



TRANSFORMING
**UK FOOD
SYSTEMS**
Strategic Priorities Fund

Culture Clash?

What cultured meat could
mean for UK farming

July 2024

Contents

Headlines	3
1. Introduction	4
2. Cultured meat	8
3. What concerns farmers	14
4. Areas of interest for farming	20
5. Using waste or by-products	25
6. Farm resilience	30
7. An inclusive debate	34
8. Building on common ground	37
9. Our approach	41
Authors & acknowledgements	45
References	48

Headlines

It may one day be possible to substitute meat grown through cell culture imperceptibly for meat from livestock.

Farmers' concerns about cultured meat go beyond the impact on their bottom line, including that it is:

- Uncertain: there are still too many unanswered questions.
- Unreliable: unbiased data is hard to come by.
- Unrealistic: work is needed to map how new supply chains could work in practice.
- Unintended: having many potential knock-on effects.
- Unfair: questioning who benefits from this further industrialisation of our food system.
- Unnatural: in contrast to the 'real' food the farmers produced.

Factors such as business diversification, tenure, assets and contractual relationships affect farmers' resilience or precarity to this potentially disruptive technology.

Yet, under the right circumstances, cultured meat could present opportunities for some UK farmers:

- Sharpening their competitive edge for selling high-value 'real meat'.
- Developing potential new markets such as supplying animal cells or raw materials.
- Generating income from processing crop or animal by-products as ingredients.
- Harnessing private investment to produce cultured meat on their own farm.
- Developing new, fairer supply-chain relationships.

Initial analysis suggests that using crop and animal by-products as amino acid sources for cultured meat production could reduce its cost and environmental footprint, while farm-scale production would cost about 30% more than factory-scale.

While some farmers were interested in exploring these possibilities further, caring for livestock remained central to their identity.

Moving beyond a polarised debate would benefit the cultured meat industry, but it may also benefit farming. Advocates of cultured meat can support this through more inclusive communication: acknowledging uncertainties, celebrating farmer innovation and working with honest brokers.

The cultured meat industry and farmers could build common ground through:

- Joint research and innovation, particularly into waste valorisation and on-farm production.
- Developing practical partnerships and mechanisms for continued dialogue, such as a platform for interested farmers to connect with cultured meat businesses and a short guide to cultured meat for farmers.
- Investors expecting cultured meat companies to include farmers in their Environmental, Social and Governance commitments to support a 'just transition'.

1. Introduction

Could growing animal cells in factories cut meat's environmental footprint? That is the promise of companies developing cultured meat, and the hope of those advocating for policies and investment to back it. Whether they succeed depends not only on overcoming a host of further scientific challenges, but also on the technology's relationship with the livestock farming it expects to displace. For now, the cultured meat industry has more at stake in that relationship than farmers do.

Every plausible path to achieving net zero in the UK – while also meeting biodiversity and other targets – relies on using less land for livestock farming and animal feed, and eating less meat.¹ While most people in the UK already eat more than enough protein,² in practice swapping meat for alternatives made from plants or other ingredients is seen as essential to achieving such a transition.³ Cultured meat offers the prospect of one day substituting imperceptibly.

Cutting livestock production might sound intrinsically unappealing to farmers. Yet responses vary. Many beef and sheep farmers are vocally opposed, supporting industry campaigns for 'natural British meat'.⁴ Some promote regenerative agriculture as enabling 'less but better' meat.⁵ Poultry producers meanwhile emphasise their low carbon footprint and high feed efficiency.⁶ Some arable farmers have championed or benefited from the growth in plant-based meat and dairy alternatives.⁷

This report explores what UK farmers think about cultured meat and how the technology could affect them in practice. It summarises a two-year interdisciplinary study, analysing social media, discussing the technology with groups of farmers, working with diverse farm businesses across the UK, and modelling novel approaches to cultured meat production based on agricultural by-products (see Section 6). Our team and partners included natural and social scientists, farming representatives, cultured meat businesses, NGOs and policy makers.

We found mixed feelings among farmers, from angry reactions on social media and concerns over the technology's wider impacts, to pragmatic engagement with the specific risks and opportunities it could present.

While the discussions focused predominantly on risks, the technology was not seen as an immediate threat to livestock farming. Indeed, its impacts seem slow burn, compared to the volatility and uncertainty farmers face daily from input costs and supply contracts, geopolitical uncertainty, trade deals and exchange

rates, policy changes, business succession and weather. Cultured meat, along with other meat and dairy alternatives, may drive substantial restructuring in farming, but on a timeframe that businesses can potentially plan for, and adjust to. The technology may even hold opportunities for some farmers, creating new markets for raw materials, adding value to current waste streams or even producing cultured meat on farm. Crucially, the ways farmers can prepare for these possibilities – the keystones of resilience and agility – are nothing new.

For the growing cultured meat industry, by contrast, the stakes in its relationship with farming may be higher. Until recently, with exceptions, the technology's implications for farming have been taken for granted and the views of farmers largely overlooked.⁸ Yet understanding agricultural supply chains, and how cultured meat would compete with or complement meat from animals, is critical to providing insights into the economic viability, and environmental and social impact of culture meat.⁹

Farmers' views may also prove pivotal to this technology's viability. Bans in Italy and parts of the US show how concerns over the effects on farming communities, existing industries and food culture can shape policy, regulation and investment.¹⁰ The recent politicisation of farmer protests in Wales and England, and their seismic impact in the Netherlands, suggest the UK is not immune to such effects.¹¹

Can farmers and the cultured meat industry find common cause? We end this report by setting out three ways this might be possible.



FARM PROFILE:

Indoor pig and arable farm, Scotland

Farm profile



Enterprises:
Pigs, arable



Size in hectares:
540

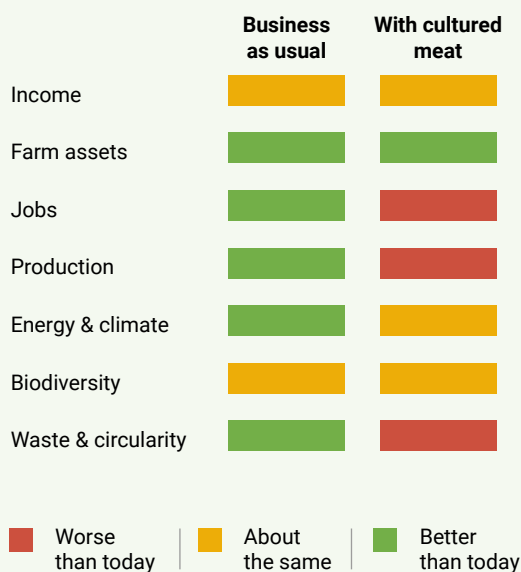


Ownership model:
Owned with mortgage

This farming couple are relatively new to farming. They took over a family arable farm and, a few years later, an opportunity came up to buy the neighbouring pig farm that produces 14,900 pigs a year. They took on considerable debt to buy the operation, but the increase in land value since the sale in 2021 means they could sell off parcels of arable land to pay their mortgage. The pigs have been a steep learning curve but they feel lucky that five skilled workers came with the business. Two of them will possibly retire in the coming 5 years. They have already recruited two new employees, one for an experienced stock man leaving for a new opportunity and another for a new role on the arable side of the business.

Their initial interest in the pig unit was as a source of manure for their arable enterprise. Now they own both farms, they are pleased to have reduced their reliance on chemical fertilisers and improved their soil. They use the straw from their arable business as bedding for the pigs. This fits with the couple's aspirations for a more circular and self-sufficient system. They are interested diversifying into a farm shop selling a range of Scottish pork products.

How do you think your business will be doing in 10 years time?



Under **business as usual**, the couple feel pretty hopeful. The arable and pig businesses complement each well now, and they are open to new opportunities, including on-farm energy production or a farm shop.

They would also be open to opportunities presented by **cultured meat**. Their options would include:

- On-farm production – might be considered, making use of a parcel of land close to an anaerobic digestion plant with good road access.
- Switching to producing rare breeds or premium products for direct sale.
- Selling the pig unit and focusing on the arable farm, if they could make this stack up economically and ecologically.

Their main concern about cultured meat is how it might affect the rural economy, particularly potential job losses.

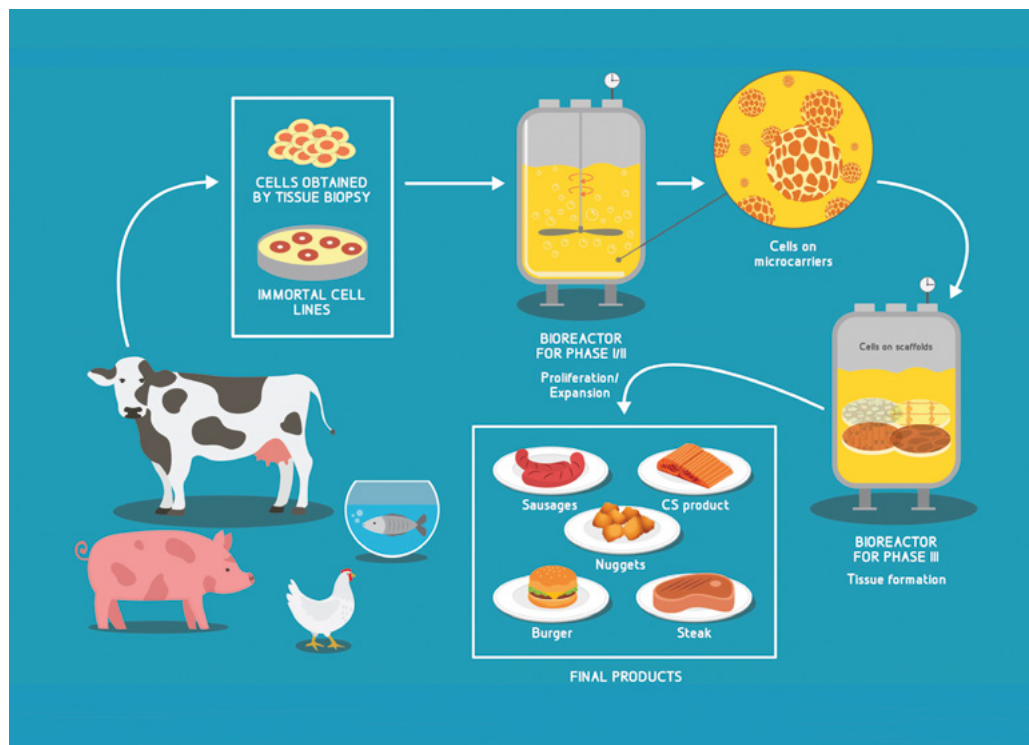
2. Cultured meat

Cultured, lab-grown or cultivated meat is produced from live animal cells grown in a broth containing the ingredients that cells need to grow and proliferate. Small amounts are already on sale in Singapore. A global race is on to reduce the cost of production and bring products to mass market.

How is cultured meat produced?

Cultured meat is a form of 'cellular agriculture'. Its production requires a source of animal cells, a medium containing the nutrients and other ingredients for cell growth, such as glucose, amino acids, trace elements and growth factors, and a means to recover and process the resulting cell mass into a food product.¹² Different companies and research groups are developing various ways to do this, although the details are often unknown due to intellectual property restrictions. A simplified overview is shown in Figure 1.

