UK Research and Innovation

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BRITISH SCIENCE ASSOCIATION

Public perceptions of engineering biology

Part 2: Food applications

Contents

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Sciencewise, a public dialogue progamme delivered by UKRI, has conducted this research with a view to identifying areas of research and innovation and technologies where early public engagement would be useful, and welcomes further discussion with research funders, government departments, government agencies and other public bodies working on these issues.

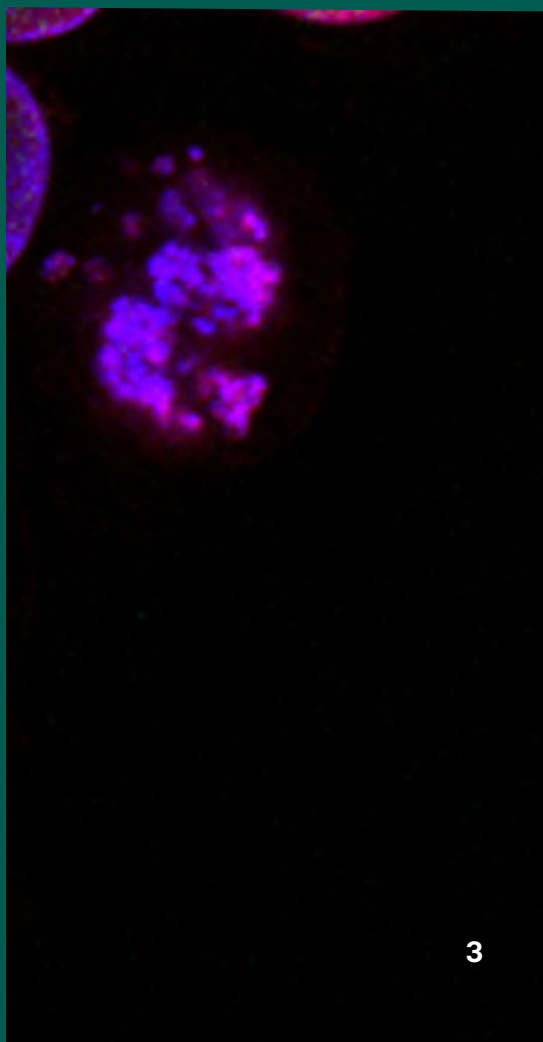
Introduction

In December 2023, the Department for Science, Innovation, and Technology (DSIT) announced its National Vision for Engineering Biology which will invest £2 billion in research, development and infrastructure over the next 10 years[1]. The vision sets out the priorities for the industry and its role in the future of UK research and innovation.

To ensure that the engineering biology vision benefits society and the social and ethical risks are properly regulated, we need to start a conversation with the public now.

This report outlines what is currently known about public views and values on engineering biology. It explores the main applications likely to impact the public in the next 15 years, such as new forms of food.

In most cases, these applications have potential public benefit, but they may also bring social risks or present ethical choices.



This report presents results from analysing sources of public opinion and identifies key themes which could be further explored through public dialogue.

In the first part of this report (published separately), we presented what is known about public opinion on engineering biology in general, and on the use of engineering biology in the health sector. This second part of the report considers the applications of engineering biology in food and agriculture.

Our four findings are:

- Public views on engineering biology are broadly similar to views on genetic modification (GM), and are context- and application-dependent. More research on perceptions of specific applications will be needed to better understand what impacts peoples' views.
- Attitudes are generally more positive towards applications that are perceived to address a clear problem such as medical or environmental, rather than in food.
- People are likely to be concerned about the 'unnaturalness' of food created with the use of engineering biology, and to view scientists as 'creating life' and 'playing god.'
- As the negative perceptions of GM appear to ease, people might be more open to the use of engineering biology in food. This is especially true for young people who are more likely to place higher importance on the sustainability benefits that engineering biology seeks to bring to the agri-food system.

[1] Department for Science, Innovation, and Technology. (2023). National vision for engineering biology.

Applications of engineering biology in food

Engineering biology is the application of engineering principles to biological systems. It has the potential to offer solutions to a wide range of challenges across different sectors, and by being a low carbon technology, it can help reach net zero[2].

One of the main sectors with a pressing need to find breakthrough solutions is agriculture and the food sector.

With numerous challenges related to food and nutrition security, sustainability, and resilience, the agri-food system is gradually stepping away from relying entirely on conventional methods in order to be more productive, diverse, and healthy[3].

[2] Council for Science and Technology. (2023). Report on engineering biology: opportunities for the UK economy and national goals.

[3] UKRI. (2023). Engineering biology missions hubs and mission awards. Accessed March 2024.

