Meat Analogues
Considerations for the EU
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Summary

- Consensus is building across the scientific, environmental and public health communities that a radical shift away from excessive meat-eating patterns is urgently needed to tackle the unsustainability of the livestock sector.

- Recognizing the scale of the challenge ahead, public policymakers, civil society and innovators have increasingly sought to prompt shifts in consumer food choices, away from the most resource-intensive meat products and towards more sustainable alternatives.

- Meat analogues – plant-based ‘meat’ and cultured meat – mark a departure from traditional meat alternatives. Both are intended to be indistinguishable from – and, in the case of cultured meat, biologically equivalent to – animal-derived meat and are marketed principally at meat-eaters.

- Innovation and investment in meat analogues have increased significantly, but the direction and pace of growth in the meat analogue industry will depend upon a multitude of factors, including public acceptance, civil society support and incumbent industry responses.

- Policymakers in the EU, where many of the frontrunners in plant-based ‘meat’ and cultured-meat innovation are located, will need to respond imminently to new production methods and products. The decisions that they take now – on the regulation, labelling and marketing of meat analogues, for example – will have a significant influence on the industry's direction and pace of growth.

- Decisions on labelling requirements for meat analogues will be particularly important in determining consumer acceptance of plant-based ‘meat’ and cultured meat as substitutes for animal-derived meat. These decisions will be based not only on technical factors but on political considerations of the future of the meat industry in the EU.

- In order to meet its climate change commitments, the EU will need to change European eating patterns, including a reduction in meat consumption. Meat analogues have the potential to contribute to existing EU climate mitigation strategies and EU priority policy initiatives in areas including reduced antibiotic use, improved public health and sustainable resource management. To achieve this, EU policymakers will need to promote a clear, transparent and inclusive regulatory environment and invest public capital in research, development and commercialization.
1. Introduction

Consensus is building across the scientific, environmental and public health communities that a radical shift away from excessive meat-eating patterns is urgently needed to tackle the unsustainability of the livestock sector. Meat production is a principal driver of environmental change and natural resource depletion: the livestock industry accounts for an estimated 40 per cent of global arable land, 36 per cent of crop calories produced, 29 per cent of agricultural freshwater use, and 14.5 per cent of all human greenhouse gas (GHG) emissions. To meet global climate targets, per capita consumption of meat would need to fall drastically: the average global citizen would need to eat 75 per cent less red meat, while citizens of the western hemisphere would need to reduce consumption by 90 per cent. Excessive levels of individual meat consumption are associated with overweight, obesity and diet-related non-communicable diseases, including cardiovascular disease, type-2 diabetes and certain cancers. It has been predicted that in 2020 consumption of red and processed meat could lead to 2.4 million deaths globally and total healthcare costs of $285 billion. Furthermore, the inappropriate use of antimicrobials in animals is recognized by the UN as a leading cause of the increased occurrence of antimicrobial resistance, while the intensification of livestock production raises serious animal welfare concerns.

Recent years have signalled a step-change in public awareness of the health (and, to a lesser extent, environmental) risks associated with overconsumption of meat, particularly red and processed meat, and an increased trend towards ‘flexitarian’ diets, in which meat intake is reduced in favour of plant-based sources of protein. Many of the larger environmental groups are actively promoting plant-based diets – Greenpeace, for example, has called for a 50 per cent reduction of meat and dairy

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and a significant increase of plant-based foods in terms of both production and consumption by 2050, and the conservation organization WWF-UK’s Livewell dietary guidelines encourage healthy and sustainable eating by focusing on moderating meat consumption – while the scientific community is advocating for meat reduction as a core principle of healthy and sustainable global diets.

Many European consumers are increasingly concerned about the impact of their current meat consumption. In 2018, an open public consultation carried out by the European Commission in member states showed that over 80 per cent of respondents were willing to ‘consider the impact of their food purchases on greenhouse gas emissions’ and 74 per cent would ‘consider changing their diets’. Globally, however, meat consumption continues to rise. Between the early 1960s and the early 2010s, worldwide availability of meat per capita almost doubled, and the Food and Agriculture Organization of the UN (FAO) expects that, by 2030, global consumption will be 76 per cent higher than it was in 2005.

Recognizing the scale of the challenge ahead, public policymakers, civil society and innovators in the agricultural sector and beyond have increasingly sought to prompt shifts in consumer food choices, away from the most resource-intensive meat products and towards more sustainable alternatives. For some, the priority lies in encouraging reduced red meat consumption and greater demand for poultry, the emissions footprint of which is lower than that of beef or lamb. For others, the aim is to encourage a shift away from meat consumption altogether and to promote vegetarian or vegan lifestyles. For others still, the most promising opportunity lies in substituting meat produced through conventional means with meat produced in an entirely new way.

Meat analogues are plant-based and cultured products that are (or aim to be) equivalent substitutes for animal-derived meat, and are produced from plant or animal cells cultured in a laboratory or bioreactor. Meat analogues are the latest in a long history of meat alternative products that are intended to replace conventionally produced meat in a meal or diet. What sets meat analogues apart from well-known meat alternatives – Quorn, for example, or tofu and wheat-based processed ‘meat’ products – is that they are aimed at meat-eaters rather than vegetarians or vegans. They are designed

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13 Gerber et al. (2013), Tackling Climate Change through Livestock: A Global Assessment of Emissions and Mitigation Opportunities.
to achieve an unprecedented degree of mimicry that enables consumers to continue experiencing the ‘sensory pleasures’ of conventional meat.\textsuperscript{14}

Interest in meat analogues – from innovators, investors and the public – is rapidly growing. In recent years, meat analogue start-ups have gained increasing amounts of attention from the global media, helped along by investments and endorsements from high-net-worth individuals including Bill Gates, Richard Branson and Leonardo DiCaprio. In September 2018, two plant-based ‘meat’ manufacturers, Beyond Meat and Impossible Foods, were jointly presented with a Champion of the Earth Award, the UN’s highest environmental honour.\textsuperscript{15}

For policymakers, civil society and industry incumbents, meat analogues raise a number of challenging questions: do meat analogues belong in the realm of meat alternatives or that of conventional meat? How should they be defined and regulated by lawmakers? And what place do they hold in a sustainable, healthy and equitable food system? With innovation continuing to happen at pace, policymakers in key markets will need to respond imminently to new production methods and products to ensure that human, animal and environmental health are protected. Decisions taken today by those actors, on how meat analogues can and should be regulated and marketed, will likely have a formative impact both on the pace of industry scale-up and on the degree to which the public, civil society and industry incumbents either accept or resist their uptake.

This paper considers the two principal categories of meat analogues: advanced plant-based ‘meat’ and cultured meat. It explores the challenges that innovators face in scaling up production and generating demand, regulatory frameworks to which they will be subject, and implications of regulatory decisions for the future of the meat industry. The paper focuses on the European Union, which is a hub of research and development in plant-based ‘meat’ and cultured meat and a region where demand for meat alternatives is experiencing rapid growth.


2. Innovation in Meat Analogues

Meat alternatives – non-traditional protein sources intended to be used and consumed in a similar way to meat products – are available around the world. Some of these have long been readily available in certain regions. For example, the Quorn meat substitute brand, launched in the UK in 1985, uses fermentation technology to create mycoprotein (a type of single-cell protein) from the soil fungus *Fusarium* and is well established in many Western markets. Insect proteins, already in the mainstream in some Asian markets, are used by a growing number of companies in Europe and North America in products for human consumption and in animal feed.

In recent years, the interest, innovation and investment in meat analogues – non-traditional protein sources that are designed to be direct, imitative substitutes for conventionally produced meat – have increased significantly. Technologies are delivering, or are expected to deliver, products that have the potential to reduce traditional meat consumption without a drastic shift in eating behaviours. These developments coincide with the growing realization that, for environmental and public health reasons, reducing global traditional meat consumption is both necessary and desirable.

Two broad categories of meat analogues – advanced plant-based ‘meat’ and cultured meat – mark a particularly radical departure from the traditional meat and non-meat options seen to date. The driving principles in their production are mimicry and efficiency – principles identified by Mark Post, the innovator behind the first lab-grown burger in 2013, as the two key requisites for the acceptance and industrialization of a meat alternative. Both raise challenging questions for producers, policymakers and consumers alike around how ‘meat’ should be defined and regulated, and around the possibility of satiating the world’s growing demand for meat while dramatically scaling back animal agriculture.

**Plant-based ‘meat’**

Advanced plant-based ‘meat’ products are those that use plant-derived ingredients to directly mimic animal-derived meat and which are designed to be indistinguishable from their animal-based equivalents. Drawing a clear line between plant-based ‘meat’ and the plant-based meat alternatives that have come before is not straightforward. The distinction on which plant-based ‘meat’ innovators have patented – or sought to patent – their products and processes lies in the versatility and sensory experience of cooking and eating. They are marketed predominantly as processed meat products – burgers, sausages, meatballs – but are distinct from more mainstream plant-based meat alternatives in that they contain novel ingredients or use innovative processes intended to achieve an unprecedented degree of mimicry in taste, texture, look and cooking qualities. Advanced plant-based ‘beef’ burgers,
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for example, developed by companies such as Beyond Meat, Impossible Foods and Moving Mountains, comprise a unique set of ingredients that, in combination, produce a patty whose texture resembles that of minced beef, has a pink hue that turns brown on cooking, and exudes liquid on eating (see Figure 1).

For the most part, these products use non-genetically engineered ingredients such as beetroot juice to achieve these qualities, while Impossible Foods’ ‘Impossible Burger’ contains soy leghemoglobin (SLH), a plant protein. SLH is isolated from the root of the soybean plant and, like haemoglobin in blood and myoglobin in muscles, it is a molecule that carries oxygen, storing it in the roots of legumes. When the ‘Impossible Burger’ is cooked and eaten, SLH is exuded as a red-tinted liquid – comparable to myoglobin, the substance that ‘bleeds’ from minced beef – and gives a metallic iron-like (and thus meat-like) flavour to this product.  