Figure 1: The process of cultured meat production¹³



Sources of cells can range from primary muscle or fat cells through to specialised cells with the capacity to become any tissue.¹⁴ The life span of the cells depends on factors including the tissue source. Unless the cells are types of stem cell that are naturally able to divide indefinitely, they are genetically modified to be ‘immortalised’, with fresh batches periodically obtained by biopsy.¹⁵

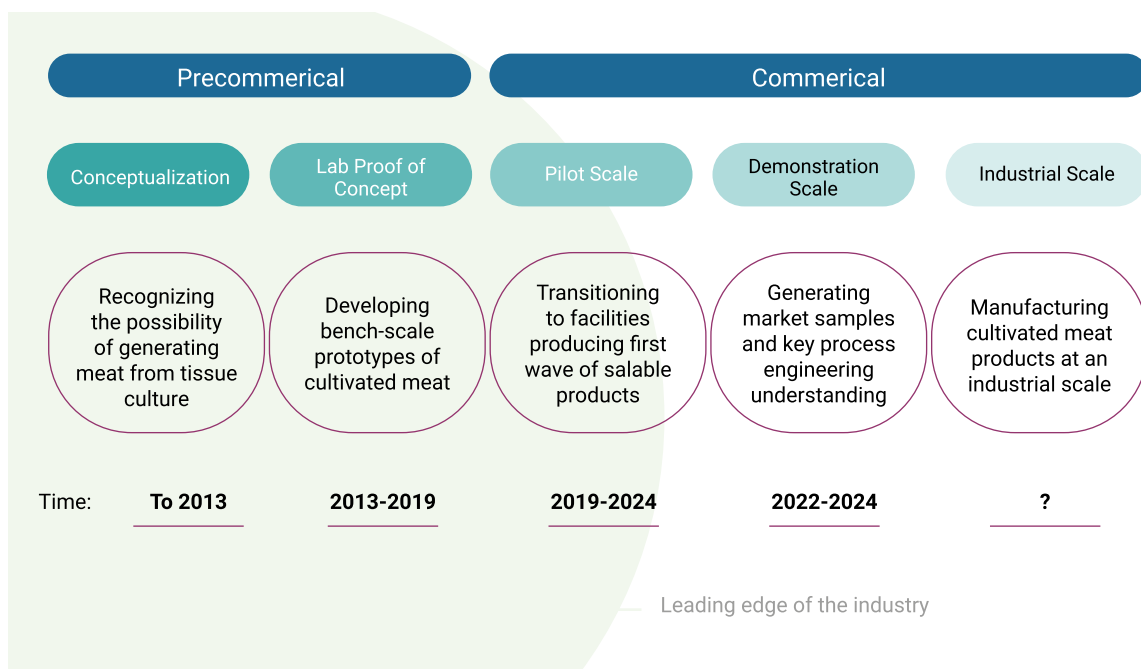
The efficiency, cost and impact of producing cultured meat depends heavily on the growth medium used. Media are estimated to account for around a third of the final product costs.¹⁶ Amino acids and glucose account for most of the media costs, followed by growth factors. Work to reduce media costs is ongoing. This includes replacing pharmaceutical-grade ingredients with food-grade alternatives, and animal-derived growth factors – most controversially from Foetal Bovine Serum (FBS) – with more ethically acceptable alternatives.¹⁷

The cells can be grown in suspension in vats of medium, creating a large mass that can then be processed into products such as burgers and sausages, potentially combined with plant-based or other ingredients, or 3-D printed. Additionally or alternatively, cells can be grown on a solid surface, known as a scaffold, which can be either a recyclable but inedible material such as polystyrene, or an edible scaffold made from protein, cellulose, soya or keratin.¹⁸ Where edible scaffolds are part of the final product, their safety, allergenicity and other potential impacts on health need to be considered.¹⁹

How close to market is cultured meat?

The technology to produce cultured meat already exists. The industry's challenge now is to produce it in a way that is economically competitive and to develop the infrastructure for it to reach consumers (Figure 2). Since 2022, cultured chicken has been on sale in certain restaurants in Singapore and, this year, in retail packs from a butchery.²⁰

Figure 2: Scaling up cultured meat production²¹



The exact costs of producing a kilogram of cultured meat are hard to determine due to variation in production methods and commercial confidentiality. Projected cost estimates rely heavily on assumptions about future innovation, the scale of production and the sources of key inputs. Estimates range from \$5–\$520/Kg (£4–£410/Kg).²² But around £2.5 billion has already been invested in bringing the cost down and getting cultured meat to market.²³ Around the world, the pace of regulatory approvals is also picking up. Cultured chicken has now been approved for human consumption in the US²⁴ and cultured beef in Israel.²⁵ In the UK, the Food Standards Agency received its first application to approve cultivated beef in Summer 2023.²⁶

So far, the industry has largely developed in isolation from farming and food supply chains, using pharmaceutical ingredients and suppliers. Yet, if it is to be commercially viable, cultured meat production will have to shift to food-grade ingredients and supply chains. It will also have to become more integrated, not only with established food processing and retail systems, but also with agriculture.

Consumer acceptance

Consumer perceptions and potential acceptance of cultured meat have been widely investigated.²⁷ Consumer responses depend on a number of factors, including ethnicity and culture.²⁸ Generally, those surveyed have tended to “perceive the benefits of cultured meat as accruing to society, but the risks accruing to themselves”.²⁹ For example, participants typically have positive feelings about the potential animal welfare and environmental benefits of cultured meat, when compared with conventional meat, though the picture is more mixed when compared with other alternative proteins. However, trust in the food industry, safety, nutrition, fear of the unknown and societal impacts (on farming, rural communities and food culture) remain barriers to acceptance across cultures.

More information and positive framings of cultured meat increase acceptance. For example, describing cultured meat as “high tech” invites more negative responses than describing the “societal benefits”.³⁰ In studies, most consumers (up to 65%) have said they would try cultured meat, but the figure fell significantly (as low as 11%) when asked if they would replace traditional meat.³¹

All or nothing?

Discussions of cultured meat sometimes imply a binary choice, that it either completely replaces traditionally reared meat or all comes to nothing. As one of the farmers involved in this study said:

“We’re terrible as the British public and as the human race, that we ping pong between extremes. Climate change; get rid of the animals, can’t do that; health reasons. We just keep on, ping pong. We never sort of sit down and work out what the middle ground is and get to that.”
(Partner Farm 2)

The emerging cellular agriculture industry and its advocates have contributed to this polarisation, with promises to ‘disrupt’ animal agriculture and stark predictions that, for example, “by 2030, the number of cows in the US will have fallen by 50% and the cattle farming industry will be all but bankrupt”.³² In recent years, there has been growing interest within the cultured meat industry in contributing to a ‘just transition’ within farming and food systems.³³ However, many cultured meat businesses still have the ambition to decouple meat production entirely from depending on animals, not only developing alternatives to FBS but also through using immortal cell lines.³⁴

This study started from a different premise – that even if cultured meat or other alternative proteins were to play a part in substantially changing diets and getting the UK on track to meet net zero and biodiversity targets, with livestock numbers falling accordingly, cultured meat and traditional livestock farming will likely coexist for decades to come. So, it makes sense to consider their interconnections and potential synergies rather than assuming one can only exist without the other.



FARM PROFILE:

Fresh produce grower, Scotland

Farm profile



Enterprises:
Soft fruit, top fruit, arable



Size in hectares:
628

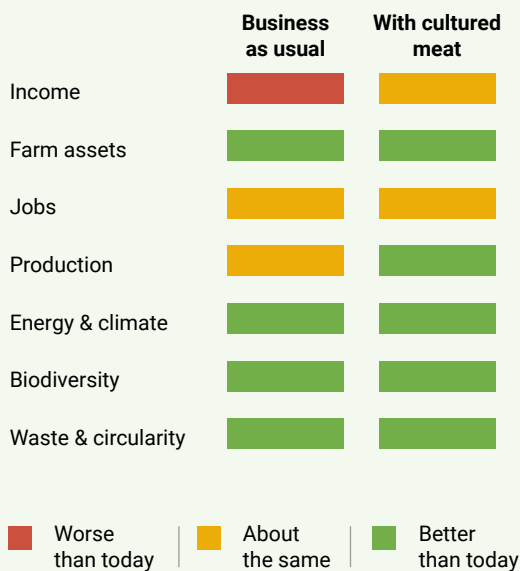


Ownership model:
Part owned, part rented

When this farmer took over the business from his father, he decided to switch from arable and dairy to fruit production. He now has a mix of soft and stone fruit, primarily grown under contract for retailers. He also has on-farm processing to sort, pack and ship the fruit, with lorries arriving to transport fruit to all the major supermarket chains. There is a farm shop and café, selling produce grown on the farm and locally. They generate electricity from solar and CHP's and recently invested in battery storage to help reduce costs. They use a lot of water (400,000 m³/year).

Like most fruit growers, their biggest challenge since Brexit has been finding labour. At the height of the picking season, the farm can employ up to 600 people, although this drops to around 100 during the winter. To adapt, they have increased wages and scaled back production. As it is now less likely the same people will return year after year, it is more difficult to support career progression or peer training.

How do you think your business will be doing in 10 years time?



For these reasons, the farm is worried about **business as usual**. Without access to more reliable labour or better-value contracts, the farm may well struggle in the next decade. So, they are looking for alternatives and are open to the opportunities that cultured meat might present.

Because of its processing facilities and established supply chain, the farm could be well suited to producing **cultured meat** on site. It has existing relationships with supermarkets, is located on a major road and has an existing workforce that could be retrained. The farm could also consider valorising some of its waste produce. Soft fruit such as strawberries and raspberries have a high pectin content, potentially an important ingredient in cultured meat production. Because the fruit is easily bruised, some currently goes to waste.

3. What concerns farmers

Some might think farmers would mainly worry about the competition from cultured meat. But those who spoke to us were more concerned about its wider social impacts than the effect on their bottom line. Talking to farmers can shed light on the challenges of fulfilling the promises made for cultured meat, and how it might be possible to overcome them.

A threat to the system

Between Autumn 2022 and Spring 2023, we discussed cultured meat with 80 farmers in seven focus groups, reflecting diverse farming systems across the four nations of the UK (see Section 9).³⁵ We then worked with nine case farms – two of which had participated in the focus groups – to explore in depth how they might adapt their businesses in a future with cultured meat.

Most of the farmers in the focus groups reacted first as consumers or citizens rather than producers. The issues they raised echoed wider public concerns – is it safe, is it natural, will it be healthy, who is in control and who benefits?³⁶

When prompted to consider how it might affect their own businesses, their answers ranged widely, highlighting direct and indirect effects on their livestock and other enterprises, practical challenges to fulfilling the promises made for cultured meat, and potential unintended consequences for farming, rural life and wider society. The farmers who spoke to us expressed six main concerns.

Uncertain

Many questions remain about how cultured meat could compare on cost and quality with livestock or plant-based proteins and, therefore, at what point and to what degree it enters the market? Would it substitute for meat in processed foods, compete with gourmet products or supplement meat-eating? Cultured meat businesses are developing propositions across the spectrum. Until it is clearer which are more likely to succeed or fail, it is hard for farmers to anticipate how the technology might affect them.

"Depends which market they're aiming at. Is it the mincemeat, the cheap end of the market or are they aiming at the steak end of the market? And my first impression is they're probably aiming for that lower end of the market, which means that maybe West Country, grass-fed systems might come [out] a little bit better." (Focus Group F, South West, Livestock)

Unreliable

Farmers expressed concerns about the data available on the technical viability, economics, and environmental and health impacts of cultured meat. There was a demand for impartial information that is transparent about assumptions and uncertainties.

"We should be pinning them down on that now and saying look ... you are now telling us this is the future; you cannot keep hiding behind commercial confidentiality of your process. You've gotta tell us what ... what it means in terms of its inputs and its outputs." (Focus Group C, National, Extensive Livestock)

Unrealistic

To date, cultured meat businesses have mainly focused on developing manufacturing systems, with less attention on the supply chains for source ingredients and final products, or on how assumed effects on diets or land use would be realised in practice. Farmers, already grappling with such real-world complexities, challenges and compromises were keen to ensure comparable issues were anticipated for cultured meat production. This kind of reality check is not only crucial to comparing livestock and cultured meat fairly, but also for the technology to make good on its potential.

"...Probably people wouldn't think about it because if they're ... gonna have it, it stitched or whatever, and they're young [calves with] lower immune systems. Plus, if they've had to have been sedated or held or whatever to... to keep them still for the procedure, then would that not then give them more risk of picking up infection?..." (Partner Farm 7 speaking about the welfare considerations of cell harvesting)

Unintended

The farmers who spoke to us were concerned about unintended effects on their business or the local community, or the overall impact of cultured meat. Table 1 gives examples of some of these possible knock-on effects.

So what is the whole idea about cultured meat? Is it to stop farming as we know farming? (Partner Farm 1)

Unfair

A common concern was over who benefits from cultured meat. There were suspicions that it could further consolidate the power of large food corporations, at the expense of farmers and the wider public. Rather than being a 'gamechanger', some feared that it could continue to exacerbate the industrialisation of food production and its disconnection from consumers and communities, seen as 'Americanisation'.

"I do wonder if [with] the production of more ... cultured protein there are going to be much larger companies that are going to ... be pushing for this and they will own the intellectual property, they will own the rights to that, they will own the formulations, and that's something which reinforces a sort of a hegemonic position. If you're interested in agroecology ... regenerative farming, you're interested in small-scale farms, I'm not quite sure where that leaves those farmers."
(Focus Group E, East/E. Midlands, Arable/Mixed)

Unnatural

Some of the farmers we spoke to contrasted the 'naturalness' and authenticity of the meat and other foods they grew with cultured meat produced in a laboratory or a factory.

