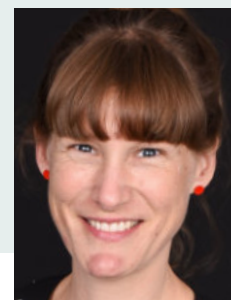


Alternative proteins as a sustainable and domestic source of food supply



Dr Julian Braybrook
Managing Director,
National Laboratories
at LGC and UK
Government Chemist



Dr Sonja Billerbeck
Associate Professor,
Bioengineering Department,
Imperial College London; Co-
Investigator, Imperial Bezos
Centre for Sustainable Protein

The UK's food system is under growing pressure due to changing climate, agricultural soil degradation and geopolitical instability^{1,2} Concurrently, the UK's growing population needs increased access to a high-quality diet.

Currently, livestock-based food production provides the bulk of high-quality protein and nutrients, but has significant environmental impacts and relies on global supply chains that are increasingly vulnerable to disruption² (Figures 1a and 1b). Specifically, in 2023, the agricultural sector accounted for ~11% of UK national greenhouse gas emissions³ and ~42% of food and animal feed was imported. This vulnerability prompted UK stakeholders to explore more sustainable and resilient ways to produce food, known collectively as alternative proteins.

Alternative proteins are a broad group of foods designed to provide the nutritional value and taste functions of conventional animal-based products, particularly protein, that have the potential to be produced domestically and reduce environmental impact.^{2,4} These include plant-based proteins, cultivated meat grown from animal cells and microbial foods produced through fermentation.⁴

Microbial food production, opportunities and challenges

Microbial foods are foods and ingredients produced using microorganisms such as yeast, fungi, algae or bacteria.⁵ These organisms can transform raw materials into edible products through biological processes used by humans for thousands of years. Many familiar foods, including bread, yoghurt and cheese, are produced through traditional fermentation. However, recent biotechnological advances allow microorganisms to produce entirely new food ingredients

or high-protein biomass. In biomass fermentation, the microorganisms themselves are grown as the food product – one well-known example is mycoprotein, produced from filamentous fungi and commercialised by Quorn. In precision fermentation, microorganisms act as 'cell factories' engineered to produce molecules such as milk proteins, fats or enzymes used in food products.

Fermentation-based food production runs in controlled environments, relying on simple inputs like sugars or agricultural by-products. The UK could source many ingredients domestically, e.g. from sugar beet, while also using food and farm waste streams, e.g. wheat bran. The potential of using carbon dioxide or industry off-gases, e.g. carbon monoxide, as a feedstock provides an opportunity to completely circumvent agriculture.^{6,7} Microbial foods are also high in protein and fibre and their replacement of some

animal-based foods could support healthier diets, by reducing the intake of saturated fats and cholesterol currently causing health issues in the UK.²

Economically, the rapidly growing alternative protein sector could drive innovation, new businesses and jobs in the UK bioeconomy.

Despite this promise, the sector faces significant challenges that limit the widespread adoption of alternative proteins, including cost, scale-up, a skilled workforce, regulation and consumer acceptance. Production at a sufficient yield and with desired texture, flavour and nutrient profiles requires substantial R&D. Further, many technologies that work well at laboratory or pilot scale face technical difficulties when expanded to industrial volumes.⁸ Consequently, early production volumes are often small, processes are still not

Figure 1a: Current food system – environmental and supply chain risks

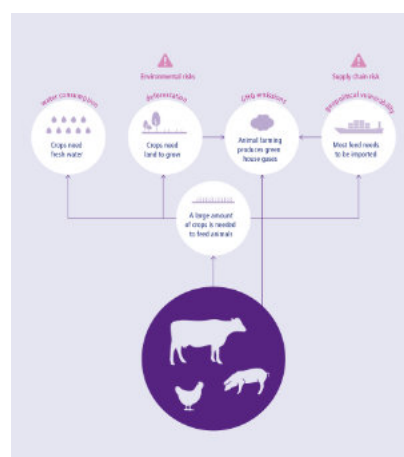


Figure 1b: Alternative proteins – potential to lower land use and greenhouse gas emissions

Product	Source	GHG emissions per kg protein	Land use per kg protein
Beef burger	Cow	54 kg CO ₂ e/kg	~50 m ²
Pork sausage	Pig	8.5 kg CO ₂ e/kg	~10 m ²
Chicken nuggets	Chicken	5.8 kg CO ₂ e/kg	~6.2 m ²
Mycoprotein burger, sausage, nuggets	Mycobacterium in a bio-reactor	2.4 kg CO ₂ e/kg	~2.2 m ²

Source: adapted from Coppens C et al. (2025).²

optimised and many microbial foods remain more expensive than conventional alternatives.

Consumer acceptance is also critical. While fermentation is familiar in foods like bread and yoghurt, many consumers are unfamiliar with new food technologies. Alternative proteins must match or exceed existing foods' culinary qualities to succeed. Price and availability also strongly influence purchasing decisions, often outweighing environmental considerations.

Food regulation can also pose challenges for microbial food companies; particularly the length of time for market authorisation. For many alternative proteins, this process is further complicated due to the highly novel nature of the foods (e.g. cell-cultivated products) necessitating potentially new regulatory pathways. In the UK, the Food Standards Agency (FSA) has been seeking to achieve this through its regulatory innovation programme, including running a regulatory sandbox for cell-cultivated products (CCPs)⁹. Encouragingly, a new report by the FSA and Food Standards Scotland (FSS) predicts that precision and biomass fermentation, as well as cell-cultivated foods, are likely to be amongst the food innovations that will reach UK consumers within 10 years.¹⁰

Call to action

The future UK food industry is integral to assuring both a healthy and secure diet for our population and helping meet our environmental sustainability goals. Diets will continue to transition slowly from meat to plant and other alternative proteins. The UK is well-positioned to play a leading role in the development of a viable global alternative protein economy, with strong cross-sector research capabilities, an established biotechnology sector and proven track record commercialising alternative proteins. However, realisation of this opportunity critically requires:

Investment into research and scale-up: The Invest 2035, the UK's modern industrial strategy,¹¹ identified growth sectors including advanced manufacturing and the life sciences.