**Cultured meat**

Cultured meat is grown *in vitro* from animal-derived stem cells using a growth medium (Figure 1). It is ‘biologically equivalent’\(^21\) to meat but is not harvested from a living animal. Culturing meat involves biotechnological processes borrowed from regenerative medicine (the branch of medicine that aims to develop ways to regenerate cells, tissues or organs)\(^22\) and aims to scale up these approaches to manufacture meat through cellular and tissue culture, termed ‘cellular agriculture’. Although no agreement has yet been reached on the definition for this process, cellular agriculture entails using a ‘set of technologies to manufacture products typically obtained from livestock farming, using culturing techniques to manufacture the individual product’.\(^23\)

The cells used to initiate the cell culture can be sourced from primary animal tissue through a biopsy procedure; alternatively, cell lines (stem cells) that can replicate indefinitely can be produced via genetic engineering, gene editing or through induced or spontaneous mutations.\(^24\) Cells are cultured within specific liquid media, which provide the conditions needed for tissue growth. The exact media used will depend on the cell species and tissue type, but the process requires nutrients (supplied by foetal calf or horse serum, chicken embryo extract, collagen, serum-free media, etc.).\(^25\) Other inorganic and organic components (antibiotic/antimitotics or carbohydrates, amino acids and vitamins) can be added to the media to enable cell growth.\(^26\) A scaffold is required for cells to proliferate and develop the structure required for producing a tissue (for example, a muscle) instead of an unorganized collection of muscle cells. The components used in these processes are dependent on their stages of development, and research in this area is still in its infancy.\(^27\) For example, even though a few companies, such as Higher Steaks and Aleph Farms, already use only animal-free growing media, more research is needed for lowering the costs of serum-free processes.\(^28\)

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\(^{22}\)Post, M. J. (2012), ‘Cultured meat from stem cells: Challenges and prospects’.


\(^{24}\)Ibid., p. 157.

\(^{25}\)Ibid., p. 159.

\(^{26}\)Ibid., p. 159.

\(^{27}\)Ibid., p. 159.

Figure 1: Cultured meat and plant-based ‘meat’ production processes

Cultured meat
- Take biopsy from animal (live or slaughtered)
- Select ‘satellite’ cells
- Use a growth medium to culture cells and promote their differentiation and maturation into muscle fibres
- Process muscle fibres into desired meat product
- Cultured meat (e.g. Mosa Meat beef burger, Memphis Meats poultry)

Plant-based ‘meat’
- Mix dry and wet plant-derived ingredients*
- Form ingredients into meat replica dough
- Apply heat and/or pressure to denature the protein material and form fibrous protein structures
- Process fibrous protein structures into desired plant-based ‘meat’ product
- Plant-based ‘meat’ with heme (e.g. Impossible Burger) or without heme (e.g. Beyond Burger)

Plant-based ‘meat’ with heme
- Isolate heme-containing protein (SLH) from soybean root
- Culture ‘heme’ using yeast

* Plant protein (e.g. pea or wheat protein); fibrous component (e.g. bamboo or carrot); flavouring (e.g. iron or salt or vegetable extract); water; fat (e.g. coconut or sunflower oil); binding agent (e.g. xanthan gum or egg albumin); colouring (e.g. beet or turmeric juice).

The current market landscape

Much of the development in the field of cultured meat has been driven by start-up companies and university laboratories, with funding from large corporations (see Annex 1). Products are mainly at the prototype stage and are not yet available for purchase in restaurants or retail outlets. It is estimated that the value of the global cultured-meat market could reach $20 million by 2027, primarily driven by increases in meat consumption and innovation in the technology necessary to scale up from laboratory to factory production.

The global market for plant-based meat alternatives was estimated to be worth $4.63 billion in 2018 and, according to business information providers Research and Markets, is projected to reach $6.43 billion by 2023 (growing at a compound annual growth rate – CAGR – of 6.8 per cent). Research published in March 2018 by Mordor Intelligence put the expected CAGR of the market over the 2018–23 period at a slightly lower 5.8 per cent. According to Mordor, Europe presented the largest regional market for meat substitute products in 2017, with 39 per cent of global market share, while the Asia-Pacific market is estimated to be the fastest growing due to rising levels of economic development and to its large population. According to research undertaken by Nielsen for the US Good Food Institute, plant-based meat analogues still accounted for less than 1 per cent of the value of the total US retail market for meat as of 11 August 2018, but had risen in value by 23 per cent since the equivalent period of 2017. The worldwide market for meat has been valued at $1 trillion.

The food service sector is also offering plant-based meat alternatives. The ‘Beyond Burger’ is already sold in over 25,000 restaurants, hotels and universities worldwide. The ‘Impossible Burger’ is available in more than 4,000 locations in the US. Moving Mountains’ products are stocked at over 500 locations in the UK and are also available in the Netherlands.

Regionally, North America is projected to dominate the cultured-meat market in 2021, as the region is characterized by significant investment in the development of meat analogues. The market is also expanding into Asia, since China’s signature in 2017 of a $300 million agreement to import cultured-meat technologies from Israel, and the Japanese government’s participation in May 2018 in a $2.7 million funding round for a new ‘clean meat’ start-up, Integriculture.

In major Western markets the retail sector is both responding to and helping to drive this rising acceptance of plant-based meat alternatives. Major grocery retailers selling plant-based meat analogues

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33 Ibid.
35 Ibid.
include UK-based Tesco, Sainsbury’s, Waitrose & Partners and Ocado, and Whole Foods, Target, Safeway, Kroger and Walmart in the US.\(^{37}\) Around the world, there has been an increase in the number of all-vegan grocery stores, which also serve as retail channels for plant-based ‘meat’ products: these include Naturalia Vegan (France), Sweet to Lick (US), Veganz (Germany and the Czech Republic), and Vegan Supply (Canada).\(^{38}\) Certain brands have been successful in penetrating multiple markets: Beyond Meat’s plant-based ‘Beyond Burger’ recently launched in Tesco, the UK’s biggest retail supermarket, with the same market strategy used in the US, whereby the product is sold alongside animal-based meat patties.\(^{39}\)

The food service sector is also offering plant-based meat alternatives. The ‘Beyond Burger’ is already sold in over 25,000 restaurants, hotels and universities worldwide, including in major restaurant chains such as TGI Fridays and BurgerFi, in the US, and Honest Burgers and All Bar One, in the UK.\(^{40}\) The ‘Impossible Burger’ – the ‘bleeding plant-based burger’ mentioned earlier – is available in more than 4,000 locations in the US (including in two major chains – Bareburger and White Castle), and has been launched in Hong Kong and Macau, with plans to expand worldwide.\(^{41}\) British company Moving Mountains’ products are stocked at over 500 locations in the UK and are also available in the Netherlands.\(^{42}\) The Vegetarian Butcher, a Dutch supplier of plant-based meat alternatives, has expanded to 3,000 sales outlets in 14 countries.\(^{43}\) The Asian market already has cultural ties with vegetarian food, and recent campaigns by restaurants, food bloggers and start-ups have contributed to an increase in consumption of meat alternatives. Hong Kong-based start-up Right Treat has developed a plant-based pork substitute, branded ‘Omnipork’, with the intention that it can be widely used within Asian cuisine.\(^{44}\) Shifts in dietary habits towards vegetarianism and a reduction in meat consumption have been a major driver behind these launches.


Summary

- Two broad categories of meat analogues – advanced plant-based ‘meat’ and cultured meat – mark a particularly radical departure from the traditional meat and non-meat options.

- Producers of both plant-based ‘meat’ and cultured meat aim to deliver products that are indistinguishable from conventional meat.

- Markets for meat analogues are growing in Europe, North America and Asia where both the retail and food service industries are increasingly selling plant-based ‘meat’. Cultured meat is not yet on the market but significant scale-up of investment has been seen in Europe, North America, China and Israel.
3. Factors in the Growth of the Meat Analogue Industry

The direction and pace of growth in the meat analogue industry will depend upon numerous factors affecting prospects both for commercially viable production systems at scale and for acceptance and demand among target consumer segments. Despite increasing consumer awareness of the environmental and animal welfare impacts of eating meat and the growing market for reduced-meat diets, the degree of consumer acceptance of meat analogues is uncertain, as is the likely level of support from Europe’s civil society groups. The role of the incumbent industry in supporting or hindering the growth of meat analogues is also unclear: while some major players in the meat industry are investing in meat analogue innovations themselves, others are actively resisting the up-swell of start-ups marketing their products as meat substitutes.

This chapter explores the ways in which consumer perceptions, civil society and incumbent industry responses, technical challenges and meat consumption trends may influence the growth of the meat analogue industry in the EU before considering, in Chapter 4, the complexities of the regulatory questions to which meat analogues give rise.

Consumer perceptions of meat analogues

Producers of meat analogues actively target their products at meat-eaters. They have aligned their marketing with that of conventional meat products – emphasizing the taste and experience of eating meat through carefully chosen language and imagery – while innovators in cultured-meat products emphasize their ability to deliver meat ‘as we know it’, without the negative environmental and welfare impacts. The mission statement of San Francisco-based Memphis Meat encapsulates this concept, with the slogan ‘Better meat, better world’.

Deep-set personal preferences for meat in Europe are nevertheless expected to present a significant obstacle to generating widespread

demand for plant-based ‘meat’ and cultured meat. A number of studies undertaken into consumer attitudes to meat analogues specifically, and plant-based diets more generally, indicate that those already seeking to reduce their meat consumption are the most likely to purchase plant-based meat alternatives, while so-called ‘meat-believers’ – those who regularly consume meat and who do not display any active intention of shifting their diets – are less likely to be tempted by new meat substitute options.