"That's a Frankenstein food. What they're trying to create there is like something I'd be trying to wash out of a shed and throw disinfectant on it to try and kill it. No, definitely not." (Focus Group A, Northern Ireland, Livestock)

Table 1: Potential unintended consequences of cultured meat as raised in farmer focus groups and interviews

Issue	Implications
Carcase balance	If cultured meat substitutes for cheaper cuts such as beef mince, this will nevertheless affect the value of the whole carcase, and the viability of producing more expensive cuts of meat. Farmers cannot raise cattle just to sell steaks, even if demand remained for these.
Cull cows / dairy bred beef	If cultured meat replaces cheaper cuts of meat, which currently go into mince, the value of cull cows and dairy-bred beef animals could fall. This would mean reduced income for many dairy businesses and could increase the environmental footprint of dairy products.
Commodity markets	If cultured meat is produced at scale, it could create demand for inputs including soya, grain and energy, with knock-on effects for other users and producers of these inputs. These systemic effects need considering in understanding the potential overall impact of cultured meat.
Non-food livestock products	Alongside meat, dairy and eggs, other products including soap, leather, cosmetics and pet food are produced from animals. Any implications for their production need to be understood in assessing the overall impact of cultured meat.
Animal health and welfare	Poor cell harvesting techniques could pose risks to animal health and welfare and to public health. The process would need transparent regulations with clear oversight and auditing.
Regenerative agriculture	Animals are crucial to nutrient cycling in low-input regenerative farming systems. Fewer animals on farm would mean relying more on artificial fertilisers. Farmers also raised concerns about the aesthetics of the countryside and cultural impact of removing animals from the landscape.
Supply chain consolidation	If production and intellectual property are owned by a few large companies, they could enforce unfair terms on the supply chain. Farmers worry they could find themselves with less decision-making and negotiation power, or with worse contracts and agreements.
Rural economy	If cultured meat displaces livestock farming there could be reduced need for local services (e.g. fencers, vets) leading to job losses and knock-on effects for local amenities in rural communities that rely on livestock farming.
Human nutrition and health	Farmers questioned the nutritional content of cultured meat, especially the micro-nutrient levels, and how this compares to farmed meat. They also wanted more information about the effects of consuming cultured meat on human health.
Arable markets	Reducing or replacing livestock would impact the demand for arable crops and grain used for animal feed, which makes up a substantial proportion of many farms' income.



FARM PROFILE:

Welsh Dairy Farm

Farm profile



Enterprises:
Dairy



Size in hectares:
182

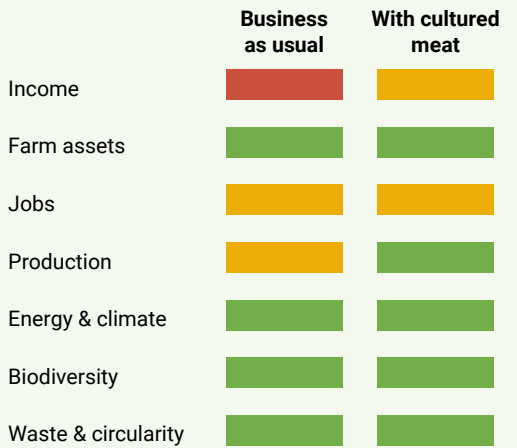


Ownership model:
Partnership

Succession planning is high on the agenda for this farm in Wales, with the farming couple keen to reduce their workload over the next ten years. Their eldest son has recently moved abroad and does not want to take on the farm. The farmers have been thinking about share farming (more than one farming business operating on the land) and mentoring young local new entrants.

The farm is very embedded in the local community and the farmers worry about the impact to local businesses if they, and others like them, no longer farmed the land. They are passionate about reconnecting young people in towns and cities to farming through food.

How do you think your business will be doing in 10 years time?



■ Worse than today |
 ■ About the same |
 ■ Better than today

Under **business as usual**, these farmers will stay involved on the farm but do less. The farm would still support grazing livestock due to its history and geography. While their previous succession plans have just been upended, they have started to implement changes to their milking system which should help secure the farm's future in dairy, whether they keep managing it or start share farming.

Whether **cultured meat** becomes a threat or opportunity would depend on how it enters the market. The farmers could see some opportunities to supply the industry but thought a small business such as theirs would have little role. They worried about the value of bull calves and cull cows (animals that are sold from the herd for variety of herd management reasons) if cultured meat replaced cheaper cuts meat, but thought there was a chance consumers might reject it.

4. Areas of interest for farming

As well as potential new markets, the farmers who spoke to us saw less obvious ways they might adapt their businesses to a world with cultured meat. Some considered possible new paths for the technology, such as adding value to agricultural waste streams. Yet, regardless of any opportunities cultured meat may offer, producing food and caring for livestock remain central to their identities.

Adapting to cultured meat

Farmers are used to the unpredictable.³⁷ The weather, markets and input costs are constantly in flux, requiring them to adapt their business from week to week and year to year. Those we spoke with in focus groups and interviews mostly saw cultured meat as one more thing they might have to adapt to. In the in-depth interviews, some imagined ways they could switch production or systems, and others thought, in certain circumstances, cultured meat could present opportunities. Some of these are outlined in Table 2.

What was clear, however, was that in order for the farms to take up these opportunities, they would need to weigh up a whole range of caveats and unanswered questions. These included the market share of cultured meat and what it was substituting for, the terms and conditions on offer, any government support and ultimately how the public received cultured meat.

Table 2: Potential opportunities presented by cultured meat for UK farming

Input supply to cultured meat production	Animal cells	Cultured meat production currently requires a source of animal cells. This offers opportunities to supply these, either one-off or ongoing.
	Ingredients for growth media	Farms could supply food-grade ingredients (e.g. glucose, amino acids, trace elements/minerals, growth factors) for the growth media used for cultured meat production. This could be from repurposing existing crops (e.g. feed wheat for glucose, oilseed rape for amino acids) or incorporating new crops into rotations (e.g. lupins).
Waste valorisation	Crop by-products and residues	Straw contains molecules (e.g. sugars, minerals) that could be used in cultured meat growth media.
		Oilseed rape meal/cake contains high levels of amino acids that could be extracted for use in cultured meat medium.
		Plant extracts such as cellulose, protein and pectin can be used as 3-D scaffolds in the production of structured cultured meat products, e.g. steaks.
Competitive edge	Animal by-products	Abattoir by-products such as blood, hooves and horns contain useful compounds such as growth factors and amino acids that could be used in cultured meat growth media. Manure contains useful compounds including amino acids that could be extracted for use in cultured meat growth media.
	'Real meat'	Re-connect with the public by telling the story of 'real meat' from the countryside.
	Unique Selling Point (USP)	Promote meat as 'special' due to its origin, high welfare or rare breed.
Supply chain relationships	Premium	Achieve a higher price for 'real meat' compared to cultured meat.
	Contractual agreements	Renegotiate or develop new, fairer agreements that work for both parties.
		Review the role of intermediaries, such as consultants and supply chain representatives, so as not to repeat issues of unfair distribution of power (e.g. concentration of power in the dairy or poultry supply chains).
		Develop local farmer co-operatives to supply ingredients or produce cultured meat.
New markets	On-farm production of cultured meat providing options for direct sales or new supply chains for finished products.	
	Producing ingredients for cultured meat opens new markets and supply chains.	
Private investment	Energy contracts	Use land or buildings that are either currently unused or that may be freed up by reducing livestock numbers to address UK energy needs – e.g. solar, wind, and battery storage. Not necessarily for cultured meat production.
	On-farm production of cultured meat	Investment in 'stainless steel' production units – e.g. bioreactors and chilled or frozen storage.
		New build or retrofit to existing infrastructure.
Attract new labour/skills	Train existing labour force with new skills.	
	Recruit and employ specialist labour with transferable skills to farming (e.g. engineers, data scientists)	

Land, livestock and identity

There were many instances where the farmers who spoke to us expressed concern for animal welfare and highlighted issues with using animals in cultured meat processing. In some systems, livestock were seen as an asset that could be sold or reduced in numbers, if needed. But for many, livestock were a critical element of a regenerative system, returning valuable nutrients to the soil and crops, reducing reliance on costly artificial inputs and diversifying income.

"... all farmers care about their stock... Because it is a living animal and you [have] lambs and you had your calves that you fed or whatever, but at the same time, like you did love them, and you cared for them and whatever. But at the same time, you knew where they were they were destined. I think that's a very hard thing for people to...to kind of understand, if you haven't lived it. But, you know there's no farmer that doesn't care about their livestock." (Partner farm 6)

While many of the farmers could think of ways cultured meat might bring new revenue streams, hardly anyone in the focus groups or the interviews suggested they would give up caring for animals and make cultured meat their sole business. The relationship between the land they farm, their livestock and their role as food producers was an important part of their identity, not just their job.

"The thing we have going for us is never, ever going to be eclipsed by a cultured meat business; you know we will always have people interested in nutrient-dense, high quality, nature-promoting foods ... anyway back to my wagtails ..."
(Focus Group 4)



FARM PROFILE:

Regenerative beef and arable farm, Staffordshire

Farm profile



Enterprises:
Beef, arable



Size in hectares:
108

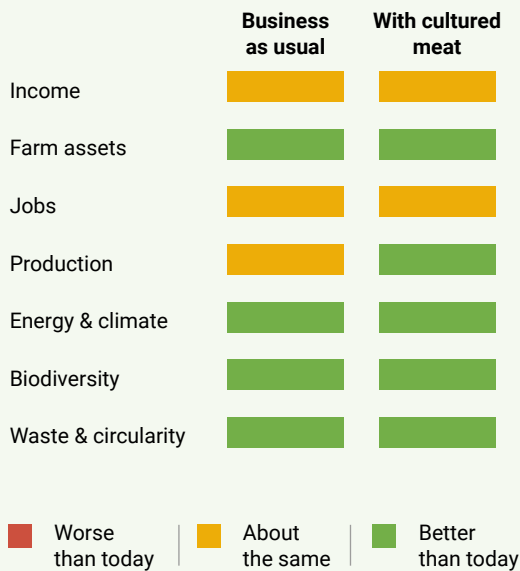


Ownership model:
Owner

This farmer is the third generation of his family to farm the land. He and his partners only took over three years ago, and are passionate about using regenerative farming methods to improve the soils, ensuring the land can be passed on in better condition than it was found. The arable rotation includes milling wheat, malting barley, oats, oilseed rape and winter beans.

Grass and clover mixes are included in the rotation. These are grazed with Aberdeen Angus-crossed cattle. Weaned calves are sourced from several dairy herds, which are sent for finishing by 24 months. This is on a contract with a major retailer, but challenges with the process have led him to trial a Wagyu-cross herd.

How do you think your business will be doing in 10 years time?



Under **business as usual**, he has clear goals to work on improving his farm's soil, biodiversity and productivity. He is open to new ideas and already has new ventures lined up.

He would be concerned if the growth of **cultured meat** put him under pressure to reduce livestock numbers, not just commercially but also because of the knock-on effects for his regenerative system. He also has concerns about supply-chain consolidation.

The farm is well located if small-scale cultured meat production proves viable and has planning permission for new sheds that might be suitable. However, this would require substantial investment. Refocusing the business to meet demand for 'naturally reared meat' would be more cost effective.

5. Using waste or by-products

One of the most promising opportunities for linking farming with cultured meat production is using farm waste or by-products as ingredients. This is just one way the two industries could complement each other, and our preliminary findings suggest it is worth exploring.

Economic impact

The cost of the pharmaceutical-grade ingredients used in growth media, particularly amino acids, is a major barrier to affordable cultured meat. We wanted to explore whether there were viable alternatives from the farming sector which are currently going to waste. Having looked into a wide range of possibilities, we focused on:

- Oilseed rape meal – the solid residue left after oil extraction, which is used as animal feed or as fertiliser.³⁸
- Hoof and horn meal – an abattoir by-product currently used in fertiliser and pet food.³⁹
- Bovine blood – another abattoir by-product that mostly goes to waste, though some is used in food and pet food.⁴⁰

To estimate how much difference these alternative growth medium ingredients could make to the cost and impact of producing cultured meat, we used DMEM (Dulbecco's Modified Eagle Medium, which is a widely used, basic growth medium) as a baseline formulation. For each of the comparisons, we substituted the relevant amino acids in DMEM with appropriate amounts of those obtained from the alternative ingredients, and assumed all the other components of DMEM would come from other sources at pharmaceutical-, food- or feed-grade prices. For full details, see Appendix 1.

