

7. Risk profile, conclusions and recommendations

In this guide

[In this guide](#)

1. [FSA Science Council Working Group 6 Final Report - Food Safety in the Net Zero Era](#)
2. [Executive Summary](#)
3. [Introduction](#)
4. [Changes underway in UK primary food and feed production](#)
5. [What food and feed safety risks have been identified?](#)
6. [Appraisal of food and feed safety risks](#)
7. [Risk profile, conclusions and recommendations](#)
8. [Acknowledgements](#)
9. [Annex 1: Methodology employed in the collation of evidence for this report](#)
10. [Annex 2: Government policies and technological changes affecting primary production](#)
11. [Annex 3: Current FSA and Defra activities highlighted during WG6's work that aim to address potential food and feed safety issues raised in the report.](#)
12. [Annex 4: References](#)

7.1 Risk profile

The primary responsibility for assessing, quantifying and managing hazards and risks through mitigation measures resides with individual food producers supported by the regulatory and enforcement activities of governments. Because this project has essentially been an exercise in looking ahead to potential food safety risks, there is, as already mentioned, almost no published quantitative information available on the likely size, impact and range of such risks with respect to their interaction with measures to move towards net zero carbon.

Several potential hazards and the risks associated with different elements of primary food and feed production have been assessed.

Table 3 takes the key potential food safety risks identified in **Table 2**, identifies factors contributing to the risk, and ranks the relative level of concern before any mitigation has occurred. This ranking was based on the degree of concern expressed in expert interviews and reading of literature. Mitigation and current controls, either via the use of existing regulations and codes of practice or the extrapolation of existing good practice to new production practices, are identified. **Table 3** is for production practices and **Table 4** is for the major inputs of water and nutrients into field-based systems of primary crop production.

Three features stand out from this exercise:

1. The rigorous employment of current regulations and codes of practice should be sufficient to reduce most potential food and feed safety concerns associated with practices to move towards net zero carbon to low risks.
2. Priority needs to be given to increased emphasis and capacity to enforce the current guidelines and regulations to meet amplifications of existing risks.
3. Much ownership of the regulations and codes of practice falls outside the FSA so that the food and feed safety responsibility of the FSA can only be achieved through active cross-departmental cooperation, especially with Defra.

Table 3: Risk profile, risk management and recommended assurance mechanisms in changed production systems that may contribute to moving towards net zero carbon. Food safety risks are allergenicity (Aller), chemical (Chem), and biological (Biol). Levels of concern are **High**, medium (**Med**) and requires further understanding (**RFU**). The leading owner of the recommended assurance mechanism is shown as (L).

Production system	Food safety risk	Factors contributing to risk	Level of concern	Mitigation and current controls	Owner	Recommended assurance mechanism
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Animal and fish feeds	Biol	Introduction of animal products directly or via waste streams.	High	Feed regulations	FSA(L) Defra	Dev Adv Con Anir ACA
Vertical farms	Chem	Dirt and dust accreting with age.	High	Good practice and retailer assurance.	Defra(L)	Rec prac to b dev
	Biol	Biofilms in pipes and media.	High	Good practice and retailer assurance.	FSA	
Novel protein sources	Aller	Plants and insects are potential allergens.	High	Product monitoring and public awareness.	FSA(L) DoH Defra	Alle labe
	Chem	Some insects and seaweed accumulate heavy metals.	Med	Selection of insect feed. Moving seaweed production offshore.	FSA(L) Defra	Mon whe con in fo

Cultured meat	Chem	Migration of chemicals from plastics.	RFU	Use of more inert materials.	FSA	Res requ
	Biol	Use of antimicrobials.	RFU	Some antimicrobial use necessary to avoid microbial contamination.	VMD(L) FSA	Res requ
Packaging	Chem	Nanomaterials.	High	Minimise metal use. Packaging regulations.	FSA	Pac regu Reu pac requ guid
	Biol	Biopolymers may allow microbial incursion.	High	Monitor and improve polymers.	FSA	
Regenerative/mixed/rewilded farming	Biol	Proximity of animals and crops.	High	Strict separation of manure and edible parts of crops.	Defra(L) FSA	Upd imp of e guid
		Interaction of wild and domestic animals.				
		Changed cropping may increase incidence of mycotoxins.		Monitoring of aflatoxins.		

