying enough high-quality nutrition to more people, while reducing negative environmental impacts.

The imperative for change in animal farming

Animal-based proteins, including meat, fish, eggs and dairy, represent a 13 trillion-dollar industry and form a significant part of humanity's gastronomic and cultural heritage, yet as a source of nutrition they may be considered an inefficient use of resources, with long-term, negative environmental effects.

Livestock has a conversion rate of about 23 crop calories to produce one calorie of beef and, including crops for animal feed, use 80 percent of the world's arable land and over 70 percent of the planet's freshwater resources. Meat, egg and dairy production are also a key source of climate-changing emissions, representing 18 percent of total global emissions and more than 83 percent of all

food system emissions in the EU. They are also a major cause of environmental eutrophication.

Moreover, consumption of animal protein – red meat and processed meat particularly – has been linked to human health issues such that the UK's National Food Strategy is now looking to evoke a voluntary 30 percent reduction in meat consumption.

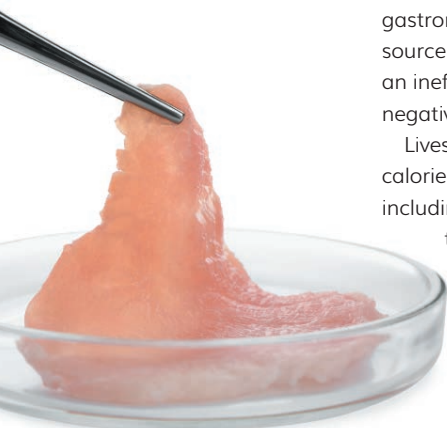
Emerging alternative protein sources offer the promise of tackling these issues and contributing to a more sustainable and healthy food system. However, good scientific data on the pros and cons of these sources of protein is often hard to come by or conflicting.

In this article we present an overview of four (see **Figure 1**) key emerging protein types and discuss the evidence for and against claims of their benefits for human health and the environment.

Alternative protein sources for human consumption

1. Plant-based meat substitutes

Plant-based meat alternatives are generally highly processed, re-engineered food products derived from ingredients such as soy or pea and processed into protein-rich products resembling meat. Such products have formed part of vegetarian fare for decades, but the sector has seen significant



innovation and numerous new products enter the market in recent years. At present, these products remain relatively niche and at premium price points, but consumer acceptance is increasing.

These products are often presented as a healthier, environmentally-friendly alternative to meat. Scientific studies on these benefits are still sparse and often funded by the industry itself.

Environmental benefits:

- Current evidence does support the claims that these products are more environmentally beneficial than beef as they certainly use significantly less arable land and water in production and generate much lower methane emissions than cattle
- However, the benefits vary greatly, depending on the local context of animal farming. Moreover, benefits are often offset by the extensive energy-intensive processing required to create the sophisticated tastes and textures demanded by consumers
- While the environmental case is reasonably compelling for beef substitutes, there is far less, if any, benefit when compared to farmed pork, poultry and fish.

Health benefits:

- The health benefit claims of these meat substitutes are largely derived from studies of traditional vegetarian or vegan plant-based diets. However, unlike whole foods, these meat substitute products are made from extracts and concentrates, fortified with beneficial nutrients and often an array of additives, normally including high levels of salt
- Moreover, the extensive processing damages the nutritional value of the ingredients and changes the way they are absorbed in the gut. As of yet, there are no longitudinal studies on the health effects of long-term human consumption of increased quantities of such processed food products. Overall, the health benefit claims of these products are questionable.

2. Novel sources of protein

By 'novel sources of protein' we refer to non-traditional sources of protein that are novel to the UK market, though have been dietary staples in other parts of the world for millennia. These include an array of insects, seaweeds, microalgae, bacteria, jellyfish and fungi. Consumer acceptance in the west is currently a significant barrier to adoption, but there is a niche market of product offerings now available in the UK, either as dried whole foods, functional food supplements, or ingredients processed into foods (eg, insects ground into snacks).