Table 3 compares the cost of producing one litre of growth medium from the three alternative sources of amino acids. The cost of producing one litre of DMEM is included for comparison. The results suggest that using agricultural feedstocks for media preparation could be cheaper than DMEM, and that large savings are potentially available from using food- or feed-grade sources.

Table 3: Comparison of total media costs (per litre wet basal media) formulated using valorised sources of amino acids and pure ingredients against costs for basal DMEM at various grades

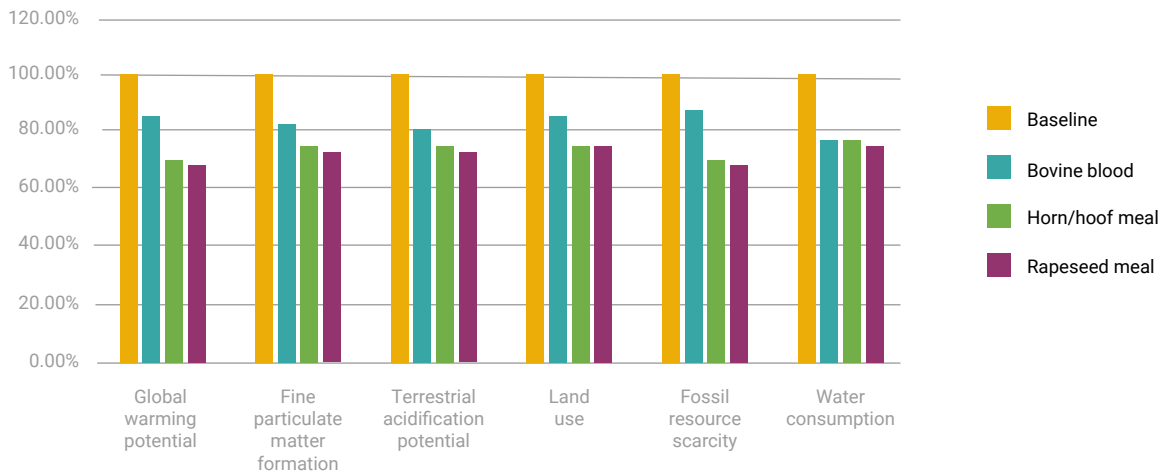
Amino acid source	Valorised amino acids		Pure amino acids	Total cost per litre final wet basal media		
	Wt.% of the total amino acids	Wt. % in final dry basal media	Wt. % in final dry basal media	Pharmaceutical grade	Food grade	Feed grade
Oilseed rape meal	52%	4.91%	4.49%	£1.81	£0.04	£0.02
Hoof and horn meal	68%	6.36%	3.04%	£1.43	£0.03	£0.02
Bovine blood	51%	4.82%	4.58%	£1.83	£0.04	£0.02
Baseline: cost of basal DMEM without valorised ingredient sources				£4.67	£0.05	£0.03

Environmental impact

As well as lowering the cost of production, could using agricultural waste or by-products reduce the environmental footprint of cultured meat? DMEM accounts for more than half the impact of cultured meat across most categories, including water consumption and global warming potential. So, reducing the impact of DMEM could substantially reduce the impact of the finished product.

We analysed the 'cradle-to-gate' life-cycle impact of the cultured meat produced with the same alternative formulations. This includes factors such as energy, scaffold material and oxygen, but does not include building construction or equipment manufacturing. We assumed that 140 litres of growth medium would be needed per kilogram of cultured meat.⁴¹

Figure 3 compares all three formulations against baseline DMEM. The impact of baseline DMEM has been set at maximum (100%). The impact of the other media are lower, with alternative ingredients outperforming the baseline DMEM across all impact areas. While this suggests it is worth investigating further, it is important to keep in mind that the data we used came from a range of different sources, and have not all been tested experimentally. For full details and limitations, see Appendix 2.

Figure 3: Comparison of valorised growth media and baseline (DMEM)

The economics of on-farm production

As it might be possible in theory to produce cultured meat on farms, and as some of the farmers who spoke to us were interested in this, we also looked at how the overall cost of producing cultured meat would be affected by the size of the manufacturing plant. We found that cultured meat produced at that small scale would cost about 30% more than the same product produced in a larger factory (see Appendix 1). This was down to the higher capital costs and more expensive inputs such as energy use and labour.

For small-scale, on-farm production to be realistic, there would need to be a drive towards capital cost reduction. This is already a major focus for cultured meat companies, as they try to maintain quality and safety while shifting from pharmaceutical-grade equipment and engineering standards to systems more suited to food production.



FARM PROFILE:

Beef and sheep, Northern Ireland

Farm profile



Enterprises:
Beef, lamb



Size in hectares:
92

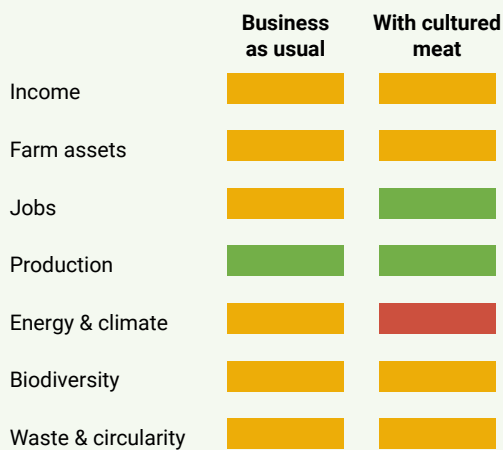


Ownership model:
partnership
(family based)

The farm has been in the same family for around 200 years. For most of this time, the main enterprise has been sheep with some cereals, raising Northern Irish lamb on the hillsides. Now though, the farmers are in the process of transitioning to beef, reasoning that cattle are easier to manage as they work towards retirement and he runs his off-farm business.

The couple have two children who work locally. Although neither were interested in taking on the farm when they were younger, they are now considering becoming more involved. However, the business may not be able to support them all. Although not part of any certification schemes, the farm is low-input, grass-based and run traditionally. They sell most of the lamb via a local farmer co-operative and the beef to a processor, taking the going price.

How do you think your business will be doing in 10 years time?



■ Worse than today |
 ■ About the same |
 ■ Better than today

Under **business as usual**, the farmer imagines the farm will continue as it always has, dialling up or down the farming enterprises and amount of work needed off the farm, depending on how many people the business needs to support.

This farmer cannot see **cultured meat** taking off in the next ten years. He thinks few people will want to eat it, so it will end up, at most, a niche product. However, if it takes off, he is concerned that it would be controlled by a small number of organisations and could have a big environmental impact because of energy requirements. As a last resort, he would consider selling the farm, but would want to avoid this if at all possible.

6. Farm resilience

What makes one farmer see cultured meat more as a threat and another look for opportunities? It is too early to tell whether cultured meat products will have a bigger impact on poultry or ruminant farming, or on intensive or extensive systems, but there were common factors among those who felt most at risk and those who felt more able to respond. This can point to the types of farms that may need more support if the UK gives cultured meat the green light.

The farmers we interviewed in detail were generally positive, seeing their current positions and future options in the round. This was despite a backdrop of uncertain international trade, volatile markets, unfair or non-existent contracts, unpredictable weather patterns and perceived hostility in the media. They took a relaxed but pragmatic approach to some of these general risks facing farm businesses, particularly the large amounts of debt, low profit margins, and other volatile elements of running a business.

What builds resilience?

Factors in the personal and business resilience of these farmers involved in the study included:

- **Relationships** with family, staff and the local community, and with processors and retailers to get early intel or better terms.
- **Stacking enterprises** to spread risk and diversify income, which was more evident in nature-focused farming approaches and usually involved livestock.
- **Experimenting**, investing and taking part in research, which also came with financial benefits like tax breaks. This reflected flexibility and an openness to new opportunities.
- **Succession** plans. Attracting and keeping a new, young, skilled workforce was also something nearly all case farms discussed.
- **Balancing** freedom and security. Some valued the security of long-term contracts, and others the freedom to operate that came from having no contracts or just short-term relationships.
- **Risk management** using performance data, weighing up concerns against capital outlay and perceived return, to inform decisions.

Despite potential disruptions to markets, income and business models from technologies such as cultured meat, the farmers who spoke to us generally felt confident in being able to adapt their businesses, and were open to exploring responses they had not anticipated. They were proud of their sectors and saw themselves getting on the front foot with cultured meat as with other emerging challenges, such as the responsible use of medicines:

"I think we're pretty resilient, I mean like ... Both medication that the birds get on ... It's ... it's minimal, really like we're ... we're pretty good. I think we need to pat ourselves on the back a bit more, the industry, for the biosecurity, I think we're top of the game you know with that." (Partner Farm 6)

Risk and precarity

A range of factors made some farms feel more vulnerable to change and disruption:

- **Tenants** had fewer assets to underpin their financial security. *"You know low, low asset value. The only assets we really own are livestock." (Partner Farm 9)*
- **Illiquidity**, with capital locked in buildings or land, and limited cash or income to take risks and invest. *"But they've sort of scaled back out of the commercial dairy herd into that, so they already have the equipment. It's not so much of a step for them, whereas for us it would be quite a step forward. Capital wise and then you've got the ... the risk that you've got to begin with, you might not have very much income. How do you sort of offset?" (Partner Farm 1)*
- **Contracts** incurred a risk for many of the farms. Some were 'price takers', subject to supplying contracts at a price set by the buyer. Others were unable to refuse to supply an order to keep a contract with a retailer, processor or integrator, which often came with many stipulations and standards, including on animal welfare but also carbon auditing. One case farm was dealing with a market that gave no notice of changes or a back-up plan if they pulled out from buying the produce, which was the norm for that sector.
- **Intermediaries** providing poor information and support put some of the farms at a disadvantage. At least three case farms (dairy, fruit and beef) were concerned with the amount of power they held.
- **Lack of a successor** and uncertainty about long-term changes and investment left some of the farms feeling vulnerable about the future. Some farms had been 'shaken up' over succession or had no succession plan, others were adamant they would keep family out of the labour force and take a purely business approach to staffing.
- **Large debts** and the associated bank charges were seen as a major strain on income for some farms.

The fact that all the case farms in this study had considered their longer-term future and were open to adapting as opportunities arose may indicate a degree of selection bias. Nevertheless, we found a degree of acceptance, or realism, of a need to have an exit plan if things did not work out in future.

"... got just over 10 years left on our tenancy, so the next 10 years are going to be really crucial to us. So it feels like one last big push. So yes, and that's why now we're, you know, we're diversifying, we're bringing more people in, we're taking a few more risks. We're trying to stay positive, working hard. And that's happening now. If it fails ... And there could be a number of different reasons that things fail ... Then we're ready to leave farming in the next 2-3, 5 years. While we're young enough to do something different." (Partner Farm 9)



FARM PROFILE:

Conventional arable farm, Gloucestershire

Farm profile



Enterprises:
Arable



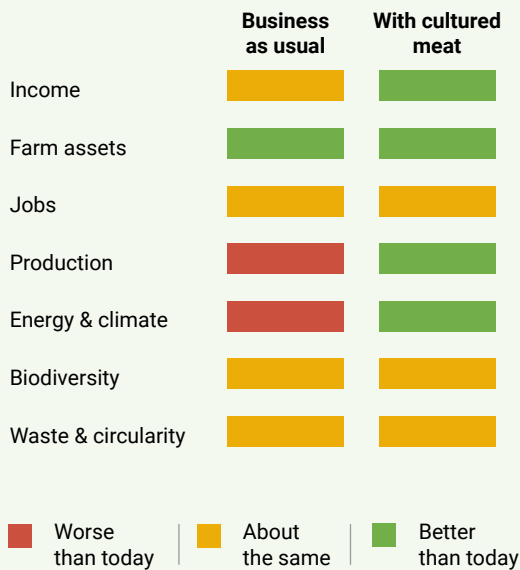
Size in hectares:
665



Ownership model:
Partnership
(family owned)

This farm is in the middle of transitioning from father to son. It is fully arable, producing wheat, barley, porridge oats and oilseed rape in a six-year rotation. Most of the wheat goes into the animal feed market although, in good years, it sometimes makes milling grade. Under **business as usual**, the profitability of the business largely depends on the cost of inputs and the price of feed wheat. Both are out of the farm's control, being influenced by everything from global weather to geopolitics.