In the UK, the food system needs to provide access to safe, nutritious, and affordable food for 68 million citizens[4]. It also plays an important socio-economic role. The agri-food sector is the largest national employer, and helps to shape the public health and environmental status of the UK[5]. But our current food system is unsustainable, and there are many stressors and shocks that could challenge it, including:

- **Environmental challenges** – Climate change and its consequences impact the functioning of the food system. Short-term extreme weather events (e.g. floods or droughts) and long-term stressors like increasing water scarcity might contribute to sudden losses in food production and are likely to disrupt the logistical infrastructure needed to distribute food.
- **Geopolitical challenges** – The UK imports 47% of its food, which means that the system is vulnerable to trade disruptions caused by conflict and political instability in regions where food is produced.
- **Public health challenges** – Public health shocks like the COVID-19 pandemic can severely disrupt the food system due to changes in food demand, shortages of workers, or restrictions put in place to tackle the disease.
- **Social and economic challenges** – Labour shortages can disrupt the activities of the food chain. Because the number of seasonal workers travelling to the UK is decreasing, food might be left unharvested, which would impact national productivity and resilience.

Engineering biology could help address several of these challenges and drive the development of novel processes and products. Engineered microbes, such as fungi and bacteria, can be used to produce new food additives, such as specific proteins, oils and fats, and sugar alternatives, as well as alternative proteins, for both human food and animal feed[6].

In agriculture, researchers and innovators are looking for engineering biology techniques which will develop, for example, biofuel feedstock, beneficial traits for crop plants, and pest control systems[7].

[4] The Parliamentary Office of Science and Technology (POST). (2017). Security of UK Food Supply.

[5] The Parliamentary Office of Science and Technology (POST). (2020). A resilient UK food system.

[6] Council for Science and Technology. (2023). Report on engineering biology: opportunities for the UK economy and national goals.

[7] SynbiCITE. Engineering biology to improve agriculture. Accessed March 2024.

[8] UKRI. (2021). Engineering biology. Accessed March 2024.

Examples of engineering biology applied in food and agriculture:

- **Sustainable flavourings** – Oxford Biotrans, a University of Oxford spinout company, developed a new method of producing grapefruit flavouring[8]. Every year around 20 tonnes of nootkatone, which is what gives grapefruit its flavour and fragrance, is used around the world, yet it takes approx. 400,000kg of grapefruit to produce just 1kg of nootkatone. Alternatively, nootkatone can be produced synthetically, but it takes a great amount of energy and generates toxic by-products. Researchers at Oxford found a sustainable way to create nootkatone from orange flavouring, which is much more easily available, using a form of an enzyme called cytochrome P450. Nootkatone is the first product marketed by Oxford Biotrans. The company is now working on developing further processes and additional products.
- **Microbes that turn CO2 into protein** – Deep Branch, a UK/Dutch start-up, developed a method for transforming carbon dioxide from industrial plants into a nutritious and sustainable protein for use in feed for fish and poultry[9]. Instead of using sugar, the main feedstock normally used, its microbes are fed carbon dioxide. The protein that is produced as a result of the process has a comparable nutrient profile to fishmeal, but its carbon footprint is 90% smaller.
- **Impossible burgers** – Impossible Foods, an American company specialising in plant-based substitutes for meat products, recognised that blood is an important element of the taste and experience of eating a hamburger[10]. Unlike most plant-based burgers, the Impossible Burger contains heme, which is the iron-containing molecule that gives blood its red colour. Heme is abundant in animal muscle tissue but is also found in plants. To improve the meaty flavours of their plant-based burgers, the scientists at Impossible Foods engineered the yeast Pichia pastoris to produce soy leghemoglobin. These burgers, which, compared to a beef patty, require 96% less land and produce 89% fewer greenhouse gases, are commercially available in the US.

The National Vision for Engineering Biology[11] highlights the role that alternative proteins such as cultivated meat, which is currently not authorised for sale in the UK, could play in meeting national objectives for economic growth and food production[12]. In their strategy for the industry, DSIT identified potential regulatory change as an opportunity to grow the alternative protein sector in the UK and confirmed that the Food Standards Agency is considering how reform of legislation could remove barriers to innovation[13] .

9 UKRI. (2021). Engineering biology. Accessed March 2024.

10 Voigt, C. (2020). Synthetic biology 2020-2030: six commercially-available products that are changing our world. Nature Communications.

11 Department for Science, Innovation, and Technology. (2023). National vision for engineering biology.

12 The Good Food Institute Europe. (2023). Cultivated meat backed by Uk government's new National Vision for Engineering Biology.