Agroforestry	Aller & Biol	Specific concerns depending on tree/crop combination.	Med	Separation of edible crop parts (e.g. nuts and grains).	Defra(L) FSA	Updated impact of e-guid
	Aller	Cross contamination of products.	Med	Quality control processes.	Defra(L) FSA	Reg goo pra
Aquaculture	Chem	Contamination of sea with heavy metals and chemicals used to treat fish.	High	Monitoring water quality and moving production pens offshore.	Defra(L) FSA	Enfo curr reg

Table 4: Risk profile, risk management and recommended assurance mechanisms for common inputs into field-based primary crop production systems that may contribute to moving towards net zero carbon. Food safety risks are allergenicity (Aller), chemical (Chem), and biological (Biol). Levels of concern are **High** and medium (**Med**) and requires further understanding (**RFU**). The leading owner of the recommended assurance mechanism is shown as (L).

Input	Food safety risk	Factors contributing to risk	Level of concern	Mitigation and current controls	Owner	Recommended assurance mechanism
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Water	Chem	Increased use of grey water with heavy metals in crop production.	Med	Enforcement of current manure, sewage and water regulations.	Defra(L) FSA	Current regulations need to be rigorously enforced.
		Contamination with nitrate and phosphorus		Enforcement of current manure, sewage and water regulations.		
	Biol	promoting algal and microbial growth.	High		Defra(L) FSA	
Manure, sludge and compost	Chem	Sludge may contain chemical contaminants.	Med	Monitoring and compliance with good practice .	Defra(L) FSA	Ensuring existing guidance is known to the farming community and rigorously enforced.
		Microbes in manure and slurry can contaminate water and crops.		Compliance with good practice guidelines.	Defra(L) FSA	
Use of food by-products	Chem	Chemical contamination.	Med	Monitoring and codes of practice.	Defra(L) FSA	Codes of practice updated to incorporate current waste materials.
	Biol	Survival of pathogens.	High	Monitoring and codes of practice.	Defra(L) FSA	

7.2 Conclusions

This report was limited to considering changes occurring in the next decade. In the longer term the UK's contribution to achieving net zero carbon globally will be very dependent on the UK's carbon footprint in primary production not being moved offshore (i.e. carbon leakage; see for example, UKCCC, 2022). The balance between UK production and imports of food is also an important driver of food safety risks and requires constant monitoring. The longer-term view on food safety will need to take account of the rapid developments in novel proteins and associated allergens, novel packaging materials and crop breeding technologies.

To respond effectively to potential food safety risks and consumer interests arising from activities to deliver net-zero carbon policies, support and research will be required from multiple government departments (see Tables 3 and 4). Some of the current Areas of Research Interest (ARIs) of the FSA (e.g. Adapting to the food and feed system of the future; Addressing Global Grand Challenges) and Defra (e.g. Climate Change and Net Zero, Land Use, Nature-Based Solutions, One Health) are relevant to a better understanding of the impact of net zero carbon policies. These ARIs provide an opportunity for cooperation, co-funding and visibility of key areas in need of more scientific data. Although it was not an objective of this report to produce a list of research needs, some obvious examples have been highlighted (e.g. mycotoxins; new food production systems such as cultured meat; impact of microplastics and other materials in waste streams and in soil). A systematic analysis of research gaps is needed to identify where further scientific evidence is required to inform policy developments. While there is some synergy between the FSA and Defra ARIs, as primary production practices change, effective horizon scanning, joint research and analysis will be needed to underpin the FSA's ability to meet the associated challenges.

We have reached the following conclusions:

- Overall, discussions with academic and business experts indicate that changes to primary food production practices to accommodate the move towards net zero carbon are likely to be largely positive for society and provide good business opportunities to develop a competitive agriculture and food production sector that delivers safe foods.
- Moves towards net zero carbon may change the degree and balance of known existing risks where novel technologies are employed.
- Known safety risks will also reappear in production systems which are based on earlier production systems for which traditional good practice-based

knowledge has been lost or is limited.