How do you think your business will be doing in 10 years time?



As the son prepares to step into his father's shoes, he is considering how to take back more control of the farm's prospects. There are large Victorian barns which he is thinking of converting to offices, a wedding venue or holiday lets, or using for batteries powered from their existing solar arrays. This would make the farm self-sufficient in energy throughout the year and generate income by selling into the grid.

The barns could also be used for **cultured meat** production. Additionally, the farm could supply cultured meat producers with arable by-products, such as straw. They currently plan to chop their straw and plough it back into the soil, adding carbon and nutrients, but this will increase their diesel bill. The farmer is looking for an alternative to oilseed rape in the rotation and so would consider growing a leguminous crop such as lupins as an amino acid source for cultured meat production. This new market could become increasingly important for the farm if cultured meat reduced reliance on traditional livestock farming, and its dependence on grain for feed.

7. An inclusive debate

With some in the cultured meat industry promising to “end animal agriculture”, it may seem inevitable that farmers are cast in opposition.⁴² Yet, our conversations with farmers found potential synergies between these two industries and communities, which could underpin a different debate and open fruitful new possibilities.

Polarised visions of the future of meat eating and land use are a source of frustration and concern for those committed to addressing the environmental and social crises linked to food.⁴³ There are many who argue that combining ‘land sparing’ and ‘land sharing’, as well as changes in technology and behaviour, will more effectively meet environmental, health and social goals than any purist approach in isolation.⁴⁴ The polarisation and politicisation of debates around cultured meat could force decision makers into ‘all or nothing’ choices, and close off more nuanced possibilities for how the technology could be developed to complement farming or healthier diets.

The cultured meat industry shows growing interest in mitigating such polarisation, because it is a major risk to market access and investment.⁴⁵ Likewise, advocates of agroecology may see common cause in avoiding any controversy that cultured meat might generate, as the fallout could in turn hinder broader changes in agricultural policy or public interest in ‘less but better’ meat. But should farmers in general share that interest?⁴⁶ Our findings would suggest some farmers think so. While many were concerned and sceptical about cultured meat, some also saw opportunities that would only be available if farmers were actively engaged in shaping the technology and its policy environment.

The potential for polarisation is evident in farmers’ online discussions of cultured meat. In our sample of UK food and farming-focused online news, media and influencers, between 2017 and 2023, there were 76 tweets mentioning ‘cultivated’, ‘lab-grown’ or other terms meaning cultured meat (Box 1). The majority of these were relatively neutral, from media outlets resharing industry news. However, the comment sections paint a picture of two warring factions, with posts such as: “They want lab-grown meat and processed foods that will leave our society even more unhealthy as the multi-national companies get rich off the backs of the poor.”⁴⁷

While the strong statements on social media tell us little about what the majority of farmers think, they show how explosive the topic can be. There are growing attempts in the US to bring cultured meat into wider culture wars, thereby further promoting polarisation of policy, regulation and market development.⁴⁸

For now, however, very few farmers based in the UK are talking about cultured meat publicly. Over the same four-year period, we found only 12 posts referring to cultured

meat on the 'The Farming Forum', the largest of its kind in the UK. By comparison, in just the single week leading up to writing, there were 122 mentioning 'rain', and 10 mentioning 'mental health'. This could be because few farmers are worrying about cultured meat, or because it is a complex and inflammatory topic that few want to charge into.

Constructive debate and collaboration are hard to achieve on social media. While we found farmers willing to discuss the pros and cons of the technology face-to-face, whether in focus groups or on their own farms, this does not mean such nuanced conversations could readily be replicated online. Yet the way companies, scientists and other proponents of cultured meat talk about the relationship between the technology and farming can either fuel or mitigate the risk of further polarisation.

Our research both highlighted ways of communicating about cultured meat that contribute to distrust or scepticism among farmers, and reflected on the alternative. Each theme that fuels the risk of polarisation implies more inclusive and empathetic ways of engaging with the farming industry that mitigate the risk of polarisation (Table 4).

Box 1: Media analysis

Building on previous media research on cultured meat,⁴⁹ our research explored the narratives of cultured meat in UK food and farming media. We wanted to know who the 'loudest' voices and media outlets were, and what stories are being told about cultured meat.

The most prominent voices were those from the cultured meat industry and industry-adjacent scientists, offering 'boosterist' accounts of the economic, environmental and social benefits of cultured meat. The farming trade media often reproduced such industry news without much critique.

The online farmers in our sample viewed cultured meat mainly as a threat to traditional livestock farming and positioned traditionally produced meat as 'good food'. Some took their critiques further by suggesting that cultured meat and its industry are designed to destroy the farming sector, put farmers out of business and make consumers eat "lab-grown factory slop". We also found a growing set of increasingly loud online farming voices reinforcing established and influential conspiracy theories associated with wider culture wars.

Table 4: Polarising vs collaborative communication

What fuels polarisation	What might support collaboration
<p>Hype: The cultured meat industry is in its infancy, with plenty of big questions still to be worked out. Yet, claims such as cultured meat “is better for the planet”⁵⁰ are common, and when hyped by the media, they can look like promises to “save the planet”,⁵¹ “disrupt the food industry”, and radically and imminently “change the way we eat”.⁵²</p>	<p>Acknowledging uncertainty: Being up-front about what still needs to be worked out, and inviting farmers and other stakeholders to help shape the technology’s future.</p>
<p>Sweeping statements about farming: Comparative claims about the potential benefits of cultured meat have been central to the industry’s account of itself. While generalising makes sense in some contexts, farming systems are diverse and vary widely in their performance. Sweeping comparisons can frustrate farmers, especially those who are innovative, committed to sustainability and animal welfare, and advocate for ‘less but better’ meat.</p>	<p>Celebrating farmer innovation: Recognising the diversity of farming systems, highlighting farmer innovation and championing the role of farmers in the transition to sustainable food systems.</p>
<p>Analysis as advocacy: Many farmers who spoke to us mistrusted information about the cultured meat industry because of a perceived lack of transparency and absence of ‘neutral’ life cycle analyses. Likewise, proponents of cultured meat have claimed other studies have made biased assumptions in favour of livestock farming.</p>	<p>Honest brokers: Research co-commissioned by multi-stakeholder groups including farming and cultured meat organisations can be more widely trusted, and ensure assumptions are critically reviewed from diverse perspectives.</p>
<p>Simplistic claims: Efforts to explain cultured meat as simply as possible can end up being inadvertently misleading. For example, “Cultivated meat is the same as the beef, pork, chicken and seafood people enjoy eating today”.⁵³</p>	<p>Inclusive authorship: Inviting livestock farmers and other people with different perspectives on the technology to co-author or review communications can help identify errors and encourage inclusive language.</p>
<p>All or nothing: Talking about a future where cultured meat entirely replaces livestock farming sets farmers up as ‘outdated’ and ‘the enemy’, with no role or valuable expertise to offer in future food scenarios.</p>	<p>Exploring synergies: As this project has shown, there are potential synergies between cultured meat and livestock farming. Exploring these is respectful of farmers and may also be more appealing to consumers.</p>

8. Building on common ground

If the cultured meat industry, farmers and campaigners see some shared interest in avoiding polarisation, where can they find common cause? While more inclusive and empathetic communication is an important step, a substantive shared stake can only come from exploring practical synergies.

Through workshops with cultured meat businesses, investors, policy makers, and food and farming groups, we identified three ways to achieve this, which we are now putting into practice:

- Joint research and innovation
- Supporting farmer engagement
- Investor criteria

Joint research and innovation

Our discussions with cultured meat businesses, farmers and scientists highlighted research that could develop synergies between this emerging technology and sustainable farming systems, potentially including livestock.

A key question is whether waste or low-value by-products from agriculture could find new markets as inputs for cultured meat production, potentially adding value for farmers and making cultured meat more affordable and sustainable. Our initial modelling suggests that rapeseed meal, blood, and horn and hoof meal are all worth exploring further. This would entail experimental work to test their efficacy in growth media, exploring the commercial viability of secondary processing (for example isolating relevant amino acids or growth factors), and gaining a better understanding of any potential regulatory, food safety and acceptability issues associated with the use of animal by-products.

A related strand of research and innovation is focused on developing agricultural supply chains for cultured meat, whether from waste valorisation, from existing products such as crops currently grown for animal feed, or from new products such as novel crops or animal cell lines. Some farmers who spoke to us were interested in the opportunity of working with this new industry to rebalance and reset supply chain relationships, with contracts and partnerships that reflect cultured meat companies' commitments to a 'just transition' in agriculture.⁵⁴

A third avenue for research and experimentation is to prototype decentralised cultured meat production on farms. This is a concept that Respect Farms⁵⁵ is pioneering in the Netherlands and Meatosys is developing in Germany,⁵⁶ and several of the farmers involved in our research were interested in exploring this possibility further. Their relevant assets ranged from farm buildings and renewable energy systems, to teams with extensive experience of managing biosecurity.

Supporting farmer engagement

Some of the farmers involved in this project were keen to engage further with cultured meat businesses. They may not be alone.

Working with CARMA (the UK Cellular Agriculture Manufacturing Hub⁵⁷), we will create a platform that connects farmers with cultured meat businesses and researchers who want to work together.

We will also create a short guide to cultured meat for farmers, outlining how it is made, potential implications for farming, and its comparative environmental and economic performance. This guide will clearly identify potential unintended consequences and key areas of uncertainty (Table 1, Section 3) and aim to provide a neutral review of current information on cultured meat from which farmers can make informed decisions. It will be reviewed by farmers and cultured meat advocates before publication.

Investor criteria

Investors involved or interested in cultured meat are alert to the possibility that the disruptions it and other alternative proteins cause to farming could limit the industries social licence, and therefore their impact and commercial potential.⁵⁸

Investors can help to address this by requiring the companies they invest in to commit to a 'just transition' within their Environmental, Social and Governance (ESG) frameworks. For example, an ESG framework for alternative proteins developed by the Good Food Institute and FAIRR expects companies to have a strategy to facilitate a just transition and to engage stakeholders.⁵⁹ We encourage cultured meat companies to engage farmers and other stakeholders meaningfully in their governance, and to disclose this voluntarily, as such activities are crucial to their sector's social licence. We are supporting ongoing work to ensure such criteria and commitments are inclusive, practical and realistic for farmers.

A close-up photograph of a butterfly with brown wings and red markings, perched on a cluster of small purple flowers. The background is a soft-focus green field. The lighting is warm and golden, suggesting late afternoon or early morning.

FARM PROFILE:

Regenerative mixed farm, Cotswolds

Farm profile



Enterprises:
Beef, lamb,
veg, events,
farm shop



**Size in
hectares:**
73



**Ownership
model:**
Farm Business
Tenancy (FBT)

The fundamental principle for this farmer is that “the only input is sunshine”. The farm operates on regenerative principles, with native rare breeds chosen for finishing well on grass. Much of the farm is in environmental schemes with rich, diverse leys and habitat mixes to encourage biodiversity. The organic beef and lamb they produce is all sold through box schemes or direct from the farm shop. The farm practices ‘enterprise stacking’, with a mix of everything from tourism, events, a livery yard, and a two-acre market garden, which is one of the most profitable areas of the business.

While building soil carbon and biodiversity, this farmer recognises that his style of production is not going to feed the world. He feels that we need game-changers to meet climate goals and is open to the idea that cultured meat might be part of the solution.

How do you think your business will be doing in 10 years time?



But he does not feel his own business would be much affected by **cultured meat**. He anticipates an ongoing and perhaps increased demand for his kind of high-welfare, grass-fed, regeneratively-farmed meat. As he sells his carcasses fully through box schemes, he feels protected from a drop in the value of cheaper cuts. However, he envisages that cultured meat might drive carcasse imbalances for other farmers, so more might set up direct sales that compete with his.

Under **business as usual**, things are going well. The mix of enterprises, the demand for their products, and the family’s satisfaction in regenerating that land means this farmer feels positive about the future. However, they still need to supplement their income with work off the farm. They have ten years left on their tenancy and feel they have “one last big push” to make it work. If things went wrong for any reason, they would consider getting out sooner while “still young enough to do something different”.

9. Our approach

The *Cultured Meat and Farmers* project was awarded funding by UK Research and Innovation as part of its Transforming UK Food Systems Strategic Priorities Fund Programme.⁶⁰ The research team included social and natural scientists, and specialists from industry and the third sector.