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Familiarity, sensory attractiveness and the prevalence of food ‘neophobia’ are all likely to play a role in strengthening or dampening public interest, particularly among meat-eaters at whom novel meat analogues are aimed. The cultivation of recognizable whole cuts of meat – as opposed to muscle cells that can be used in minced-meat products (sausages, burgers, etc.) – in a way that is economically viable at scale remains a long-term goal. The technological process involved in producing a steak in vitro, for example, requires culturing a more complex tissue, including multiple cell types, and considerable progress is needed to achieve a steak or similar whole-cut of meat that achieves the colour, flavour and nutritional profile of meat harvested from an animal – and to do so in a manner that is economically viable is even more challenging, and therefore significantly further from market. Even with further technical breakthroughs, consumer concerns over the ‘naturalness’ of cultured meat are expected to be a major obstacle to the future widespread adoption of cultured-meat products.

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Early research indicates that cultured meat can evoke feelings of disgust and strangeness – often referred to as the ‘yuck’ factor – and that many consumers may view in vitro products as ‘freakish’.56

The (perceived) nutritional quality of meat analogues and their safety compared with conventional meat is also likely to be an important factor in their uptake.57 Relative to the conventional processed meat products that they are intended to replace (including burgers, sausages, nuggets, and so on), plant-based ‘meat’ products tend to contain lower levels of saturated fat, cholesterol and calories, and often contain higher levels of micronutrients such as zinc, iron and calcium.58 Beyond Meat and Impossible Foods both report that their burgers have a protein content comparable to that of an average conventional beef burger.59 Some studies have nevertheless demonstrated that individuals are worried about the production process and ingredients involved in manufacturing – for instance, over processing and high use of salt and genetically modified organisms (GMOs)60 – while others perceive meat analogues to be lacking nutritionally as compared with conventional meat.61

In the case of cultured meat, the controlled conditions for production raise the possibility of meat that is free from food-borne disease and that is at low risk of contamination. Furthermore, tightly controlled production procedures obviate the need for antibiotics while creating new opportunities for the addition of desirable vitamins and the reduction of fat and fatty acid content.62 Perceptions of the health impacts of consuming cultured meat vary considerably, in part due to a high degree of uncertainty among the public surrounding both the relevant technology and the production processes.63 While studies have indicated that some consumers acknowledge the potential health benefits and increased food safety of cultured meat compared with conventional meat, others argue that there persist several ‘unknowns’ about the long-term side-effects of eating cultured meat. Such arguments place particular emphasis on the risks of developing cancer and of catching food-borne diseases such as zoonoses (infectious diseases that are transmitted naturally between animals and humans).64 Another study demonstrated that those individuals with a greater degree of concern for the environmental impacts of meat consumption were more likely to express an interest in eating cultured meat.65
Support among environmental and animal welfare groups

Public attitudes to meat analogues, and particularly to cultured meat, will be shaped to a significant degree by civil society narratives. Civil society has played an important role in raising awareness among citizens about the impacts of their diets, and environmental groups in particular are deemed one of the most helpful sources of public information in Europe relating to meat consumption and the climate. The growing number of meat reduction campaigns, such as ‘Meat Free Monday’ and ‘Veganuary’, among others, have also been influential in raising awareness of the benefits of eating less meat and fostering the consumption of more plant-based meat alternatives. Yet past experience of civil society-led public discourse on GMOs in Europe, and its influence on low public acceptance of GM technologies in the EU, is indicative of the power of NGOs to shape both public opinion and public policy and regulatory responses.

Plant-based ‘meat’ and cultured meat present a dilemma to NGOs advocating a shift in meat-eating habits. For the most part, NGOs active on this issue promote messages of step-wise changes in diets, encouraging a flexitarian lifestyle and/or the substitution of ruminant meat (beef, lamb) for monogastric meat (chicken, pork). Few organizations – principally those concerned with animal welfare – are openly supportive of a shift to meat-free diets. Most NGOs, in shaping their campaigns around meat consumption, aim for moderate messaging that is accessible and appealing to mainstream audiences, and that avoid creating a perception of the organization as radical in its mission. Manufacturers and marketers of meat analogues are, in their own way, promoting a shift away from conventional meat but the means of their production and the way in which they are marketed raise certain questions for environmental and animal welfare groups (see below). In addition, there are concerns that the promotion of cultured meat may yield an ‘addition effect’ (also known as the ‘Jevons Paradox’) in which these new products do not replace conventional meat but instead contribute to even higher levels of total meat consumption (cultured and conventional combined).

Early assessments indicate that meat analogue production is significantly less resource-intensive than conventional meat production: based on current projections, a 50 per cent replacement of meat products by cultured meat, imitation meat (plant-based ‘meat’) and insects could be expected to yield a 38 per cent reduction in agricultural land demand. In the case of cultured meat, the concentration of resources on producing only muscle tissue that will be eaten – and therefore avoiding the energy-, resource- and time-intensive production of waste or by-products – is one of its most important

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attributes, according to advocates. Life-cycle assessments (LCAs) of the most well-known plant-based meat analogues indicate that plant-based ‘meat’ is, on the whole, significantly less emissions-intensive than conventional meat. The relative environmental impact of cultured-meat production compared with conventional-meat production is more uncertain. Cultured-meat production is expected to be less land- and energy-intensive than beef production, however, land requirements are anticipated to be similar to those of poultry production while direct energy inputs will be significantly higher.

Until such time as cultured meat is being produced at scale in industrial bioreactors it is not possible to assess fully the resource intensity of production.

LCAs of cultured meat at this stage are, however, highly speculative and are based on modelled rather than actual production methods. Until such time as cultured meat is being produced at scale in industrial bioreactors – at which point it may be assumed that cultured meat will have been approved under EU regulation and investments will have been made in the necessary infrastructure – it is not possible to assess fully the resource intensity of production. In addition, while assessments of actual production methods are possible with plant-based ‘meat’, producers have retained a degree of secrecy around the ingredients and techniques that achieve their unique degree of mimicry, meaning that the precise resource intensity of their production – embedded land use, for example – remains uncertain.

The ‘clean’ nature of meat analogues has also been questioned by civil society in response to the use of GMOs in certain plant-based ‘meat’ products and cultured-meat processes. In the US, civil society groups – including Friends of the Earth, ETC Group and PETA – have voiced concerns over the use of genetic engineering processes in the creation of the Impossible Burger and in certain cultured-meat production methods, and over the degree of processing involved in producing both plant-based ‘meat’ and cultured-meat products.

Among the animal welfare and animal rights communities, the prospect of ‘slaughter-free’ meat has garnered considerable support for the nascent cultured-meat industry: in 2008, the US-based animal welfare NGO People for the Ethical Treatment of Animals (PETA) announced a $1 million prize for the first research team to produce commercially viable in vitro chicken cells; more recently, in early 2018 Humane Society International/India launched a partnership with India’s Centre for Cellular and Molecular Biology to encourage both an expansion in production and a growth in demand for cultured meat in India, and other organizations, including Compassion in World Farming and Mercy for Animals, have publicly voiced their support for the scaling-up of cultured-meat production.
and consumption\textsuperscript{81} as a means of reducing the number of animals slaughtered each year for meat (estimated at 7.5 billion animals each year in the EU, and 9.1 billion in the US).\textsuperscript{82} The two longest-standing cultured-meat companies in Europe, Mosa Meat and Cellular Agriculture Ltd., currently harvest cells at the point of slaughter, however, and so are not ‘slaughter-free’. The continued use of foetal bovine serum (FBS) by many of the major cultured-meat companies is also likely to present a barrier to generating support among the animal welfare community, owing to the effects on the calf foetus in the process of its extraction,\textsuperscript{83} although serum-free media are already in use or in development by others in the sector.\textsuperscript{84}

\textbf{Economics of production}

Currently, cultured-meat production is highly labour intensive. In shifting from the laboratory to industrial-scale bioreactors, cultured-meat producers should be able to achieve economies of scale, but tissue engineering to this extent is both unprecedented and unproven.\textsuperscript{85} The price of production will need to fall dramatically if the end product is to be affordable and appealing for consumers.\textsuperscript{86} The start-up Aleph Farms recently announced it had been successful in producing a small strip of beef steak for $50 – compared with the $330,000 it cost to produce the first cultured-meat burger in 2013\textsuperscript{87} – while cultured minced meat also remains costly to produce at $11 per hamburger.\textsuperscript{88} Technical breakthroughs will be needed before prices drop further: today, 80 per cent of the costs of the final product result from the need for expensive growth factor proteins.\textsuperscript{89} Scale-up would also require associated investments in infrastructure and logistics, the cost and resource efficiency of which have yet to be examined.\textsuperscript{90} Sector stakeholders anticipate that it will be between five and 10 years before industrial-scale cultured-meat production is possible.\textsuperscript{91}

Industrial-scale production of plant-based ‘meat’ and cultured meat could bring fundamental changes to today’s food system. Growth in demand for plant-based ‘meat’ will generate greater demand for plant protein crops such as pea and wheat, creating an incentive for some livestock producers to


\textsuperscript{88} Ibid.


\textsuperscript{90} Stephens et al. (2018), ‘Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture’.

\textsuperscript{91} Insights from Chatham House expert roundtable, ‘Meat Analogues: What do they mean for the EU?’, held at Chatham House in London on 12 September 2018.
transition away from industrial animal farming. While new jobs would be created with the scaling up of cultured-meat production, they would likely be far fewer in number with much of the production process automated, and those that are created may be located in the industrial heartlands of Europe rather than in its agricultural regions. Power balances among industry players may see less change, however: while it is predominantly start-up companies and universities leading innovation in the meat analogue industry, several major agribusinesses are moving to buy stakes in the ‘disruptor’ companies and to invest in in-house innovation in plant-based ’meat’ and cultured meat.