13 Department for Science, Innovation, and Technology. (2023). National vision for engineering biology.

Engineering biology and synthetic biology

Synthetic biology and engineering biology are two terms which significantly overlap and are often used interchangeably by experts. While synthetic biology is the design and fabrication of biological components and materials from biological elements, engineering biology is the process of taking those synthetic biology concepts and translating them into solutions[14].

In other words, synthetic biology is a field of science focused on building new biological systems, while engineering biology captures the entire innovation ecosystem, including advances in synthetic biology research, as well as its translation, commercialisation and application.

In this report, we have looked at sources of public opinion on both synthetic biology and engineering biology.

Public opinion on applications of engineering biology in food

Engineering biology promises to offer a wide range of solutions to the agrifood sector. It could be used to improve crops and soil health, control pests and crop diseases, and deliver novel food ingredients and innovative food packaging[15].

But despite the versatility of the technology and the growing interest in its potential applications, we have not found many UK-based studies from the last five years on public attitudes to the use of engineering biology in food.

From previous evidence on public perceptions of the food system, we know that public priorities around food are complex and multi-layered[16].

Research commissioned by the Food Standards Agency and Food Standards Scotland found that many people reported feeling pressured and unsupported in their food choices.

There is an increasing sense of 'no choice is perfect,' as people juggle competing drivers such as price, health, and convenience, and align their purchasing decisions with both their short-term and long-term concerns and priorities.

This sense of conflicting priorities and making difficult compromises is also present across many of the studies and surveys on public attitudes to engineering biology that we looked at.

[14] UKRI. (2021). Engineering biology. Accessed March 2024.

[15] Jin, S., Clark, B. et al. (2019). Synthetic biology applied in the agrifood sector: Public perceptions, attitudes and implications for future studies. Trends in Food Science & Technology.

[16] Food Standards Agency and Food Standards Scotland. (2022). The UK Public's Interests, Needs and Concerns Around Food.

Views on engineering biology similar to those on GM but more ambivalent

In 2020, the Food Standards Agency published a rapid evidence assessment of consumer views on emerging food technologies[17]. Their review of existing literature found that one of the key themes across the reviewed papers was that views towards synthetic biology in food have some similarities to views towards genetic modification (GM). Several studies note that negative views towards the use of synthetic biology in food follow similar lines to negative perceptions of GM technology[18]. People often cite potential environmental and human health impacts, as well as moral and value-related issues as key concerns about both synthetic biology and GM. The public are also worried about increased control of these technologies by large companies, and their unknown long-term health impacts.

However, there is also limited evidence that public attitudes towards synthetic biology might be more ambivalent than they have been towards GM. Research shows that people often refer to a sense of hope when talking about synthetic biology and its potential to address societal challenges such as food security[19]. A study by researchers in China and the UK suggests that rather than being inherently negative or positive, public perceptions of synthetic biology are dependent on the context, such as the product type, portrayal in the media, peer influence, and risk framing[20]. This implies that more systematic studies into specific food-related applications of engineering biology are needed to better understand which factors impact peoples' perceptions of the technology.

To illustrate the ambivalence of views on synthetic biology, the Food Standards Agency[21] refers to a quote from a Sciencewise-supported public dialogue that took place in 2009: 'there was conditional support for synthetic biology- while there was great enthusiasm for the possibilities of the science; there were also fears about control; who benefits; health or environmental impacts; misuse; and how to govern the science under uncertainty.'[22]

Although public concerns about the use of synthetic biology in food may be similar to those on GM foods, experts caution against overgeneralisation[23]. There is much less research available on public perceptions of synthetic biology, and the limited evidence that does exist suggests that the landscape is nuanced and context dependent. For this reason, it should not be assumed that engineering biology and other agrifood innovations will be met with similar scepticism or controversy[24].

17 Food Standards Agency. (2020). A rapid evidence assessment of consumer views on emerging food technologies.

18 Food Standards Agency. (2020). A rapid evidence assessment of consumer views on emerging food technologies.

19 Food Standards Agency. (2020). A rapid evidence assessment of consumer views on emerging food technologies.

20 Jin, S., Clark, B. et al. (2019). Synthetic biology applied in the agrifood sector: Public perceptions, attitudes and implications for future studies. Trends in Food Science & Technology.

21 Food Standards Agency. (2020). A rapid evidence assessment of consumer views on emerging food technologies.

22 Sciencewise. (2010). Synthetic biology dialogue.

From research on other emerging food technologies, we know that how the discussion is framed and what terminology is used have an impact on consumer attitudes. For example, a study of public perceptions of lab-grown meat at the University of Bath[25] found that there were no significant differences in consumer attitudes when using the terms 'cultured' and 'lab-grown' meat. However, 'clean meat' and 'animal free meat' were associated with much more positive perceptions.