Environmental benefits:

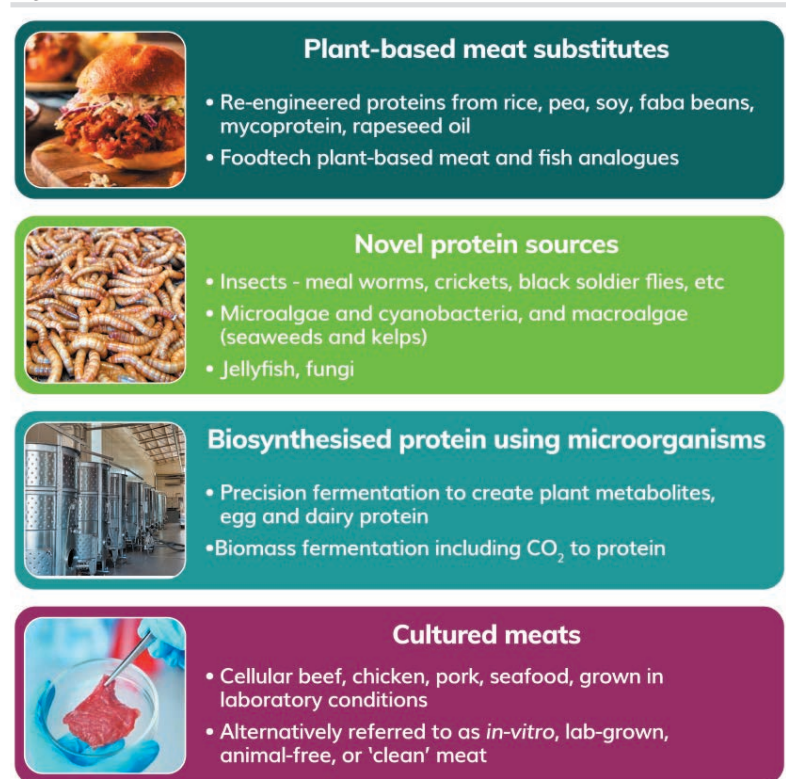
- The evidence suggests these sources of protein can represent a good option for sustainability. The conversion ratio from feedstock to protein can approach two to one for these organisms and, in general, novel proteins like insects and algae can make use of organic waste streams as feedstock and require less intensive processing. They can also be produced using low technology solutions, making them viable for less developed and low capital investment contexts
- However, the way source organisms are grown at modern industrial scale, eg, in vertical insect farms, can be energy intensive and often involves novel production technologies. Furthermore, exposure of these organisms to manmade environments and novel feed sources may introduce new challenges.

Health benefits:

- Many of these source organisms offer high quality proteins and amino acids, and other beneficial nutrients and antioxidants
- Although consumption is commonplace in some parts of the world, when introduced to a population with no previous experience or tolerance to these organisms there are concerns over potential allergenicity, and the implications on human >>

“Consumer acceptance in the west is currently a significant barrier to adoption”

Figure 1



Key emerging protein types. Source: FSA report on Alternative Proteins.



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“Cultured meat is produced from animal-derived cells grown under laboratory conditions”



Dr Bernhard Strauss

Bernhard is Co-founder and Director of Research and Operations at Camrosh. He is a molecular cell biologist by training and has previously spent over two decades in the biomedical and biotech sectors. After undergraduate studies in Biology and Medicine at University of Vienna, Austria, he obtained his PhD at the University of Cambridge, UK.

health of long-term intensive consumption are still unknown

- Concerns arise specifically over the use of waste streams as feedstock, which although promise benefits of circularity, raise significant uncertainties over human health.

3. Biosynthesised proteins

This category of protein source covers two types. Firstly, proteins generated through biomass fermentation processes of yeasts and fungi, which has been used for several decades to create products such as Quorn. There has been significant innovation in this area to produce products with meat-like textures for consumption on their own, or as ingredients in meat-based substitutes. Secondly, proteins generated by precision fermentations using genetically modified yeasts, fungi or microbes to generate desired specific protein molecules.

Precision fermentation is perhaps of most interest as it offers the promise of synthesising milk and egg proteins, which from traditional sources might have a more negative environmental impact. In the longer-term, biosynthesis offers the potential to synthesise a host of food molecules with the potential to profoundly change the entire food system. However, the industry faces technological challenges to operate at scale, and success will be subject to customer perceptions and regulation with respect to the sources; for example, the use of genetically modified organisms or the media used for production.