Responses from industry incumbents

As in many sectors of the economy, incumbent meat industry has an important role to play in either accelerating or dampening innovation, depending on whether it views that innovation as a risk or opportunity. Lessons from other sectors, including the energy and utilities sectors, show that the response of industry incumbents to innovation can influence to a large extent its nature and success, particularly when market power is concentrated (as it is in the food sector) and when those incumbents take active steps to influence laws, regulations and public discourse.

On the one hand, the rise of plant-based ’meat’ and cultured meat poses a risk to conventional meat producers, and to processors, marketers and logistics operators along the supply chain: increased demand could prompt a shift among consumers away from conventional meat and could either incentivize more localized meat production or relocate production, all with potentially adverse implications for meat industry incumbents. On the other hand, meat analogues offer an opportunity for businesses in the meat industry to diversify their offering and spread their risk: early investment in meat analogue start-ups and in research and development (R&D) for proprietary meat alternatives could offer a means of hedging against future demand shifts. In 2016, a coalition of institutional investors, with assets worth a collective $5.3 trillion, called on meat companies to diversify the protein products they sell and invest in plant-based alternatives, outlining the multiple and growing investment risks associated with factory farming. Analysts have also noted the relatively stable prices of meat alternatives compared with conventional meat, as they are less reliant on seasonal supply fluctuations and offer opportunities for (potentially) longer shelf-life and easier storage.

Major players in the meat and food industries have already invested in plant-based ‘meat’ and cultured-meat start-ups – including Tyson Foods (with investments in Memphis Meats, Beyond Meat), Cargill (with investments in Memphis Meats), PHW (with investments in SuperMeat), Unilever (with investments in the Plant Meat Matters consortium and Vegetarian Butcher) and Jan Zandbergen (the company recently signed a distribution agreement with Moving Mountains) – though their investments remain small as a share of their overall R&D activities. Others in the industry have

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97 Kumar et al. (2017), ‘Meat analogues: Health promising sustainable meat substitutes’.
taken a more defensive approach to the rising number of meat analogue companies: some industry incumbents in the US have lobbied for a clarification of legal definitions of meat and for more stringent regulation of meat-alternative labelling.98

Meat consumption trends

Another likely factor in determining the scale of the future meat analogue industry lies in current trends in meat consumption, not only in Europe but globally. Since the 1960s, global patterns of meat consumption have shifted significantly. Worldwide demand for meat has steadily increased over this period, a trend that is expected to continue: the International Panel on Climate Change (IPCC) stated in a 2018 report that in the absence of proactive policy interventions to reduce meat consumption, ‘prevailing trends are for increasing rather than decreasing demand for livestock products at the global level’.99 This growth in overall consumption has been driven primarily by a rapid surge in consumption of poultry – the average per capita intake of which increased more than fourfold between 1961 and 2013 – with consumption of pork also showing a strong upward trend. By contrast, per capita consumption of meat from ruminants such as cattle, sheep and goats, plateaued over the same period.100

Worldwide demand for meat has steadily increased since the 1960s, a trend that is expected to continue.

Change over this period has looked very different from region to region. In Asia, per capita meat consumption grew significantly, driven principally by a surge in demand for pork and poultry. In South America, overall consumption has risen modestly but there has been a dramatic shift in demand from beef to poultry. In Europe and North America, poultry also took a growing share of total per capita meat consumption by the end of the 1961–2013 period, with a marked downturn in overall consumption occurring in North America from 2007 onwards (see Figure 2).

Total demand for meat in Europe has not dramatically changed in recent years although there has been a discernible shift away from the more resource-intensive ruminant meats (beef and lamb) and towards less resource-intensive monogastric meats (poultry and pork). In light of the reluctance of meat-eaters to shift to meat analogues, widespread growth in demand for plant-based ‘meat’ and cultured meat among target audiences may depend on a broader shift in social and cultural norms towards acceptance of flexitarian lifestyles and towards a food environment in which plant-based options are both more visible and more appealing.101 For those EU companies looking to export their products, booming markets in South America and Asia present a promising opportunity,

101 Stoll-Kleemann and Schmidt (2017), ‘Reducing Meat Consumption in Developed and Transition Countries to Counter Climate Change and Biodiversity Loss: A Review of Influence Factors’.
with growth in total consumption expected to remain strong and, in some countries (China and Singapore, for example), growth in the meat analogue industry is already underway. An increasing preference for poultry in these markets is also likely to create more favourable market conditions for cultured-meat manufacturers; chicken and duck meat are expected to be the first cultured meats to be market ready.

Figure 2: Meat consumption in Asia, South America, North America and Europe by type, 1961–2013


Summary

• Early studies of consumer attitudes to meat analogues suggest that concerns over the naturalness, healthiness and newness of meat analogues, together with high retail prices, may present a significant barrier to scaling up demand among meat-eaters, the target population segment for meat analogue producers.

• Among environmental and animal welfare NGOs, views on the merits of meat analogues are split. While many welcome plant-based ‘meat’ as a less resource-intensive alternative to conventional meat, others are concerned by the use of GMOs in the production of certain plant-based ‘meat’ products and cultured-meat products, and by the energy-intensive nature of cultured-meat production. Similarly, while cultured meat is welcomed by certain animal welfare groups, others criticize the continued use of FBS as a growth medium.

• Incumbent industry has responded to innovation in meat analogues in different ways. While certain companies – including major players such as Cargill and Tyson – have invested in the enterprises and technologies behind the growth in the meat analogue industry, others have called for more stringent regulation that would prevent meat analogue products from being labelled with meat-related names.

• Growing demand for meat in South America and Asia offers a promising export opportunity for European meat analogue producers if they are successful in achieving a high degree of mimicry of conventional meat. In Europe, where demand for meat remains strong, widespread uptake of meat analogues among meat-eaters may depend first on a broader shift in attitudes towards greater acceptability of plant-based diets.
4. The Regulatory Landscape in the EU

Public policymakers may take different approaches to encouraging – or inhibiting – innovation in the meat analogue industry. Firstly, they may impose strict rules on conventional corporate practices, forcing businesses to innovate. Secondly, they may create the conditions within which innovation brings a competitive advantage, for example, by introducing additional standards related to corporate practices or products, or through the introduction of sustainability criteria in public procurement policies – such that those who do not innovate risk missing out on market opportunities. Thirdly, they may introduce or maintain certain procedural, economic or political barriers to innovation and to the marketing of innovative solutions or products.

In the EU, where many of the frontrunners in plant-based ‘meat’ and cultured-meat innovation are located, current regulation and policy are largely supportive of investments and innovation in alternative proteins. In 2012, the European Commission adopted a flagship strategy, Innovating for Sustainable Growth: A Bioeconomy for Europe, in which it committed to developing new technologies, processes and markets in support of a sustainable, low-emissions, resource-efficient food system. A regulation adopted in 2017 has committed the European Commission to ‘review the supply and demand situation for plant proteins in the EU and to explore possibilities to further develop their production in an economically and environmentally sound way’. Moreover, in late 2018, the European Commission presented what has become known as its ‘EU Protein Plan’, which encourages the production of alternative proteins for human consumption, and notes that a number of existing EU policy instruments ‘provide options for strengthening the development of EU-grown plant proteins’.

A 2018 expert report, commissioned by the Directorate-General of Research and Innovation, identified the development of new meat alternatives as an important pathway to achieving the EC’s Food 2030 Initiative, to deliver a climate-smart, sustainable food system in Europe.

Public policymakers may take different approaches to encouraging – or inhibiting – innovation in the meat analogue industry.

The following section briefly outlines how plant-based ‘meat’ and cultured meat are – or may be – regulated by EU legislation. It identifies principal areas of uncertainty for regulators and meat-alternative developers with regards to their licensing and industrialization within the EU.

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European Union regulations: The broad picture

EU Food Law (Regulation EC No. 178/2002) sets the general principles and objectives of protecting human life, health and consumer interests and ensuring fair practices in food trade, undertaking a precautionary approach and enabling the free movement of food within the EU. Since its entry into force in 2002, innovation in the food sector has been tightly regulated across the EU. The 178/2002 Regulation was drafted in the wake of a series of food safety scares in the late 1990s and early 2000s, including the outbreak of bovine spongiform encephalopathy (BSE), and it established the European Food Safety Agency (EFSA), an independent body tasked with ensuring the safety of foods placed on the European market and of informing the development of EU-wide food policy. Today, the EFSA supports the EC in the approval of 'novel' foods, being inter alia an adviser to the EC on the safety of products to be placed on the EU market.

EU Novel Food Regulation

Newly developed foods are regulated under the Novel Food Regulation. ‘Novel’ foods are those that do not have a history of consumption in the EU before 15 May 1997 (the date on which the first Regulation on novel foods entered into force), either owing to new ingredients or to previously unused production processes. The Regulation is concerned with the safety of foods on the EU market and ensures that novel food products are: (a) safe to consume; (b) labelled properly so as not to mislead consumers; and (c) not nutritionally disadvantageous when compared with any existing food they seek to replace. The approval of novel whole foods – as opposed to food allergens or chemicals contained in foods – is regulated using a risk-based approach; testing for the presence of hazardous elements is just one of several checks that novel foods must go through before they are licensed for the EU market.

Testing for the presence of hazardous elements is just one of several checks that novel foods must go through before they are licensed for the EU market.