We set out to embed principles of responsible research and innovation in the design and execution of the project.⁶¹ The purpose of the project was to include farmer voices in debates around cultured meat, helping to anticipate both opportunities and risks, as well as intended and unintended consequences. Though a reflective evaluation of the project identified some challenges around constraints of funding landscapes and the difficulty of balancing interests within a large consortium, most researchers and members of the stakeholder advisory board felt that the project had taken important steps to substantively include the farming community in debates around cultured meat.⁶²

Our aim is to ensure that farmer voices are part of setting ‘just’ and sustainable agri-food transitions and our results offer the opportunity to incorporate more reflexive and responsive policies to guide future change.

The questions the project set out to answer were:

1. How do UK farmers currently perceive cultured meat?
2. What threats and opportunities does the development of cultured meat pose UK farm businesses in different scenarios?
3. Under what conditions, if any, would on-farm production of cultured meat be practical, economically viable and desirable in the UK?

The first phase of the study addressed farmers’ attitudes towards cultured meat. Discussions were held with 80 farmers in seven focus across the UK and different sectors (Table 5).⁶³

We were also interested in what was being said about cultured meat online and in the media. We developed a list of online food and farming media, farming organisations and online farmers through The Farming Forum and social media. We searched these outlets for a series of keywords and, looking from 2017 to 2023, we returned a total of 259 pieces of media that mention cultured meat in some way. We then analysed the terms used for cultured meat and the ways it was presented by different actors. We also analysed the imagery used and looked at how those with different interests chose different accompanying images.⁶⁴

Alongside this work, we carried out techno-economic modelling and a life cycle impact analysis to assess the anticipated economic and environmental impacts of using valorised amino acid sources to produce DMEM growth medium. The methods we used and more detailed results can be found in Appendix 1 and Appendix 2.

We partnered with nine farms, selected for their different sectors, scales, tenure and locations, to explore how farms across a range of contrasting but common situations might fare and adapt in a world with cultured meat. (Table 6). Profiles of seven of these farms can be found throughout the report – two were omitted to preserve their anonymity. Each partner farm was interviewed on two separate occasions, with each meeting lasting 1.5–3hrs. Discussions followed a semi-structured approach, designed to elucidate how the farmers saw their business in ten years' time. The purpose was not to be representative of UK farming, but to provide an in-depth analysis of some perceptions, understanding, and implications for farmers. Each considered their own version of three different pathways, namely:

- 'Business as usual', where the business carried on following its current trajectory.
- 'Cultured meat', where cultured meat was widely available on the market.
- 'Wildcard', for any other options.

Recordings of the discussions with the nine partner farms were transcribed and analysed using recognised qualitative approaches. This analysis was based both on predetermined factors and on themes that are drawn from an analytical interpretation of the qualitative data.

Following the interviews, several of the partner farms hosted visits by groups of people involved in the culture meat business, policy or NGOs. The insights these stakeholders gained from the visits informed their contributions to three workshops with wider groups to explore the practical implications of this study.

Table 5: Farmer focus groups held Autumn 2022 to Spring 2023

Location	Sectors	Approach	Number of farmers
Northern Ireland	Beef, sheep, dairy, poultry	On-line	23
Wales	Beef, sheep, dairy	Face-to-face	11
UK-wide	Pasture/conservation grazing, organic	On-line	7
Midlands	Protein crop (pulses, beans etc.)	Face-to-face	13
East/E. Midlands	Arable/mixed	Face-to-face	13
South West	Dairy, beef, calf rearing	Face-to-face	8
UK-wide	Poultry	On-Line	5

Table 6: Partner Farms

Partner farm	Farming sector/system	Area
1	Grazing Dairy	On-line
2	Regenerative Arable & Beef	Face-to-face
3	Indoor Pigs & Arable	On-line
4	Fresh Produce - fruit	Face-to-face
5	Beef & Sheep	Face-to-face
6	Poultry Integrator company	Face-to-face
7	Beef/sheep & Processor	On-Line
8	Arable	Face-to-face
9	Pedigree, Pasture-fed, organic beef	On-Line



Authors & acknowledgements

Authors

Tom MacMillan,^a Katherine Lewis,^a John Dooley,^a Lisa Morgans,^a Alex Sexton,^b Mustafa Ali,^c Scott Allan,^d Iain Argyle,^d Illtud Dunsford,^d Mike Goodman,^g John Lynch,^e Louise Manning,^f Viren Ranawana,^h David Rose,ⁱ Rachael Rothman,^c Will Sibly,^j Anastasios Vasilopoulos^k and Adele Wylie^g

^a Royal Agricultural University, Cirencester, GL7 6JS

^b Department of Geography, University of Sheffield, Sheffield, S3 7ND

^c Department of Chemical, Materials and Biological Engineering, University of Sheffield, Sheffield, S1 3JD

^d Cellular Agriculture, Unit 4 Corsham Science Park, Park Lane, Corsham SN13 9FU

^e Department of Biology, University of Oxford, 1a Mansfield Road, OX1 3SZ

^f The Lincoln Institute for Agri-Food Technology, University of Lincoln, Lincoln, LN2 2LG

^g Department of Geography and Environmental Science, University of Reading, Reading, RG6 6UR

^h School of Medicine and Population Health, University of Sheffield, Sheffield, S1 4DA

ⁱ Food, Land and Agribusiness Management, Harper Adams University, Edgmond, Newport, TF10 8NB

^j Linking Environment and Farming, Avenue J, Stoneleigh Park, Kenilworth, Warwickshire, CV8 2LG

^k Enginering Ltd., 8 Lonsdale, Linton, Cambridgeshire, CB21 4LT

Suggested citation:

MacMillan, T.C., Lewis, K., Dooley, J.J., Morgans, L.C., Sexton, A.E., Ali, M., Allan, S., Argyle, I., Dunsford, I., Goodman, M.K., Lynch, J., Manning, L., Ranawana, V., Rose, D.C., Rothman, R., Sibly, W., Vasilopoulos, A., Wylie, A. (2024). Culture Clash? What cultured meat could mean for UK farming. Transforming UK Food Production. July 2024.

Acknowledgements

We are grateful to the following people and organisations for their invaluable help, without which this work would have not been possible. Their participation implies no endorsement of this report.

Members of the project advisory group

Cai Linton (Mulus), Marianne Ellis (Bath University), Claire Hughes (Sainsbury's), Craig Leadley (Campden BRI), Daniel Blaustein-Rejto (Breakthrough Institute), Duncan Harding (Defra), Elena Walden (GFI), Gavin Hodgson (Sainsbury's), Greg Jones (Campden BRI), Harpinder Sandhu (Federation University), Heidi Allen (RSPCA), Jim Elliott (Green Alliance), Jens Tuidter (ProVeg), Julia Martin (ProVeg), Jyoti Fernandes (Landworkers Alliance), Lee Recht (Aleph-farms), Luke Halsey (AIIM Partners), Marianna Digka (ENgineering), Mathilde Alexandre (ProVeg), Peter Newton (University of Colorado), Rob Percival (Soil Association), Seren Kell (GFI), Sue Pritchard (FFCC), Valeria Crowder (Farm491), Victor Aguilera (Defra), Yadira Tejada-Saldana (New Harvest).

Contributors or participants in research activities

Deborah Crossan (Innovation for Agriculture), Jenna Thompson (Pasture for Life) and Daryl McLaughlin (formerly of Ulster Farmers Union) for organising and managing or recruiting of farmer focus groups.

Ignacio Parreno (RAU) for helping ensure the project ran smoothly.

Abi Kay (Farmers Weekly), Andrew Curry (School of International Futures), Linus Pardoe (GFI), Ira Van Eelen (RESPECTfarms), Symcha Nyssen (GAIA) and others who wished to remain anonymous, for contributions to policy, media, investor and investor discussions at various points in the project.

Former members of the team or advisory group who have moved on during the project

Heather Browne (Defra), Duncan Cameron (University of Sheffield), Sarah Carr (RAU), Clara Hagedorn (ProVeg), Stephanie Jacznikowska-McGirr (ProVeg), Jo Lewis (Soil Association), Marcus Martin (ProVeg), Alexa Masterton-Jones (Sainsbury's), Nick Millard (RAU), Helene Miller (Aleph Farms), Peter Mundy (consultant), Lara Pappers (ProVeg), Jennifer Robertson (QMS), Vicky Robinson (LEAF)

Farmers

Last but not least, all the partner farmers for providing in-depth information and frank discussion about their farm businesses, and to all the farmers who gave up their time to participate in the focus groups and for providing helpful discussion and comments

Funding

The Cultured Meat and Farmers research project (<https://www.rau.ac.uk/research/research-at-rau/cultured-meat-and-farmers>), grant no. BB/W01808X/1, was funded by UK Research and Innovation's (UKRI) Transforming UK Food Systems Strategic Priorities Fund (<https://ukfoodsystems.ukri.org/>).



References

- ¹ Committee on Climate Change. (2020). Land use: Policies for a Net Zero UK. Available from: <https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/> [Accessed June 2024].
- ² Gibson-Moore, H. Nutrition information about protein and plant-based protein. British Nutrition Foundation. Available from: <https://www.nutrition.org.uk/nutritional-information/protein/> [Accessed June 2024].
- ³ Dimbleby, H. (2021). The National Food Strategy: The Plan. Available from: <https://www.nationalfoodstrategy.org/> [Accessed June 2024].
- ⁴ AHDB “We Eat Balanced” campaign. Available from: <https://ahdb.org.uk/WeEatBalanced> [Accessed June 2024].
- ⁵ Cusworth, G., and Garnett, T. (2023). What is regenerative agriculture? TABLE Explainer. TABLE, University of Oxford, Swedish University of Agricultural Sciences and Wageningen University and Research. DOI: 10.56661/2caf9b92 [Accessed July 2024].
- Trewern, J., Chenoweth, J., and Christie, I. (2022). “Does it change the nature of food and capitalism?” Exploring expert perspectives on public policies for a transition to ‘less and better’ meat and dairy. *Environmental Science and Policy* 128: 110–120. DOI: 10.1016/j.envsci.2021.11.018
- Johnston, J., Weiler, A., and Baumann, S. (2022). The cultural imaginary of ethical meat: A study of producer perceptions. *Journal of Rural Studies* 89: 186–198. DOI: 10.1016/j.jrurstud.2021.11.021
- ⁶ Roe E., Maye D., Lambton S., Mafulul D., Helweggen M., Green S., and Hasnain S. (2024). Changing Agri-Chicken for Net Zero. Findings from an industry workshop. University of Southampton, Southampton. 22 pages. Available from: <https://zerocluckprints.wordpress.com/wp-content/uploads/2024/05/changingagr-chickenreportfinal30may.pdf> [Accessed June 2024].
- Gaillac, R., and Marbach, S. (2021). The carbon footprint of meat and dairy proteins: A practical perspective to guide low carbon footprint dietary choices. *Journal of Cleaner Production* 321: 128766. DOI: 10.1016/j.jclepro.2021.128766
- ⁷ Cusworth, G., Garnett, T. & Lorimer, J. (2021). Legume dreams: The contested futures of sustainable plant-based food systems in Europe. *Global Environmental Change*, 69: 102321. DOI: /10.1016/j.gloenvcha.2021.102321
- ⁸ Research and thinking on the technology’s relationship with farming include:
Aleph Farms and Federation University Australia. Aleph Farms Partners with Federation University to Examine the Role of Cultivated Meat in a Just Transition. Available from: <https://aleph-farms.com/journals/role-of-cultivated-meat-in-just-transition/> [Accessed June 2024].
- Crawshaw, C., and Piazza, J. (2023). Livestock farmers’ attitudes towards alternative proteins. *Sustainability* 15: 9253. DOI: 10.3390/su15129253
- Morais-da-Silva, R.L., Villar, E.G., Reis, G.G., Sanctorem, H., and Molento, C.F.M. (2022). The expected impact of cultivated and plant-based meats on jobs: the views of experts from Brazil, the United States and Europe. *Humanities and Social Sciences Communications* 9: 297. DOI: 10.1057/s41599-022-01316-z
- Newton, P., and Blaustein-Rejto, D. (2021). Social and economic opportunities and challenges of plant-based and cultured meat for rural producers in the US. *Frontiers in Sustainable Food Systems* 5: 624270. DOI: 10.3389/fsufs.2021.624270
- Räty, N., Tuomisto, H.L., and Ryyänen, T. (2023). On what basis is it agriculture?: a qualitative study of farmers’ perceptions of cellular agriculture. *Technological Forecasting and Social Change* 196: 122797. DOI: 10.1016/j.techfore.2023.122797
- Recht, L., and Toubia, D. (2021). An Inclusive Transition to a Sustainable and Resilient Meat Sector. White Paper. Aleph Farms. Available from: https://static1.squarespace.com/static/60ad4c818f17ff59e340d0e1/t/6138fb1393764a70ed96933b/1631124245517/AF_WP+2021_08_31LOW.pdf. [Accessed July 2024]
- RESPECTfarms. (2023). Cultivated meat to be grown on farms across Europe? Available from: <https://www.respectfarms.com/news> [Accessed June 2024].
- Shaw, E., and Mac Con Iomaire, M. (2019). A comparative analysis of the attitudes of rural and urban consumers towards cultured meat. *British Food Journal* 121: 1782–1800. DOI: 10.1108/BJFJ-07-2018-0433
- University of the Fraser Valley. (2023). Exploring the potential for increasing food security, local economic development, and environmental sustainability in Canada. Available from: <https://www.uvf.ca/food-agriculture-institute/the-research/cellular-agriculture/local-cellular-agriculture/> [Accessed June 2024].
- ⁹ Kumar, A., Sood, A., and Han, S.S. (2023). Technological and structural aspects of scaffold manufacturing for cultured meat: recent advances, challenges, and opportunities. *Critical Reviews in Food Science and Nutrition* 63(5): 585–612. DOI: 10.1080/10408398.2022.2132206
- ¹⁰ Honderich, H. (2024). Ron DeSantis bans ‘global elite’ lab-grown meat. Available from: <https://www.bbc.co.uk/news/world-us-canada-68947766> [Accessed June 2024].
- Stone, E. (2024). France takes up plant protein labeling and cell-cultured meat. The National Agricultural Law Center. Available from: <https://nationalaglawcenter.org/france-takes-up-plant-protein-labeling-and-cell-cultured-meat/> [Accessed June 2024].
- ¹¹ Frampton, B., Cassidy, M., and Walsh, A. (2024). Thousands of farmers stage payments protest. Available from: <https://www.bbc.co.uk/news/live/uk-wales-68417615> [Accessed June 2024].
- Holligan, A., and Kirby, P. (2024). Farmers’ protest party win shock Dutch vote victory. Available from: <https://www.bbc>