Another study looking at cultured meat found that attitudes were more positive when cultured meat was discussed in the frame of potential societal benefits that it could bring, rather than when the emphasis was put on the 'high tech' nature of the product[26]. This suggests that much more research on perspectives towards terminology and labelling will be needed to better understand the nuances of public attitudes to the use of engineering biology in food.

Use of engineering biology in food less accepted than in health or environment

In the first part of the report on the use of engineering biology in health applications, we found that support for the technology is highest when there is a public health need or an environmental benefit. Our research into the food applications of engineering biology is consistent with this finding and suggests that public attitudes are generally more positive towards applications that address a clear medical or environmental problem rather than in food[27].

A study by Hart Research Associates[28] found that the use of synthetic biology to eradicate malaria via mosquitoes was viewed as positive, while agrifood applications, such as the creation of a crop-enhancing fertiliser and new food additives, were perceived more negatively by research participants. However, it needs to be noted that this study was conducted in the US in 2013, and it cannot be assumed that similar results would be found in the UK today, especially in the light of rapid development of engineering biology over the last 10 years.

More recently, Australian researchers at Commonwealth Scientific and Industrial Research Organisation (CSIRO) studied public perceptions of synthetic biology solutions for environmental problems, such as invasive pest management and bioremediation of waterways[29]. An online survey of 4,500 Australians included questions like "To what extent would you be willing to eat seafood caught from a waterway where synthetic biology technology has been used to remove pollution?". The study found that more people were willing to swim in water treated by synthetic biology technology than were willing to drink water or eat seafood sourced from treated waterways. 23% were not willing to swim in the water, while almost 40% were not willing to drink the water or eat seafood caught in the water.

[23] Food Standards Agency. (2020). A rapid evidence assessment of consumer views on emerging food technologies.

[24] Frewer, L.J., Coles, D. et al. (2016). Synthetic biology applied in the agrifood sector: societal priorities and pitfalls. APSTRACT: Applied Studies in Agribusiness and Commerce.

[25] Bryant, C., Barnett, J. (2019). What's in a name? Consumer perceptions of in vitro meat under different names. Appetite.

[26] Bryant, C., Dillard, C. (2019). The Impact of Farming on Acceptance of Cultured Meat. Frontiers in Nutrition.

[27] Food Standards Agency. (2020). A rapid evidence assessment of consumer views on emerging food technologies.

[28] Hart Research Associates. (2013). Awareness & Impressions of Synthetic Biology: A report of findings.

Viewing medical and environmental applications as more acceptable than food applications is not unique to synthetic biology. Research suggests that public attitudes to other emerging technologies, such as GM and nanotechnology, follow a similar pattern[30]. It is possible that people perceive medical applications as more "necessary" than agricultural and food applications, and, therefore, as more acceptable. However, even within the agrifood sector, different applications are likely to evoke different perceptions. For example, applications with tangible benefits, such as novel food products with health benefits (e.g. nutraceuticals), might be viewed more positively than food applications with no health benefits[31].

"Unnaturalness" and "playing god" as key concerns

When expressing their concerns about engineering biology, people often refer to "unnaturalness". This, again, is consistent with public attitudes to other emerging food technologies, and a general tendency towards greater acceptance of products and processes which are perceived as natural[32].

In their report on "Consumer attitudes towards emerging food technologies", the Food Standards Agency notes that synthetic biology applications where the transfer of biological material is closer or the same as that of the host culture (e.g. plant to plant) are viewed as more natural than those that cross species (e.g. plant to animal)[33]. In relation to synthetic biology applications, naturalness seems to be perceived as 'goodness' in terms of quality of the product.

Similarly, a Sciencewise dialogue on Genome Editing in Farmed Animals found that there was little support for the use of technologies in food production, as it did not sit well with participants' concept of 'natural farming', which was equated with better-quality meat and nutrition. Another perception was that technologies would be used to maximise productivity for the benefit of businesses rather than consumers[36].

Unnaturalness is also linked to the idea of scientists "creating life" and "playing god."[37] Ethical issues and religious beliefs have often been studied in the context of public attitudes to synthetic biology, with research suggesting that those with strong religious beliefs are more likely to be opposed to the use of synthetic biology[38].

29 Hobman, E., Mankad, A., Carter, L. (2022). Public Perceptions of Synthetic Biology Solutions for Environmental Problems. Frontiers in Environmental Science.