Environmental benefits:

- There is little sustainability data on these processes at present, mainly because production processes are mostly still in the pilot phase and there's little understanding of how efficiencies may change with scale. Based on the limited studies to date, milk protein fermentation might be better for the environment when compared to traditional dairy production, but the benefits for egg protein production are less certain
- In both cases, production processes are energy intensive and the benefits will only be realised with a fully decarbonised energy system.

Health benefits:

- There is currently no longitudinal health data on consumption of these synthesised proteins. Theoretically they are chemically identical to their animal-based counterparts, but the production processes, including extraction and combining with other molecules to create a complex food product, raise uncertainties over the final nutritional quality and composition. As with all processing, it also raises the potential for contamination.

4. Cultured meat

Cultured meat is produced from animal-derived cells grown under laboratory conditions (*in vitro*). This is arguably the most controversial alternative source of protein but could offer the most radical potential for disrupting the conventional food system. Significant processing is required to create the fibrous texture of real meat, including some form of edible 'scaffolding' (often collagen-based) upon which to grow the cells, and blending with other molecules such as fats to create a realistic sensory meat experience. Some simple meat types, like chicken nuggets, have been successfully demonstrated, but significant challenges remain to create a convincing steak.

Environmental benefits:

- The industry makes bold sustainability claims based on the potential to radically reduce land and water use, as well as greenhouse gas emissions associated with livestock production. While there are likely to be environmental benefits relative to livestock, these are substantially less for pork, poultry and fish
- The benefits are currently more than offset by the extensive energy requirement for production and processing, as well as high costs for often animal-based production ingredients.

Health benefits:

- Although cultured meat is made up of animal muscle cells, the nutritional content of such a product is currently inferior to animal meat, lacking iron and other nutrients
- Nonetheless, cultured meat can be created without saturated fats, which could offer important health benefits.

Alternative protein benefits are far from clear

There are a range of novel ingredients/foods entering the food system, offering the potential to dramatically reshape the way food is produced.

The environmental case for alternative proteins is still unclear because sustainability data is limited and difficult to compare meaningfully across the different protein types. Most do seem to offer benefits compared to beef and dairy production in terms of methane emissions, land and water use, and eutrophication, but the benefits over other animal proteins are much less definitive.

Most of these alternative protein sources require high levels of energy-intensive processing to extract proteins and to create the complexity of food structures demanded by consumers. Efficiencies are likely to improve as the technologies evolve, but at least until the energy system is fully decarbonised, chicken, pork, fish and novel sources that require limited processing (ie, insects and algae) will be better for the planet.

Complex processing raises issues around nutritional density, introduces contamination risks, and raises potential concerns over labelling, traceability, authenticity and regulatory oversight. However, perhaps the biggest concern over all these alternative protein sources is the limited understanding of the nutritional and long-term health implications associated with consumption.

Beyond alternative proteins for a sustainable food system

Alternative proteins are attracting significant investment and attention, so despite uncertainties, they are almost certain to make an increasingly important contribution to the food system over time.

In parallel though, the food system must make better use of existing protein – this means tackling the current levels of waste in the global food system and moderating consumer demand to address over-consumption in the west. We should also not forget the value of embracing more plant-based whole foods and minimally processed foods, such as traditional legumes and pulses, which, although not as 'exciting', are the better option for the environment and human health. 🍓

“Alternative proteins are attracting significant investment and attention”

Alternative protein sources

For a more in-depth review of these alternative protein sources, read the FSA report here: www.food.gov.uk/research/research-projects/alternative-proteins-for-human-consumption



Emerging Tech Report

The authors of this article recently co-authored *New Food's* Emerging Tech Report, available to download here: <https://bit.ly/3cpEgMZ>

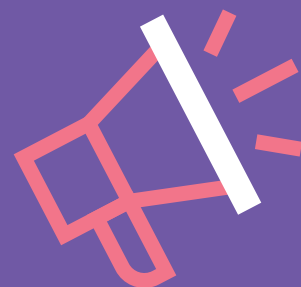


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