- co.uk/news/world-europe-64967513 [Accessed June 2024].
- Prior, M., and Vladev, L. (2024). Tractors gather at Parliament in farmer go-slow protest. Available from: <https://www.bbc.co.uk/news/science-environment-68655661> [Accessed June 2024].
- ¹² Knežić, T., Janjušević, L., Džisalov, M., Yodmuang, S., and Gadjanski, I. (2022). Using Vertebrate Stem and Progenitor Cells for Cellular Agriculture, State-of-the-Art, Challenges, and Future Perspectives. *Biomolecules* 12: 699. DOI: 10.3390/biom12050699
- ¹³ Post, M.J., Levenberg, S., Kaplan, D.L., Genovese, N., Fu, J., Bryant, C.J., Negowetti, N., Verzijden, K., and Moutsatsou, P. (2020). Scientific, sustainability and regulatory challenges of cultured meat. *Nature Food* 1: 403–415. DOI: 10.1038/s43016-020-0112-z
- ¹⁴ Chen L., Guttieres D., Koenigsberg A., Barone P.W., Sinskey A.J., and Springs, S.L. (2022). Large-scale cultured meat production: Trends, challenges & promising biomanufacturing technologies. *Biomaterials* 280: 121274. DOI: 10.1016/j.biomaterials.2021.121274
- David, S., Tsukerman, A., Safina, D., Maor-Shoshani, A., Lavon, N., and Levenberg, S. (2023). Co-culture approaches for cultivated meat production. *Nature Reviews Bioengineering* 1: 817–831. DOI: 10.1038/s44222-023-00077-x
- ¹⁵ David, S., Tsukerman, A., Safina, D., Maor-Shoshani, A., Lavon, N., and Levenberg, S. (2023). Co-culture approaches for cultivated meat production. *Nature Reviews Bioengineering* 1: 817–831. DOI: 10.1038/s44222-023-00077-x
- ¹⁶ Garrison, G.L., Biermacher, J.T., and Brorsen, B.W. (2022). How much will large-scale production of cell-cultured meat cost? *Journal of Agriculture and Food Research* 10: 100358. DOI: 10.1016/j.jafr.2022.100358
- ¹⁷ Flaibam B., da Silva, M.F., de Melo, A.H.F., Carvalho, P.H., Galland, F., Pacheco, M.T.B., and Goldbeck, R. (2024). Non-animal protein hydrolysates from agro-industrial wastes: A prospect of alternative inputs for cultured meat. *Food Chemistry* 443: 138515. DOI: 10.1016/j.foodchem.2024.138515
- Hubalek, S., Post, M.J., and Moutsatsou, P. (2022). Towards resource-efficient and cost-efficient cultured meat. *Current Opinion in Food Science* 47: 100885. DOI: 10.1016/j.cofs.2022.100885
- ¹⁸ Kumar, A., Sood, A., and Han, S.S. (2023). Technological and structural aspects of scaffold manufacturing for cultured meat: recent advances, challenges, and opportunities. *Critical Reviews in Food Science and Nutrition*, 63(5): 585–612, DOI: 10.1080/10408398.2022.2132206
- ¹⁹ FAO and WHO. (2023). Food safety aspects of cell-based food. Rome. Available from: <https://doi.org/10.4060/cc4855en> [Accessed June 2024].
- Smith-Uchotski, R., Wanjiru, P., Willis, R., and Adkin, A. (2022). Hazard identification: Identification of hazards in cultured animal cells. FSA Report. Available from: https://www.food.gov.uk/sites/default/files/media/document/Cultured%20meat%20hazard%20identification%20final_0.pdf [Accessed June 2024].
- Manning, L. (forthcoming). Responsible innovation: conceptualising the food safety aspects of cultured meat production, *Journal of Food Science*.
- ²⁰ Marsh, N. (2023). Why Singapore is the only place in the world selling lab-grown meat. BBC News. Available from: <https://www.bbc.co.uk/news/business-65784505> [Accessed June 2024].
- Although sold as cultivated chicken, these 120g packs, which retailed at \$7.20 (~£4.20), only contain 3% cultivated meat, the rest being plant-based proteins (see: <https://www.goodmeat.co/butchery> [Accessed June 2024]).
- ²¹ Image adapted from Figure 2 in Byrne, B. and Murray, S. (2021). 2020 State of the industry report: Cultivated Meat. Good Food Institute. Available from: <https://gfi.org/resource/cultivated-meat-and-seafood-state-of-the-industry-report/>. [Accessed July 2-24]
- ²² Rubio, N.R., Xiang, N., and Kaplan, D.L. (2020). Plant-based and cell-based approaches to meat production. *Nature Communications* 11: 6276. DOI: 10.1038/s41467-020-20061-y
- Specht, L. (2020). An analysis of culture medium costs and production volumes for cultivated meat. The Good Food Institute. Available from: <https://gfi.org/wp-content/uploads/2021/01/clean-meat-production-volume-and-medium-cost.pdf> [Accessed June 2024].
- Garrison, G.L., Biermacher, J.T., and Brorsen, B.W. (2022). How much will large-scale production of cell-cultured meat cost? *Journal of Agriculture and Food Research* 10: 100358. DOI: 10.1016/j.jafr.2022.100358
- ²³ Bushnell, C., Specht, L., and Almy, J. (2024). 2023 State of the Industry Report: Cultivated meat and seafood. Good Food Institute. Available from: <https://gfi.org/2023-cultivated-meat-and-seafood-state-of-the-industry-report-pdf> [Accessed June 2024].
- ²⁴ US Food and Drug Administration. Human Food Made with Cultured Animal Cells Inventory. Available from: <https://www.cfsanappsexternal.fda.gov/scripts/fdcc/?set=AnimalCellCultureFoods> [Accessed June 2024].
- ²⁵ Aleph Farms Granted World's First Regulatory Approval for Cultivated Beef. Available from: <https://aleph-farms.com/journals/aleph-farms-granted-worlds-first-regulatory-approval-for-cultivated-beef/> [Accessed June 2024].
- ²⁶ Morrison, O. (2023). UK's first cultivated meat approval submitted. Food Navigator (Europe). Available from: <https://www.foodnavigator.com/Article/2023/08/04/UK-s-first-cultivated-meat-approval-submitted> [Accessed June 2024].
- ²⁷ Bryant, C., and Barnett, J. (2018). Consumer acceptance of cultured meat: A systematic review. *Meat Science* 143: 8–17. DOI: 10.1016/j.meatsci.2018.04.008
- Bryant, C., and Barnett, J. (2020). Consumer acceptance of cultured meat: An updated review (2018–2020). *Applied Sciences* 10, 5201. DOI: 10.3390/app10155201
- Bryant, C., and Dillard, C. (2019). The Impact of Framing on Acceptance of Cultured Meat. *Frontiers in Nutrition* 6: 103. DOI: 10.3389/fnut.2019.00103
- Hansen, J., Sparleanu, C., Liang, Y., Büchi, J., Bansal, S., Caro, M.A., and Staedtler, F. (2021). Exploring cultural concepts of meat and future predictions on the timeline of cultured meat. *Future Foods* 4: 100041. DOI: 10.1016/j.fufo.2021.100041
- Siegrist, M., and Hartmann, C. (2020). Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. *Appetite* 155: 104814. DOI: 10.1016/j.appet.2020.104814