30 Jin, S., Clark, B. et al. (2019). Synthetic biology applied in the agrifood sector: Public perceptions, attitudes and implications for future studies. Trends in Food Science & Technology.

31 Jin, S., Clark, B. et al. (2019). Synthetic biology applied in the agrifood sector: Public perceptions, attitudes and implications for future studies. Trends in Food Science & Technology.

32 Food Standards Agency. (2020). Consumer attitudes towards emerging food technologies.

33 Food Standards Agency. (2020). Consumer attitudes towards emerging food technologies.

34 The Roslin Institute. (2021). Genetic modification FAQs. Accessed March 2024.

35 Food Standards Agency. (2021). Consumer perceptions of genome edited food.

36 Sciencewise. (2022). Genome editing in farmed animals.

Genetic modification (GM) and gene editing (GE)

Genetic modification is the process of changing the DNA of an organism (e.g. plant or animal) by introducing elements of DNA from a different organism34.

Gene editing involves changing an organism's DNA by making altercations to its genetic code. These are often small changes that could happen in nature.

Research suggests that genome edited food is generally more acceptable than GM food among the public35. Again, this is most likely because people view gene editing as more natural and less risky than GM.

Early signs that negative perceptions are shifting

As most studies on public perceptions of engineering biology focus on the technology itself rather than on specific applications, evidence on how views affect food choices is lacking. One of the themes explored by researchers is perceived anti-GM sentiment, which continues to affect the attitudes of policy leaders and science communities[39]. These groups often express concerns about the public acceptability of genetic technologies in food production, but there are early signs that attitudes might be shifting.

Eurobarometer research shows that between 2005 and 2019, the level of concern about the use of GM ingredients in food or drinks has dropped from 63% to 27%[40]. Similar results were reported by the Alliance for Science (AfS) in their study funded by the Bill and Melinda Gates Foundation. They looked at over 100,000 articles published in English and social media interactions between 2018 and 2020, and found that the overall tone of coverage and conversations about GM was positive, with 73% either neutral or favourable comments.

Moving towards more favourable conversations on GM might have profound consequences for the development of synthetic biology in the food sector[41]. Although GM and synthetic biology are two separate technologies, synthetic biology is predicated on genetic engineering, and it is possible that consumers might interpret food products created with the use of synthetic biology as genetically modified organisms.

There are also signals that young people might be more open to genetic engineering in consumer products. A YouGov study from 2021 found that in Great Britain, 18% of adults responsible for grocery shopping reported that they think that GMOs are not that unhealthy, but the views of Gen Z[42] adults who do grocery shopping were more balanced[43]. 33% of them said that GMOs and additives are not that unhealthy, compared to 37% who disagreed.

A study by Barclays[44] looking at the likelihood of UK consumers buying genetically engineered (GE) products also found that young people are more likely to buy a product that has a GE-ingredient[45]. The main driver for that seems to be sustainability. As a low carbon technology, engineering biology can provide access to hard-to-source ingredients or novel foods that are superior to products currently available on the market. This is likely to appeal to young people, as the Barclays study found that messages like 'sustainable' and 'meat-free' resonated more with younger shoppers than 'GMO-free' claims.

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37 Food Standards Agency. (2020). A rapid evidence assessment of consumer views on emerging food technologies.

38 Dragojlovic, N., Einsiedel, E. (2013). Playing God or just unnatural? Religious beliefs and approval of synthetic biology. Public Understanding of Science.

39 Carter, L., Mankad, A. et al. (2022). Three synthetic biology applications and their paths to impact in Australia: Cane toads, bacteriophages, and biomining microbes. Biotechnology Journal.

40 Food Navigator Europe. (2022). Is the stigma of 'Frankenfood' lifting? Investigating attitudes to GMOs, genetic engineering and synbio in food. Accessed March 2024.

41 Food Navigator Europe. (2022). Is the stigma of 'Frankenfood' lifting? Investigating attitudes to GMOs, genetic engineering and synbio in food. Accessed March 2024.

42 Generation Z, often shortened to Gen Z, is a term used by researchers and popular media to describe the demographic cohort of people born between 1996/97 and 2011/12.

43 YouGov. (2021). Gen Z grocery shoppers show signs of being more accepting of GMO food: Key markets. Accessed March 2024.

44 Barclays. (2022). Synthetic biology in consumer goods: The next big frontier.

45 Food Navigator Europe. (2022). Is the stigma of 'Frankenfood' lifting? Investigating attitudes to GMOs, genetic engineering and synbio in food. Accessed March 2024


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