On 1 January 2018, a revised iteration of the Novel Food Regulation, (EU) No. 2015/2283 (replacing Regulation (EC) No. 258/97 and Regulation (EC) No. 1852/2001), entered into force. This aimed to address certain areas of ambiguity and to streamline and centralize the authorization process. Under the revised regulation, the average timeline for approval is expected to drop from 3–4 years to 1.5–2 years, and companies may now request that the data collated and used in support of their application – provided it is proprietary and exclusive – be protected for a period of five years. This process will, in theory, be more streamlined as a consequence of a shift away from an applicant-specific approach to approval towards generic product approval (reducing the long-
term procedural burden for the European Commission by preventing duplicate applications), and also as a consequence of the centralization of the safety assessment process under the European Commission and the EFSA as opposed to its devolution to member state authorities (Figure 3).

Other changes include the introduction of a light-touch process for approval of traditional foods that have a history of safe food use in non-EU countries, the explicit inclusion of whole insects as novel foods (only insect parts having been explicitly included under the previous iteration of the Regulation), and the introduction of a category for ‘food consisting of, isolated from or produced from cell culture or tissue culture derived from animals, plants, microorganisms, fungi or algae’.

Figure 3: Novel Food Regulation: overview of approval process under Regulation 2015/2283


116 Article 3(2)(a)(vi) of Regulation No. 2015/2283.
Meat Analogues: Considerations for the EU

What the Novel Food Regulation means for meat analogues

In 2007, an assessment of the EU Novel Food Regulation’s impact on private-sector willingness to launch new food products identified four key characteristics of a regulatory environment that encourage innovation: firstly, efficient and transparent procedures for assessment and approval; secondly, a consistent and limited timeframe for approval; thirdly, financial incentives for innovation and approval, including the recouping of R&D costs; and fourthly, certainty regarding the legal status of the approved novel product.17

The 2018 revision of the Novel Food Regulation sought to ensure the first two of these conditions by setting out a clear process for product authorization and streamlining that process to enable more rapid approval of products for market. The third condition – financial incentives for innovation – lies outside of the scope of the Novel Food Regulation itself, though the provision for five years’ data protection for proprietary, newly developed scientific evidence or data supporting the application offers a degree of financial assurance for manufacturers by protecting their competitive advantage for a time-limited period.

The fourth condition – certainty regarding the legal status of the approved product – is more readily met for manufacturers of cultured meat than plant-based ‘meat’ products. While cultured meat is mentioned explicitly under the Novel Food Regulation, there is less clarity around whether plant-based ‘meat’ products are considered as novel foods in the EU. For the majority of the plant-based ‘meat’ products currently available in the EU, the component ingredients have a long history of consumption in Europe or in third countries. What renders the products ‘novel’ is the innovative processes by which these ingredients are manipulated to create a product that is – or aims to be – indistinguishable from meat. These new processes raise questions regarding the appropriate quality and safety standards to be applied, including those relating to the ingredients. In cases where these starting materials do not themselves have a history of use in Europe or in third countries, plant-based ‘meat’ products may be considered a novel food and therefore subject to the Novel Food Regulation.

Product labelling

Rules on the labelling of food products in the EU are laid out in the Food Information to Consumers Regulation (FIC) (EU Regulation No. 1169/2011). The regulation on the provision of food information to consumers states that:

Food information shall not be misleading … by suggesting, by means of the appearance, the description or pictorial representations, the presence of a particular food or an ingredient, while in reality a component naturally present or an ingredient normally used in that food has been substituted with a different component or a different ingredient.118

The FIC Regulation requires that clear, precise and easily understandable food labelling be provided to enable consumers to make an informed choice and to ensure the ‘safe use of food, with particular regard to health, economic, environmental, social and ethical considerations’.119 The name of the food

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should be its legal name (names that may only be used on a product if it meets certain conditions stipulated in the Regulation) but if there is no such name, then the name of the food shall be its customary name (a name by which it is commonly known by EU consumers, without need for further explanation). If neither a legal nor a customary name exists, then a descriptive name (a name describing what the product is or contains) of the food must be provided.

In the case of novel foods, further labelling requirements may be imposed on manufacturers. The Novel Food Regulation No. 2015/2283 states that, when a novel food is added to the EU list of authorized novel foods, further requirements may follow relating to product labelling to ensure that consumers are fully informed of its nature, either in the description of the food or in information on its composition.

What product labelling regulation means for meat analogues

Labelling is one of the main regulatory bottlenecks for plant-based ‘meat’ options already on the market and the same is likely to be true for cultured-meat products. Policymakers, meat analogue producers and incumbents in the meat industry alike all want to ensure – for cultural, health and safety, and marketing reasons – that their products are easily identified and attractive to consumers. The specific nature of meat analogue products, however, raises difficult questions with regard to the legal or customary name under which they may be marketed. In the absence of specific regulations on plant-based ‘meat’ or cultured meat, the general labelling rules laid out in the FIC Regulation will apply. While the basic principles of product information provided to consumers – that it be clear, precise, easy to understand and not misleading – apply equally to plant-based ‘meat’ and cultured meat, issues relating to product labelling differ considerably between the two.

Studies indicate that the way in which these products are marketed will have a material impact on consumer demand. Approaches to labelling and marketing that highlight the environmental benefits of meat analogues as compared with conventional meat is expected to be a particularly effective way of appealing to the preferences and values of meat-reducing consumers (as opposed to those already following a vegetarian or vegan lifestyle). The legal, customary or descriptive name for cultured meat is likely to have a particularly marked impact on consumer demand: recent surveys have demonstrated that the use of the terms ‘clean’ and ‘slaughter-free’ has been shown to increase the acceptability of cultured meat, while ‘lab-grown’ is more likely to deter potential consumers. Any stipulations relating to the permitted positioning of meat analogues in-store – alongside conventional meat or separate to it – may similarly impact positively or negatively on sales.

Plant-based ‘meat’

The use of terms usually associated with conventional meat – ‘steak’, ‘fillet’, ‘bacon’, ‘sausage’, and so on – in the labelling of plant-based products has been subject to scrutiny and, in some cases, restriction in certain EU member states. Central to the argument against the use of meat-related

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120 Apostolidis and McLeay (2016), ‘Should we stop meating like this? Reducing meat consumption through substitution’.
terms such as ‘burger’ and ‘Schnitzel’ has been the assertion that their use risks confusing or misleading consumers.

In April 2018, the French National Assembly passed an amendment to the country’s Rural Code, stating that designations associated with animal products cannot be used to market food products of which a significant part is vegetable-based. To justify this change, members of Parliament referred to a decision by the European Court of Justice (ECJ) issued in June 2017 on the use of terms like ‘soy milk’ and ‘vegan cheese’. In this case, concerning the German company TofuTown, the ECJ ruled that sales designations for dairy products cannot be used to market purely plant-based products since Regulation No. 1308/2013, establishing a common organization of the markets in agricultural products, defines ‘cheese’, ‘milk’ and similar designations as coming from an animal.

The ECJ did not, however, comment on meat products. Regulation No. 1308/2013 does not define meat-related terms such as ‘steak’ or ‘burgers’, and EU law does not explicitly forbid the use of these meat-related terms. These terms could, in principle, be used for plant-based products so long as their use does not mislead consumers.

Arriving at a consensus among policymakers regarding a definition for meat analogues and requirements for their labelling is likely to be challenging.

In Germany, a 2017 appeal to the German Food Code Commission (DLMBK) by the German food minister and national farmers’ and butchers’ associations to restrict the use of terms such as ‘vegan Schnitzel’ and ‘vegetarian Bratwurst’ led to the publication of new guidance in August 2018. The guidance, from the DLMBK, indicates that terms relating to whole animals or to specific parts of animals – such as ‘ham’ or ‘sausage’ – may not be used for meat substitutes, and that references to names such as ‘Schnitzel’, ‘goulash’ or ‘meatballs’ may only be made if the substitute products are sufficiently similar in taste.

In an opinion published in October 2017, the EC recognized that greater clarity is needed and, as part of its Regulatory Fitness and Performance Programme, it announced that a review of the labelling of vegan and vegetarian food will begin in 2019. The Commission will likely prepare an implementing act, specifying how these foods may be labelled, as indicated in Article 26 of the FIC Regulation.

In November 2018, the European Commission set in motion a European Citizens’ Initiative on mandatory labelling of food as non-vegetarian, vegetarian or vegan to which Europeans may register their support. Should one million statements of support be received within a year, from at least seven member states, the European Commission will be required either to commit to implementing such mandatory labelling or explain its reason for not doing so. Arriving at a consensus among policymakers regarding a definition for meat analogues and requirements for their labelling is

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nevertheless likely to be challenging for the EU multi-levelled governance system: labelling decisions will need to be coordinated with processes in all member states, where cultural views of meat and meat alternatives vary considerably.129

Cultured meat

The naming and labelling of \textit{in vitro} meat raises two key issues: firstly, whether a product’s name and label should be required to indicate clearly the process of its production; and secondly, whether \textit{in vitro} meat can and should be referred to as ‘meat’.

As \textit{in vitro} meat is not yet authorized for the EU market, there is no agreement on its legal name. There are already a range of names given to meat products grown \textit{in vitro} both by those developing the technologies and by social commentators: cultured meat, clean meat, lab-meat are all commonly used, but these are not ‘customary names’ as defined by the FIC Regulation. Given that the key objective of the FIC Regulation is to ensure that fair, clear and precise information is provided to consumers – including on the method of manufacture or production – it seems likely that operators in the EU will need to ensure that the consumer is made aware via the product label that the meat in question was grown \textit{in vitro} rather than by conventional production processes, and that the legal name of the product will need to indicate this. This transparency requirement may be reinforced by the Novel Food Regulation: \textit{in vitro} meat is a novel food and will require authorization under the procedure laid out under the Novel Food Regulation No. 2015/2283.130 It appears likely, therefore, that the addition of \textit{in vitro} meat to the EU list of authorized novel foods will be accompanied by a specification that the production process be evidenced on the product label.