- New high-protein foods from plant, insect and animal cell cultivation raise particular issues about allergenicity and other legitimate factors such as ethical considerations.
- New entrants to novel technologies for food production may be unfamiliar with the food safety and other regulations which already exist. While new ideas and sources of funding are welcome, inexperience with practical risk assessment and management protocols is a concern.
- Existing regulations, codes of practice and guidelines should be sufficient, if fully implemented, to reduce to acceptable levels the food safety risks identified in this report which are associated with the move towards net zero carbon. However, there is evidence (e.g. for water) that these frameworks are neither followed in practice nor rigorously enforced. This should be a matter of concern for the FSA.
- The involvement of multiple government departments in the regulation of the UK food system increases the likelihood that some food safety issues associated with moves to net zero carbon may be overlooked or fall between departmental remits.
- Several sections of this report point to the increasing complexity and pace of developments. Changes to production practices are occurring quickly so agility and vigilance will be needed to ensure a speed of response that keeps ahead of these developments. This will require regular, collaborative horizon scanning and data gathering in collaboration between government departments and agencies.

7.3 Recommendations

Throughout this report and especially in Tables 3 and 4, it is clear that the mitigation of many food safety issues stems in whole or part from policies or regulations overseen by government departments other than the FSA. For example, water and manure regulations are the responsibility of Defra in the UK Government while any changes envisaged in the land use, land use change and forestry sector to move towards net zero carbon will also involve the devolved administrations. The Science Council is constituted to make recommendations to the FSA alone, but in several places the recommendations will require the FSA to facilitate discussions with other government departments and investigate these multifaceted problems collaboratively.

We have grouped our recommendations for food and animal feed safety into three major themes: i) surveillance of emerging technologies and engagement with producers and consumers; ii) inter-departmental cooperation and regulatory review; and iii) research and horizon scanning:

7.3.1 Surveillance of emerging technologies and engagement with producers and consumers

We recommend that the FSA:

1. Maintains active surveillance of likely areas of production changes in response to net zero carbon policies and encourages food and feed businesses to embed responsibility for food safety into their innovative practices following PAS 440 principles (from the BSI).
2. Develops guidance that will ensure safe food at the site of production through active engagement with new food-producing technologies (e.g. vertical farming, novel proteins such as insect rearing and cultured meat).
3. Develops and communicates advice for primary producers and consumers on how to minimise food safety risks when producing or consuming foods that they perceive as contributing towards net zero carbon or sustainability agendas (e.g. recycling of food by-products, reuse of packaging, foraging).

7.3.2 Inter-departmental cooperation and regulatory review

We recommend that the FSA:

4. Engages with other government departments to assess the effectiveness of current regulation, enforcement, codes of practice and guidance in assuring future food and feed safety and, given the changes to primary production practices described in this report, whether the balance and scope of these assurance mechanisms is appropriate.
5. Ensures that the regulatory framework for animal feed is sufficiently agile to cope with fast-moving changes and any accompanying risks arising from the many innovative net zero carbon developments including new and novel protein sources, food waste recycling, by-product/co-product use and new supplements.
6. Rapidly establishes whether the current risk analysis and regulatory frameworks in place are able to cope with the novel technologies, ingredients and products which might be used in food.

7. Reviews the potential impacts on food safety arising from the use of manure, compost, slurry, sewage sludge and food by-products applied to land to determine whether current regulatory frameworks are fit for purpose as companies and consumers move towards net zero carbon.

7.3.3 Research and horizon scanning

We recommend that the FSA:

8. Undertakes a systematic analysis of research gaps to identify where scientific evidence is needed to understand the risks and benefits associated with production and consumption of food and feed in a low carbon economy. The added challenge of a food supply that provides sustainable healthy diets should not be underestimated in the context of the above recommendations and necessitates a strong programme of horizon scanning and analysis to stay ahead of technological, commercial and social developments.

Work is already underway in the FSA and Defra to mitigate several of the potential food safety risks identified in this report. **Annex 3** outlines some of the current work to mitigate some of the risks identified and to improve regulatory frameworks which deliver safe food and feed from primary producers.