Continued Government investment to support the research, scale-up and

implementation of new manufacturing practices of future food technologies (including engineering biology, automation, AI and scaled process engineering) is paramount to ensuring the UK as a hub for the new agri-food revolution. It is already actively investing in alternative proteins¹² with global acknowledgement of our growing national capability in the form of the Imperial Bezos Centre for Sustainable Protein¹³, the UKRI Microbial Food Hub¹⁴ and the National Alternative Protein Innovation Centre (NAPIC).¹⁵

Investment in skills: To truly seize this opportunity, the provision of the next generation entrants to the future food supply system must be seen as a matter of national importance.¹⁶ Further and higher education funding bodies should ensure courses are well-resourced and that recurrent capital funding is protected in the long-term. A starting point is a new Master of Research in Alternative Protein offered at Imperial College London¹⁷, but high-calibre undergraduate courses and food-aware high school curricula are missing. Beyond the current GCSE Food Preparation and Nutrition, there is no A-Level in Food Science or Food and Nutrition, with previous A-levels in Food Technology and Home Economics (Food, Nutrition and Health) having been discontinued over 2016-2018. Syllabus reviews of existing Biology, Chemistry and Physics A-Levels are therefore needed to ensure inclusion of future food-related technical and sustainability challenges. The vocational post-16 Level 3 AAQ qualifications, replacing the current WJEC / Eduqas Level 3 Food Science and Nutrition widely used in schools and colleges across England and Wales, must be tailored to deliver future skills requirements.

Proportionate regulation: The FSA's Innovation Hub is working to accelerate and simplify a more proportionate regulatory process for novel foods, one which maintains the balance between food safety and ensuring consumer choice and trust. Ongoing investment in the continued innovation of such a regulatory environment is essential.

Conclusion

Alternative proteins represent a promising pathway toward a more

sustainable and resilient food system. Policymakers should shape the conditions under which new food technologies can be developed locally and adopted broadly, to effect a vibrant UK food system.

References

- ¹ The World Economic Forum (2024). *Mainstreaming Food Innovation: A Roadmap for Stakeholders White Paper*. www3.weforum.org/docs/WEF_Mainstreaming_Food_Innovation_2024.pdf
- ² Coppens C et al. (2025). *Microbial Food as a Sustainable, Healthy, and Resilient Source of Nutrients for the UK*. doi.org/10.25560/118311
- ³ DEFRA (2024). *Agri-climate report 2023*. www.gov.uk/government/statistics/agri-climate-report-2023/agri-climate-report-2023
- ⁴ The Good Food Institute Europe (n.d.). *What Are Alternative Proteins*. <https://gfi.org/defining-alternative-protein>
- ⁵ Graham AE et al. (2023). The microbial food revolution. *Nature Communications* 14: 2231. doi.org/10.1038/s41467-023-37891-1
- ⁶ Jiang W et al. (2021). Metabolic engineering strategies to enable microbial utilization of C1 feedstocks. *Nature Chemical Biology* 17(8):845–855. doi.org/10.1038/s41589-021-00836-0.
- ⁷ Bernal-Cabas M et al. (2025). Food production from air: gas precision fermentation with hydrogen-oxidising bacteria. *Trends in Biotechnology*. doi.org/10.1016/j.tibtech.2025.08.003
- ⁸ The Food Navigator (2025). *Upscaling Fermentation Is Not Just More of the Same*. www.foodnavigator.com/Article/2025/06/17/how-to-scale-fermentation-processes-from-lab-to-factory
- ⁹ Food Standards Agency (2024). *Groundbreaking Sandbox Programme for Cell-Cultivated Products Announced*. www.food.gov.uk/news-alerts/news/groundbreaking-sandbox-programme-for-cell-cultivated-products-announced
- ¹⁰ Food Standards Agency (2026). *Future Foods That Could Transform UK Plates by 2035*. www.food.gov.uk/news-alerts/news/future-foods-that-could-transform-uk-plates-by-2035
- ¹¹ Department for Business & Trade (2024). *Invest 2035: The UK's Modern Industrial Strategy*. www.gov.uk/government/consultations/invest-2035-the-uks-modern-industrial-strategy
- ¹² UKRI (2025). *Alternative Proteins: New Horizons for Novel and Traditional Food Production*. www.ukri.org/what-we-do/ukri-challenge-fund/clean-growth/alternative-proteins-new-horizons-for-novel-and-traditional-food-production
- ¹³ Imperial Bezos Centre for Sustainable Protein (website). <https://bezoscentre.co.uk>
- ¹⁴ UKRI (n.d.). *Engineering Biology Hub for Microbial Food*. <https://gtr.ukri.org/projects?ref=BB%2FY008510%2F1>
- ¹⁵ The National Alternative Protein Innovation Centre (website). <https://napic.ac.uk>
- ¹⁶ DEFRA (2023). *Independent Review into Labour Shortages in the Food Supply Chain*. www.gov.uk/government/publications/independent-review-into-labour-shortages-in-the-food-supply-chain
- ¹⁷ www.imperial.ac.uk/study/courses/postgraduate-taught/alternative-protein