Anticipating whether operators marketing \textit{in vitro} meat will be permitted to label their products as ‘meat’ is more difficult. Under the FIC Regulation, for labelling purposes, meat is defined as ‘skeletal muscles of mammalian and bird species recognised as fit for human consumption with naturally included or adherent tissues’. The application of this definition to \textit{in vitro} meat will likely be up for debate: cultured meat may not be considered ‘skeletal muscle’ (which the Regulation in turn defines as ‘muscles under the voluntary control of the somatic nervous system’) nor does it consist of ‘naturally included or adherent tissues’ owing to the production process involved. If such a conclusion were reached, the term ‘meat’ could not be applied to \textit{in vitro} meat under current EU legislation.

If, on the other hand, it were determined that \textit{in vitro} meat could be defined as ‘meat’ under the FIC Regulation, further issues would need to be addressed, not least whether operators would be required to indicate a country of origin or place of provenance of the slaughtered animal, as is expected of operators marketing meat produced by conventional means.

As noted in a recent article exploring the challenges in bringing cultured meat to market, the degree of contestation over how cultured meat should be referred to reflects a deeper disagreement over what exactly cultured meat is and how it should be positioned in relation to conventional meat.131 Decisions relating to the terminology permitted in the marketing of future cultured-meat products will likely


\footnotesize{131}Stephens et al. (2018), ‘Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture’.

28 | Chatham House
be influenced not only by technical considerations but by political arguments too: permission for manufacturers of cultured meat to label their products as ‘meat’ with few additional caveats would likely meet with resistance from the traditional livestock industry; a decision to require that those manufacturers label their product as ‘artificial muscle proteins’ or similar may be expected to prompt a similar degree of resistance from the meat analogues industry.

**Regulation of GMOs and good manufacturing practice**

Food containing GMOs, or produced from a GMO source material, is subject to separate approval under Regulation No. 1829/2003 and does not come under the Novel Food Regulation. According to EU regulations, the decision to allow the import or production of a GM crop in any given member state may be taken on the basis of a risk-based safety assessment, as well as economic and consumer acceptance factors. Depending on whether the production process of cultured meat is considered to approximate pharmaceutical production more than food manufacture, cultured-meat production plants may also be subject to good manufacturing practice (GMP) guidelines. (GMP is an international system for quality and consistency control that aims to mitigate residual risks arising from pharmaceutical production that cannot be ruled out based solely on final product testing).

**What GMO regulation and GMP guidelines mean for meat analogues**

The decision to regulate either a plant-based ‘meat’ or cultured-meat product under GMO regulation would have implications for manufacturers, including specific stipulations for environmental and human safety assessments and product labelling. Perhaps more importantly, the use of GMOs in meat analogues is likely to dampen demand among European consumers who continue to negatively view genetic modification in food.

For most plant-based ‘meat’, the component ingredients have a history of consumption in the EU and the production techniques are already commonly used. Companies including Beyond Meat and Moving Mountains are already selling their ‘bleeding’ plant-based ‘meat’ products in EU countries without prior authorization under the Novel Food Regulation, though a retrospective decision to require that they be assessed and approved under the Regulation remains a possibility. In the case of the plant-based ‘Impossible Burger’, it remains unclear whether the Novel Food Regulation or Regulation No. 1829/2003 on GM food and feed would apply. ‘Heme’ (the key ingredient in the ‘Impossible Burger’, which supplies the characteristic taste and aroma of meat and which is carried in SLH) is produced through cell culture using genetically engineered yeast. Under the definition of the Novel Food Regulation, ‘heme’ may be considered a novel ingredient as it is produced ‘from cell/tissue culture derived from plants, animals, microorganisms, fungi or algae’. But, while the burger...
itself does not contain any genetically engineered material, its use in the production process will likely mean it must be regulated under the GMO Regulation. Certain methods of producing cultured meat also involve the use of GM organisms, raising similar questions around the regulatory pathway under which they would fall. Until such time as meat analogues produced using GM organisms are authorized for sale and consumption the EU, their import from non-EU producers will not be permitted.

The use of FBS in manufacturing practices for medicinal products has been discouraged globally under GMP protocols and under the EU Good Cell Culture Principles (GCCP). The use of FBS is further discouraged under EU regulations relating to the use of chemicals (Regulation No. 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals – REACH) and, where the foetus from which serum is harvested is not first killed, under regulations to protect animals used for scientific purposes (EU Directive No. 2010/63/EU).

Summary

• In the EU, cultured meat will be regulated under the Novel Food Regulation unless GMOs are used in the production process. In this case, and in the case of plant-based 'meat' techniques that make use of GMOs, products will likely be controlled under Regulation No. 1829/2003 on GMOs in food and feed.

• Plant-based 'meat' may not require authorization under the Novel Food Regulation if the component ingredients and processing techniques have a history of use in the EU. In the case of the Impossible Burger, which contains plant 'heme' produced using GM yeast, authorization under either the Novel Food Regulation or the GMO Regulation is likely to be required.

• Labelling requirements and restrictions are regulated under the FIC Regulation but there remains a high degree of uncertainty around how plant-based 'meat' and cultured meat may be named and marketed. Restrictions on the use of meat-like names for plant-based products in France and Germany indicate that future decisions taken at the EU level on meat analogue labelling are likely to be highly politicized.

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138 Ibid.
5. Looking Ahead: Considerations for EU Policymakers

As innovation continues in plant-based ‘meat’ and cultured meat, European policymakers will need to consider how the EU positions itself in the nascent global meat analogue industry. Certain European universities and companies have been central in the early development of meat analogue techniques but, with markets in North America, Asia and Israel growing rapidly, further financial investment and the resolution of outstanding regulatory uncertainties will be needed if the EU is to be a significant global player in this space. Perhaps more importantly, EU decision-makers and member states will need to consider if and how meat analogues contribute to the realization of existing policy strategies and priorities, not only in terms of environmental governance but also public health and the transition to a circular economy.

Considering the role of meat analogues in broader food system reform

The strength of incumbent industry and the perception of the livestock sector’s cultural importance have made meat consumption a politically sensitive issue in the EU and, in the absence of effective policy interventions to promote a large-scale shift away from conventional meat production and consumption, public investment in meat alternatives has been relatively muted. Despite the considerable negative externalities associated with meat production and consumption, EU efforts to promote a more sustainable food system are not without political challenges. Environmental concerns have at times clashed with economic and political priorities among the many formal and informal actors and networks that interact to define European regulation, and the EU's first draft sustainable food strategy, developed in 2013, was not published. Moreover, efforts to reform the Common Agricultural Policy (CAP) have repeatedly been slowed owing to strong economic and political support from EU member states for maintenance of the existing system – the CAP received approximately 38 per cent of the EU budget for 2014–20 (€408.31 billion over that period).

As the EU looks to meet its ambitious commitments on climate change mitigation, sustainable consumption and public health in the coming decades, it is crucial that public policymakers view meat analogues and their regulation within the broader context of food system reform. Meat analogues have the potential to galvanize the EU’s success in meeting many of its more ambitious policy goals, including the EC’s Food 2030 Initiative.

The EU’s plan to reduce GHG emissions under the UN Framework Convention on Climate Change (UNFCCC), for example, is among the most progressive in the world, and research has illustrated the

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vital importance of a reduction in meat consumption in the EU in meeting these climate targets. In 2018, new analysis from the RISE Foundation found that EU livestock production and consumption are currently exceeding sustainable levels for Europe and identified the substitution of conventional meat for cultured meat and plant-based alternatives are as a potential strategy for adjusting current livestock consumption patterns. Further research is needed to assess the resource footprint of cultured meat and plant-based ‘meat’ production at scale, and to develop a low-carbon energy source for the production of cultured meat. Early studies indicate that meat analogues could play a key role in satisfying current and future demand for meat in the EU, while significantly reducing the emissions and resource intensity of production and freeing up much-needed land for use in renewable energy production and carbon capture.

Early studies indicate that meat analogues could play a key role in satisfying current and future demand for meat in the EU, while significantly reducing the emissions and resource intensity of production and freeing up much-needed land for use in renewable energy production and carbon capture.

Meat analogues could play a similar role in delivering improved public health targets at the European and national levels. In 2015, European health ministers committed to the European Food and Nutrition Action Plan 2015–2020, which aims to create healthy food environments and tackle diet-related non-communicable diseases. As a result, several EU member states have taken steps to promote reduced consumption of meat in their national dietary guidelines, recognizing the links between excessive consumption of red and processed meat and diet-related diseases including obesity, type-2 diabetes, heart disease and certain cancers. Theoretically, cultured-meat cells may be engineered to create a healthier product, altering the balance of harmful components – saturated fats, for example – with desirable components such as poly-unsaturated fatty acids, while plant-based ‘meat’ products, unless highly processed, tend to contain relatively low levels of saturated fat, cholesterol and calories. At the EU level, the One Health Action Plan against Antimicrobial Resistance seeks to position the EU as a ‘best practice region’ in the fight against unsustainable antibiotic use, including through boosting innovation: if its producers succeed in scaling up

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146 Alexander et al. (2017), ‘Could consumption of insects, cultured meat or imitation meat reduce global agricultural land use?’.  


production in a sterile environment, cultured meat could offer a means of delivering a product that is healthier for consumers and produced without the need for antibiotics.

More broadly, investment in research, development and innovation in the meat analogue industry could form a keystone of the EU’s Circular Economy Action Plan and its Food 2030 Initiative, which both prioritize research and innovation in circularity and resource efficiency in the food system. Under the Circular Economy Action Plan, the EU has committed to implementing an ambitious package of measures aimed at promoting a ‘sustainable, low carbon, resource efficient and competitive economy’ in which innovative new ways of producing and consuming are promoted as a means of protecting the environment, buffering businesses against resource scarcity and price volatility, and unlocking new jobs.\textsuperscript{152} The development of a meat analogue industry that encourages the use of plant protein crops for direct human consumption rather than as animal feed, and creates new economic opportunities for European farmers outside conventional livestock production, may boost EU policymakers’ efforts to deliver on the circular economy.