- Verbeke, W. Marcu, A., Rutsaert, P., Gaspar, R., Seibt, B., Fletcher, D., and Barnett, J. (2015). 'Would you eat cultured meat?': Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Science* 102: 49–58. DOI: 10.1016/j.meatsci.2014.11.013
- ²⁸ Siegrist, M., and Hartmann, C. (2020). Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. *Appetite* 155: 104814. DOI: 10.1016/j.appet.2020.104814
- Hansen, J., Sparleanu, C., Liang, Y., Büchi, J., Bansal, S., Caro, M.A., and Staedtler, F. (2021). Exploring cultural concepts of meat and future predictions on the timeline of cultured meat. *Future Foods* 4: 100041. DOI: 10.1016/j.fufo.2021.100041
- ²⁹ Bryant, C., and Barnett, J. (2020). Consumer acceptance of cultured meat: An updated review (2018–2020). *Applied Sciences* 10, 5201. DOI: 10.3390/app10155201
- ³⁰ Bryant, C., and Dillard, C. (2019). The Impact of Framing on Acceptance of Cultured Meat. *Frontiers in Nutrition* 6: 103. DOI: 10.3389/fnut.2019.00103
- Siegrist, M., and Hartmann, C. (2020). Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. *Appetite* 155: 104814. DOI: 10.1016/j.appet.2020.104814
- Verbeke, W. Marcu, A., Rutsaert, P., Gaspar, R., Seibt, B., Fletcher, D., and Barnett, J. (2015). 'Would you eat cultured meat?': Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Science* 102: 49–58. DOI: 10.1016/j.meatsci.2014.11.013
- Bryant, C., and Barnett, J. (2020). Consumer Acceptance of Cultured Meat: An Updated Review (2018–2020). *Applied Science* 10: 5201. DOI: 10.3390/app10155201
- ³¹ Bryant, C., and Barnett, J. (2018). Consumer acceptance of cultured meat: A systematic review. *Meat Science* 143: 8–17. DOI: 10.1016/j.meatsci.2018.04.008
- ³² Tubb, C., and Seba, T. (2019). Rethinking Food & Agriculture 2020–2030. Available from: <https://23227526.fs1.hubspotusercontent-na1.net/hubfs/23227526/RethinkX%2BFood%2Band%2BAgriculture%2BReport-3.pdf> [Accessed June 2024].
- ³³ Murphy, S.P., Cannon, S.M., and Walsh, L. (2022). Just transition frames: Recognition, representation, and distribution in Irish beef farming. *Journal of Rural Studies* 94: 150–160. DOI: 10.1016/j.jrurstud.2022.06.009
- Verkuijl, C., Strambo, C., Hocquet, R., Butterfield, R., Achakulwisut, P., Boyland, M., Araújo, J.A.V., Bakhtaoui, I., Smit, J., Lima, M.B., and Green, J. (2023). A just transition in animal agriculture is necessary for more effective and equitable One Health outcomes. *CABI One Health*. DOI: 10.1079/cabionehealth.2023.0021
- ³⁴ Believer Meats. (2023). What are immortalized cells and why do we use them? Available from: <https://www.believermeats.com/blog/what-are-immortalized-cells-and-why-do-we-use-them> [Accessed June 2024].
- ³⁵ Manning, L., Dooley, J.J., Dunsford, I., Goodman, M.K., MacMillan, T.C., Morgans, L.C., Rose, D.C., and Sexton, A.E. (2023). Threat or opportunity? An analysis of perceptions of cultured meat in the UK farming sector. *Frontiers in Sustainable Food Systems* 7: 1277511. DOI: 10.3389/fsufs.2023.1277511
- ³⁶ Our findings are consistent with those from previous studies of farmers' perceptions: Rätty, N., Tuomisto, H.L., and Rynänen (2023). On what basis is it agriculture? A qualitative study of farmers' perceptions of cellular agriculture. *Technological Forecasting & Social Change* 196: 122797. DOI: 10.1016/j.techfore.2023.122797
- Verbeke, W. Marcu, A., Rutsaert, P., Gaspar, R., Seibt, B., Fletcher, D., and Barnett, J. (2015). 'Would you eat cultured meat?': Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Science* 102: 49–58. DOI: 10.1016/j.meatsci.2014.11.013
- Bryant, C., and Barnett, J. (2018). Consumer acceptance of cultured meat: A systematic review. *Meat Science* 143: 8–17. Available from: <https://doi.org/10.1016/j.meatsci.2018.04.008>
- Gousset, C., Gregorio, E., Marais, B., Rusalen, A., Chriki, S., Hocquette, J.-F., and Ellies-Oury, M-P. (2022). Perception of cultured "meat" by French consumers according to their diet. *Livestock Science* 260: 104909. Available from: <https://doi.org/10.1016/j.livsci.2022.104909>
- ³⁷ Meuwissen, M.P.M., Feindt, P.H., Spiegel, A., Termeer, C.J.A.M., Mathijs, E., de Mey, Y., Finger, R., Balmann, A., Wauters, E., Urquhart, J., Viganì, M., Zawalińska, K., Herrera, H., Nicholas-Davies, P., Hansson, H., Paas, W., Slijper, T., Coopmans, I., Vroeghe, W., Ciecchomska, A., Accatino, F., Kopainsky, B., Poortvliet, P.M., Candel, J.J.L., Maye, D., Severini, S., Senni, S., Soriano, B., Lagerkvist, C.-J., Peneva, M., Gavrilescu, C., and Reidsma, P. (2019). A framework to assess the resilience of farming systems. *Agricultural Systems* 176: 102656. doi.org/10.1016/j.agsy.2019.102656
- ³⁸ Jankovska-Bortkevič, E., Jurkonienė, S., Gavelienė, V., and Prakas, P. (2022). 'Oilseed Rape: Biology, Use, Current Cultivation Issues and Agronomic Management'. In Hasanuzzaman, M., and Nahar, K. (eds), *Oilseed crops – Uses, Biology and Production*. DOI: 10.5772/intechopen.100889
- ³⁹ Al-Zohairi, S., Trydeman Knudsen, M., and Mogensen, L. (2023). Utilizing animal by-products in European slaughterhouses to reduce the environmental footprint of pork products. *Sustainable Production and Consumption* 37: 306–319. DOI: 10.1016/j.spc.2023.03.005
- ⁴⁰ Ragasri, S., and Sabumon, P.C. (2023). A critical review on slaughterhouse waste management and framing sustainable practices in managing slaughterhouse waste in India. *Journal of Environmental Management* 327: 116823. DOI: 10.1016/j.jenvman.2022.116823
- ⁴¹ Hubalek, S., Post, M., and Moutsatsou, P. (2022). Towards resource-efficient and cost-efficient cultured meat. *Current Opinion in Food Science* 47: 100885.
- ⁴² Card, J. (2017). Lab-grown food: 'the goal is to remove the animal from meat production'. *The Guardian*. Available from: <https://www.theguardian.com/small-business-network/2017/jul/24/lab-grown-food-indiebio-artificial-intelligence-walmart-vegetarian> [Accessed June 2024].
- ⁴³ Benton, D., and Wheeler, F. (2023). Crossing the divide: the potential for consensus between four worldviews of

- agriculture's future. Policy Insight. Green Alliance. Available from: <https://green-alliance.org.uk/publication/crossing-the-divide/> [Accessed June 2024].
- Dimbleby, H. (2021). The National Food Strategy: The Plan. Available from: <https://www.nationalfoodstrategy.org/> [Accessed June 2024].
- ⁴⁴ Benton, D., and Wheeler, F. (2023). Crossing the divide: the potential for consensus between four worldviews of agriculture's future. Policy Insight. Green Alliance. Available from: <https://green-alliance.org.uk/publication/crossing-the-divide/> [Accessed June 2024].
- van der Weele, C., Feindt, p., van der Goot, A.J., van Mierlo, B., and van Boekel, M. (2019). Meat alternatives: an integrative comparison. *Trends in Food Science & Technology* 88: 505–512. doi.org/10.1016/j.tifs.2019.04.018
- ⁴⁵ Holmes, D., Humbird, D., Dutkiewicz, J. Tejada-Saldana, Y., Duffy, B., and Datar, I. (2022). Cultured meat needs a race to mission not a race to market. *Nature Food* 3: 785–787. DOI: 10.1038/s43016-022-00586-9
- Aleph Farms. (2022). Impact Report 2022: Our Sustainability Journey. Available from: <https://aleph-farms.com/wp-content/uploads/2023/07/Aleph-Farms-Impact-Report-2022.pdf> [Accessed June 2024].
- Newton P and Blaustein-Rejto D. (2021) Social and Economic Opportunities and Challenges of Plant-Based and Cultured Meat for Rural Producers in the US. *Frontiers in Sustainable Food Systems* 5: 624270. DOI: 10.3389/fsufs.2021.624270
- Recht, L., and Toubia, D. (2021). An Inclusive Transition to a Sustainable and Resilient Meat Sector. White Paper. Aleph Farms. Available from: https://static1.squarespace.com/static/60ad4c818f17ff59e340d0e1/t/6138fb1393764a70ed96933b/1631124245517/AF_WP+2021_08_31LOW.pdf. [Accessed July 2024]
- ⁴⁶ Benton, D., and Wheeler, F. (2023). Crossing the divide: the potential for consensus between four worldviews of agriculture's future. Available from: <https://green-alliance.org.uk/wp-content/uploads/2023/12/Crossing-the-Divide.pdf> [Accessed June 2024].
- Bryant, C.J., and van der Weele, C. (2021). The Farmers' Dilemma: Meat, Means and Morality. *Appetite* 167: 105605. Doi.org/10.1016/j.appet.2021.105605
- Crawshaw, C., and Piazza, J. (2023). Livestock Farmers' Attitudes towards Alternative Proteins. *Sustainability* 15: 9253. DOI: 10.3390/su15129253
- ⁴⁷ Jones, G.W. (2021) Twitter/X. Available from: <https://x.com/1garethwynjones/status/1352605340433608706> [Accessed June 2024].
- ⁴⁸ Reynolds, M. (2024). States Are Lining Up to Outlaw Lab-Grown Meat. *Wired*. Available from: <https://www.wired.com/story/cultivated-meat-florida-ban/> [Accessed June 2024].
- ⁴⁹ Painter, J., Brennen, J.S., and Kristiansen, S. (2020). The coverage of cultured meat in the US and UK traditional media, 2013–2019: drivers, sources, and competing narratives. *Climate Change* 162: 2379–2396. DOI: 10.1007/s10584-020-02813-3
- Helliwell, R., and Burton, R.J.F. (2021). The promised land? Exploring the future visions and narrative silences of cellular agriculture in news and industry media. *Journal of Rural Studies* 84: 180–191. DOI: 10.1016/j.jrurstud.2021.04.002
- Stephens, N., and Ruivenkamp, M. (2016). Promise and Ontological Ambiguity in the In vitro Meat Imagescape: From Laboratory Myotubes to the Cultured Burger. *Science as Culture* 25(3): 327–355, DOI: 10.1080/09505431.2016.1171836
- ⁵⁰ GOOD Meat. Available from: <https://www.goodmeat.co/purpose> [Accessed July 2024]
- ⁵¹ Monbiot, G. (2020). Lab-grown food will soon destroy farming – and save the planet. Available from: <https://www.theguardian.com/commentisfree/2020/jan/08/lab-grown-food-destroy-farming-save-planet> [Accessed July 2024].
- ⁵² Ostroff, J. (2018). How manufactured meat could disrupt the food industry – and change the way we eat. Available from: <https://sharpmagazine.com/2018/10/03/how-manufactured-meat-could-disrupt-the-food-industry-and-change-the-way-we-eat/> [Accessed July 2024].
- ⁵³ GFI. (2023). Everything a journalist needs to know about cultivated meat: A short handbook of key facts, statistics and resources. Available from: https://gfieurope.org/wp-content/uploads/2023/08/Cultivated-meat-in-Europe-handbook_Aug-23.pdf [Accessed July 2024].
- ⁵⁴ Murphy, S.P., Cannon, S.M., and Walsh, L. (2022). Just transition frames: Recognition, representation, and distribution in Irish beef farming. *Journal of Rural Studies* 94: 150–160. DOI: 10.1016/j.jrurstud.2022.06.009
- Verkuijl, C., Strambo, C., Hocquet, R., Butterfield, R., Achakulwisut, P., Boyland, M., Araújo, J.A.V., Bakhtaoui, I., Smit, J., Lima, M.B., and Green, J. (2023). A just transition in animal agriculture is necessary for more effective and equitable One Health outcomes. *CABI One Health*. DOI: 10.1079/cabionehealth.2023.0021
- ⁵⁵ RESPECTfarms. Available from: <https://www.respectfarms.com/> [Accessed June 2024].
- ⁵⁶ MEATOSYS. Available from: <https://meatosys.com/> [Accessed June 2024].
- ⁵⁷ CARMA (the UK Cellular Agriculture Manufacturing Hub). Available from: <https://www.bath.ac.uk/projects/carma-cellular-agriculture-manufacturing-hub/> [Accessed June 2024].
- ⁵⁸ Coggin, C. (2021). Cultured meat: can investors have their meat and eat it too? FAIRR. Available from: <https://www.fairr.org/news-events/insights/cultured-meat-having-your-meat-and-eating-it-too> [Accessed June 2024].
- ⁵⁹ GFI and FAIRR. (2024). Alternative Proteins ESG Reporting Frameworks. Available from: <https://gfi.org/industry/esg-reporting/> [Accessed June 2024].
- ⁶⁰ TUKFS website. Available from: <https://ukfoodsystems.ukri.org/> [Accessed July 2024].
- ⁶¹ Owen, R., Stilgoe, J., Macnaghten, P., Gorman, M., Fisher, E., and Guston, D. (2013). 'A framework for responsible innovation'. In Owen, R., Bessant, J., and Heintz, M. (eds), *Responsible Innovation* (Chichester: John Wiley & Sons, Ltd), 27–50. DOI: 10.1002/9781118551424.ch2
- ⁶² Prof David Rose interviewed the research team and members of the stakeholder advisory board to gather views on the strengths and weaknesses of our approach, which are due to be published separately.
- ⁶³ This phase of the research has been published in Manning, L., Dooley, J.J., Dunsford, I., Goodman, M.K., MacMillan, T.C., Morgans, L.C., Rose, D.C., and Sexton, A.E. (2023). Threat or opportunity? An analysis of perceptions of cultured meat in the UK farming sector. *Frontiers in Sustainable Food Systems* 7: 1277511. DOI: 10.3389/fsufs.2023.1277511
- ⁶⁴ This phase of the research has been submitted for publication and is under review.

Culture Clash? What cultured meat could mean for UK farming

Suggested citation: MacMillan, T.C., Lewis, K., Dooley, J.J., Morgans, L.C., Sexton, A.E., Ali, M., Allan, S., Argyle, I., Dunsford, I., Goodman, M.K., Lynch, J., Manning, L., Ranawana, V., Rose, D.C., Rothman, R., Sibly, W., Vasilopoulos, A., Wylie, A. (2024). Culture Clash? What cultured meat could mean for UK farming. Transforming UK Food Production. July 2024.