**Ensuring a clear regulatory framework and evidence-based decision-making**

EU regulation has the potential to affect the nature, scale and pace of innovation, from the research and development stage right through to commercialization.\textsuperscript{153} Consumer safety and good manufacturing standards must remain the priority of regulators as they consider whether novel meat alternatives should be licensed for sale, and under what conditions. But, with legal definitions of meat and meat-related terms already being debated in European courts, EU policymakers will need to consider the broad range of issues and concerns surrounding meat analogues if they are to ensure a clear, transparent and evidence-based regulatory framework.

As it stands, the Novel Food Regulation provides for a technical assessment of the safety of meat analogues for humans, animals and the environment. The EFSA undertakes an assessment of potential nutritional, toxicological or allergenic hazards and recommends a decision to the Standing Committee, after which the European Commission and member states may raise specific safety concerns as they see fit before a final decision on approval is made. Less transparent is the process for deciding on specific stipulations regarding product labelling that may accompany an approval under the Novel Food Regulation, and on the process for determining legal, customary and descriptive names under the FIC Regulation on product labelling.

Insights from research into the labelling and marketing of vegetarian products and the impact of these activities on sales indicate the importance of labelling decisions and regulation in determining the future of the meat analogue industry. Clear and consistent product packaging and nutritional labels are vital to enabling consumers to make informed decisions and to fostering consumer trust in the European food system, particularly in the wake of the 2013 European horsemeat scandal: many consumers report paying more attention to labels on meat products, while others report a lack of


confidence in the honesty and accuracy of labels. The European Commission, recognizing that greater clarity is needed for innovators, incumbent industry and consumers, is set to undertake a review of the labelling of vegan and vegetarian food, for which preparatory work will start in 2019.

In order to ensure that product labelling prioritizes consumer information and trust, and is not co-opted by lobbyists from industry or third parties, European consumer watchdogs and government regulators should commission market research to explore consumer attitudes towards plant-based ‘meat’ and cultured meat, their labelling, and the information that consumers need to make an informed purchasing decision. Beyond technical considerations, the future growth of the meat analogue industry will depend on a host of social, economic and political factors. Any review process should involve engagement with the public, producers, specialists in environmental and human health, and experts in product labelling and consumer behaviour.

The same process should apply to cultured meat. In recognition of the European Commission’s reactive rather than proactive approach to novel food safety assessments (the process of assessment and approval is initiated only when an application is formally submitted by a producer), it may be necessary to establish an independent advisory committee to ensure timely consideration of the complex regulatory questions concerning cultured-meat products. This committee could be tasked with reviewing developments in the meat analogue space, considering likely safety concerns and labelling requirements arising from new techniques or products, and engaging with producers early on in the approval process to provide support and ensure that policymakers are kept abreast of developments. The generation of research data to support the EFSA assessment of novel foods and their safety will also be important to avoid bottlenecks in the approval process.

Beyond technical considerations, the future growth of the meat analogue industry will depend on a host of social, economic and political factors.

Furthermore, in taking early action to create a clear regulatory landscape, the EU could pioneer international standards for this new industry, thereby strengthening its position as a hub of innovation and contributing to a supportive global environment for European meat analogue companies wishing to export overseas.

**Investing public funds in research and development**

The costs associated with meat analogues, at the point of both production and retail, are likely to remain a significant barrier to widespread uptake in Europe in the near to medium term. Investments by traditional meat companies in plant-based ‘meat’ and cultured-meat companies may help to accelerate both innovation and the scale-up of production and distribution infrastructure.
However, policymakers at the EU and member-state levels have a key role to play, for example, in lowering market barriers to entry for new producers and facilitating the commercialization of research.

As major food companies move into the meat analogue space, public support for non-exclusive research and for the sharing of research findings will be important in keeping the field open to new entrants, particularly to small- and medium-sized enterprises, which have driven innovation to date. Public capital will also be needed to bridge the gap between innovations developed in the laboratory and their commercial exploitation: large up-front investments in the infrastructure to support the scale-up of new products or technologies are often difficult to secure from low-risk investors, particularly for small- and medium-scale producers; public capital can help to catalyse the commercialization of new innovations while mitigating against the risk that promising innovations are acquired and developed by actors outside the EU. This will be particularly important if the EU is to retain its position as a global hub of innovation in the meat analogue industry. The use of non-exclusive licensing arrangements with any third parties seeking to commercialize the end product can help ensure that foundational knowledge developed with public finance remains in the public sphere.

The EU has one of the world’s largest public-sector R&D programmes and has already committed significant public funds to supporting meat analogue innovation. Between 2010 and 2013, the EU provided over €1 billion for research into high-quality plant-based ‘meat’ products under the ‘LIKEMEAT’ project and, in 2017, it announced a further €1 billion investment in innovation in the agri-food sector under its Horizon 2020 R&D programme, including a €32 million budget for innovation in ‘alternative proteins for food and feed’. In addition, a number of other budgets could be used to further R&D in the field, including anticipated funds with the explicit aim of supporting high-risk disruptive innovations. Existing mechanisms can also support investment in research and innovation, including the European Fund for Strategic Investments (€500 billion), the InvestEU programme (€38 billion) and the Smart Specialisation Strategy (€41 billion).

A coordinated strategy at the EU level will be crucial to ensure that any funding resources channelled into meat analogue innovation are optimized efficiently and transparently and consistent with EU policy priorities. A unified research and innovation strategy for a climate-smart, sustainable food system could steer the consolidation of the above funds and target related financing sources, for example, climate-related research (which is due to get 35 per cent of the proposed €100 billion Horizon Europe research

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and innovation budget for the period 2021–27)\textsuperscript{364} and innovation under the circular economy and One Health agendas. A core component of such a unified strategy should be the optimization of investment in meat analogues that offer sustainable and healthy alternatives to conventional meat.

**Conclusion**

Meat production and consumption are highly politicized issues in the EU and globally. Meat analogues, while in their infancy, are already the subject of much speculation and debate among innovators, incumbent industry, civil society and the public. As innovation continues to evolve at pace in Europe and around the world, it is crucial that EU policymakers take stock of this nascent industry and consider its place in EU-wide policy priorities and industrial strategies.

A thriving meat analogue industry in the EU has the potential to contribute to existing policy priorities in a number of areas, including climate mitigation, reduced antibiotic use, improved public health and more circular means of production. To harness this potential, early and sustained public investment is needed in research, development and commercialization to ensure that innovations transition from the laboratory to European markets. Equally important will be a proactive and inclusive approach to resolving outstanding regulatory uncertainties, particularly around product naming and labelling. In the absence of such an approach, there is a risk that key policy decisions – decisions that will likely have a material impact on the response of the public and civil society to novel products and production systems – are made in the courtroom and shaped by third-party interests rather than by policymakers in a timely, transparent and evidence-based manner.

Global efforts to promote sustainable and equitable food system reforms and mitigate the environmental impact of food – particularly meat – production on the environment and on public health are gathering momentum. A timely and coordinated strategy at the EU level to harness the potential of the nascent meat analogue industry within this context, and to promote a regulatory environment that is clear, transparent and inclusive, could help to cement the EU’s place at the forefront of innovation in the sustainable resource economy and as a global leader in the meat industry of tomorrow.

Annex 1: Companies Active in the Production of Plant-based ‘Meat’ and Cultured Meat

<table>
<thead>
<tr>
<th>Company</th>
<th>Founded</th>
<th>Origin</th>
<th>Funds raised</th>
<th>Investors</th>
<th>Activities</th>
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</thead>
<tbody>
<tr>
<td><strong>Plant-based ‘meat’ companies</strong></td>
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<tr>
<td><strong>Beyond Meat</strong></td>
<td>2009</td>
<td>US</td>
<td>$72m</td>
<td>Bill Gates; Tyson Foods; Twitter co-founders Biz Stone and Evan Williams; Leonardo DiCaprio; former McDonald’s CEO Don Thompson.</td>
<td>Retail distribution, particularly through Whole Foods Market Inc. On 12 April 2018, Germany’s PHW Group announced it had become a strategic partner to Beyond Meat to launch its plant-based burger in Europe.</td>
</tr>
<tr>
<td><strong>ChickP</strong></td>
<td>2016</td>
<td>Israel</td>
<td>$0.5m</td>
<td>Agrinnovation, an investment company that commercializes agricultural technologies generated by The Hebrew University of Jerusalem’s faculty of agriculture.</td>
<td></td>
</tr>
<tr>
<td><strong>Dao Foods</strong></td>
<td>2018</td>
<td>China</td>
<td>Seed funding (undisclosed)</td>
<td>Dao Ventures; Moonspire Social Ventures; New Crop Capital.</td>
<td>Venture group that aims to create meat alternatives for Chinese consumers.</td>
</tr>
<tr>
<td><strong>Gold &amp; Green</strong></td>
<td>2015</td>
<td>Finland</td>
<td>Paulig acquired a 51% stake for an undisclosed amount in 2016. Prior to this, the company had raised over €1m.</td>
<td>Finnish food company Paulig has been the majority shareholder since 2016.</td>
<td>Gold &amp; Green’s products are made from oats as an alternative to mince or as an ingredient in salads or sandwiches. The company says it hopes to launch its products in the UK ‘in the near future’.</td>
</tr>
<tr>
<td><strong>Impossible Foods</strong></td>
<td>2011</td>
<td>US</td>
<td>$387m</td>
<td>Bill Gates; Open Philanthropy Project; Khosla Ventures; Google Ventures; UBS Group AG; Viking Global Investors; Horizons Ventures; Temasek; Sailing Capital.</td>
<td>Supplying the food service industry; product available in more than 4,000 locations in the US, Hong Kong and Macao.</td>
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166 Ibid.
167 Ibid.
168 Ibid.
169 Ibid.
170 Ibid.
171 Ibid.
172 Ibid.
173 Ibid.
174 Ibid.
### Plant-based ‘meat’ companies (continued)

<table>
<thead>
<tr>
<th>Company</th>
<th>Founded</th>
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<th>Investors</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ojah</td>
<td>2009</td>
<td>Netherlands</td>
<td>Undisclosed</td>
<td>Korys; Kerry Group will become a shareholder pending merger approval from the European Commission.</td>
<td>Ojah’s technology enables the company to produce wet texturized plant protein with a meat-like taste and texture. The range is also gluten-free and additive-free. Ojah exports its products to more than 21 countries.</td>
</tr>
<tr>
<td>Right Treat</td>
<td>2018</td>
<td>Hong Kong</td>
<td>Undisclosed</td>
<td>Undisclosed.</td>
<td>Developing a plant-based protein for Asian consumers. Plant-based ‘Omnipork’ launched in 2018, designed as a versatile product that can be used to cook a variety of Asian dishes.</td>
</tr>
<tr>
<td>Sunfed Meats</td>
<td>2015</td>
<td>New Zealand</td>
<td>Undisclosed</td>
<td>Jeremy Coller of Coller Capital; New Crop Capital; ‘angel investors’ from New Zealand, the US and the UK.</td>
<td>Established company in New Zealand, distributing frozen product through Countdown and New World supermarkets, among others. It emphasizes the chicken-like taste and texture of its products. The company is planning to expand internationally, with the UK as a key future market.</td>
</tr>
<tr>
<td>The Vegetarian Butcher</td>
<td>2010</td>
<td>Netherlands</td>
<td>$10m</td>
<td>Private investors, who bought €2.5m in bonds; Triodos Bank.</td>
<td>Innovative plant-based meat and fish substitutes, which are in several European countries through their own or third-party stores. The Vegetarian Butcher has expanded to 3,000 sales outlets in 14 countries and has its own production plant. The company also has a partnership with UK-based Waitrose &amp; Partners to supply the meat alternatives for its new plant-based range of ready meals.</td>
</tr>
</tbody>
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174 Glotz (2018), ‘Meat the disruptors: 15 startups shaking up the $90bn global meat industry’.
175 Ibid.
177 Glotz (2018), ‘Meat the disruptors: 15 startups shaking up the $90bn global meat industry’.
178 Ibid.
179 Ibid.
181 Glotz (2018), ‘Meat the disruptors: 15 startups shaking up the $90bn global meat industry’.
## Meat Analogues: Considerations for the EU

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Cultured-meat companies</strong></td>
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</tbody>
</table>
| Aleph Farms                   | 2017    | Israel | Undisclosed  | Aleph Farms was co-founded in 2017 by Technion and Israeli food-tech 'incubator' The Kitchen, a part of the Strauss Group, and is supported by US and European venture capital firms.  
[182](#) | The company uses 3D technology and applies the tools of regenerative medicine to produce cultured meat.  
[183](#) |
| Finless Foods                 | 2017    | US     | $3.5m        | A total of 13 investors, including Harrison Blue Ventures; Hemisphere Ventures; StarLightMedia; Olive Tree Capital; Softmatter VC; U-Start; Yakumi Investment; Blue Horizon Equity; Babel Ventures; Draper Associates.  
[184](#) | This biotechnology company is at an early stage of developing and mass producing pioneering marine animal food products for human consumption.  
[185](#) |
| Future Meat Technologies      | 2018    | Israel | $2.2m        | SZG Ventures; HB Ventures; Yissum (the technology transfer company of The Hebrew University); Neto Group; BimsXBits; Agrinnovation; Tyson New Ventures.  
[186](#) | The only company worldwide holding an unlimited cell source that was not genetically modified, capable of differentiating to both muscle and fat. The technology was exclusively licensed from The Hebrew University of Jerusalem.  
[187](#) |
| Higher Steaks                 | 2017    | UK     | Undisclosed  | Undisclosed                                                               | The company is developing a production method that substantially reduces the amount of media needed to produce cell-based meat; an intelligent in-process monitoring system to improve efficiency; and a biomaterial that allows the generation of more structurally complex products.  
[188](#) |

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185 Ibid.


187 Ibid.

<table>
<thead>
<tr>
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<th>Investors</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integriculture Inc.</td>
<td>2015</td>
<td>Japan</td>
<td>¥300m</td>
<td>Real Tech Fund; Beyond Next Ventures; A-FIVE (Agriculture, Forestry and Fisheries Fund Corporation for Innovation, Value-chain and Expansion Japan); MTG Co., Ltd.; euglena Co., Ltd.; Dr Hiroaki Kitano (CEO of Sony Computer Science Laboratories, Inc.); and other investors.</td>
<td>Food tech company aiming to reform current agriculture through cultured-meat production, has developed patented general-purpose large-scale cell culture system, 'CulNet System'. Demonstrated a clean chicken foie gras product in 2017.</td>
</tr>
<tr>
<td>JUST</td>
<td>2011</td>
<td>US</td>
<td>$220m</td>
<td>Temasek; Mitsubishi; Founders Fund; Li Ka-shing; the Heineken family.</td>
<td>The company is still developing its lab-grown meat, but it is confident it can make scalable lab meat that is safe, free of antibiotics and carries less risk of food-borne illness.</td>
</tr>
<tr>
<td>Memphis Meats</td>
<td>2015</td>
<td>US</td>
<td>$20.1m</td>
<td>Tyson Foods; Draper Fisher Jurvetson; Cargill; New Crop Capital; Richard Branson; Bill Gates.</td>
<td>Considered the leading company in the cultured-meat market, the company has already cultured a ‘clean’ beef meatball and in 2017 unveiled lab-grown chicken and duck.</td>
</tr>
<tr>
<td>Mosa Meat</td>
<td>2013</td>
<td>Netherlands</td>
<td>€7.5m</td>
<td>M Ventures; Bell Food Group.</td>
<td>Dutch start-up co-founded by Mark Post, the scientist who invented the first lab-grown burger. It expects to introduce its first product made of lab-grown meat to the market by 2021.</td>
</tr>
<tr>
<td>SuperMeat</td>
<td>2015</td>
<td>Israel</td>
<td>$3.5m</td>
<td>Stray Dog Capital; New Crop Capital. Germany’s PHW Group, one of Europe’s largest poultry producers, became a strategic investor in January 2018.</td>
<td>Its technology relies on a single biopsy, which can allow for scaling up production of cultured-meat products.</td>
</tr>
<tr>
<td>Wild Type</td>
<td>2016</td>
<td>US</td>
<td>$3.5m</td>
<td>Mission Bay Capital; Root Ventures; Spark Capital.</td>
<td>The company aims to develop a technology that would multiply basic animal cells in the lab to create a technology that could be applied across all kinds of different animal species and culture all types of meat.</td>
</tr>
</tbody>
</table>

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185 Ibid.
186 Glotz (2018), 'Meat the disruptors: 15 startups shaking up the $90bn global meat industry'.
187 Ibid.
188 Ibid.
189 Ibid.
191 Ibid.
192 Ibid.
193 Glotz (2018), 'Meat the disruptors: 15 startups shaking up the $90bn global meat industry'.
194 Ibid.
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Acknowledgments

Special thanks go to Isadora Fernandes Ferreira (Energy, Environment and Resources Department, Chatham House) and Anne-Marie Benoy (Hoffman Centre for Sustainable Resource Economy, Chatham House) for their invaluable research and input into the project.

Thanks also go to Rob Bailey (formerly Chatham House), Professor Tim Benton (University of Leeds and Chatham House), Benjamina Bollag (Higher Steaks), Alexandra Clark (Humane Society International/Europe), Illtud Dunsford (Cellular Agriculture Ltd), Olga Kikou (Compassion in World Farming), Katia Merten-Lentz (Keller and Heckman LLP) and Alexandra Sexton (University of Oxford) and two anonymous reviewers for their review and reflections on the research.

We are very grateful for the insights of those who participated in our ‘Meat Analogues: What do they Mean for the EU?’ workshop held in London on 12 September 2018. Special thanks go to Professor Allan Buckwell (Institute for European Environmental Policy), Nicolas Carbonnelle (Bird & Bird), Sarah Castell (Ipsos MORI), Dr Marianne Ellis (University of Bath), Helen Harwatt (Harvard Law School), Abigail Herron (Aviva Investors), Niccolo Manzoni (Five Seasons Ventures), Peter Verstrate (MosaMeat) and to the reviewers listed above for their interventions during the workshop.

We are grateful to our editors Mike Tsang, Vera Chapman Brown and Jo Maher for their enthusiastic and meticulous editing of the report and for all of their feedback, support and patience throughout the process.

Thanks also go to Nick Capeling, Stuart Coles, Jordan Lim, Nina Black, Thomas Farrar, Gitika Bhardwaj, Jessica Pow and Jason Naselli for their help with the launch; and to Autumn Forecast at Soapbox for her work on the design and production of the report.

A number of members of the Chatham House Energy, Environment and Resources Department – both staff and interns – provided research and administrative support throughout the process. Sincere thanks go to Sean Alexander, Sofia Palazzo Corner, Caitlin Mackridge, Neal Millar and Ruth Quinn.

Finally, thanks go to Compassion in World Farming and Humane Society International for their generous support of this research.
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Cover image: The Impossible Burger 2.0, the new and improved version of the company’s plant-based vegan burger that tastes like real beef is introduced at a press event during CES 2019 in Las Vegas, Nevada on 7 January 2019. Copyright © Robyn Beck/AFP/Getty Images

ISBN 978 1 78413 312 2