An Exploratory Study of Sociotechnical Imaginaries Surrounding Cultured Meat: Visions of Proponents and Opponents in the European Union

by

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Executive summary

The global food system faces pressing challenges, including environmental degradation, resource scarcity, and ethical concerns surrounding conventional meat production. Cultured meat has emerged as a potential solution, promising to address sustainability, food security, and animal welfare issues. However, its future remains uncertain due to conflicting sociotechnical imaginaries—collective visions of desirable futures and how science and technology shape society.

This study examines the imaginaries of both proponents and opponents of cultured meat within the European Union (EU), exploring how these visions influence present day actions, governance, policy, and the broader protein transition. The research reveals that competing imaginaries shape the discourse on cultured meat. Proponents emphasize economic opportunities, food security and sustainability benefits, and the potential to create a cruelty-free food system. They argue that cultured meat can reduce greenhouse gas emissions, land use change, provide a stable protein source amid growing global demand and increase European competitiveness. In contrast, opponents frame cultured meat as a disruptive force that threatens socio-economic stability, cultural traditions, and sustainability. They highlight concerns over monopolization, regulatory uncertainties, health and environmental impacts as well as effects on culture and farming traditions.

Despite these opposing views, governance solutions are actively being debated. Proponents advocate for favorable regulatory frameworks, public investment, and incentives to accelerate commercialization. Opponents, however, call for strict labeling laws, potential bans, and policies that protect traditional farming communities. The EU's Novel Food Regulation plays a critical role in determining whether cultured meat gains market access, with some Member States considering national restrictions.

The findings suggest that the trajectory of cultured meat will depend on which imaginaries gain political and social dominance. While technological advancements and regulatory approvals may pave the way for its adoption, acceptance remains a key challenge that is influenced by different sociotechnical imaginaries, their values and interests. Understanding these competing visions can help policymakers navigate conflicts, design effective governance mechanisms, and ensure a balanced approach to food system transformation. Cultured meat represents both a disruptive

innovation and a contested technology. As stakeholders negotiate its role in the future food system, addressing ethical, environmental, and economic concerns will be essential for shaping a sustainable and inclusive protein transition in Europe.

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List of Abbreviations

CAFO – Concentrated Animal Feeding Operations
EFSA – European Food Safety Authority
ESG – Environmental, Social, and Governance
R&D – Research and Development
EU – European Union
FBS – Foetal Bovine Serum
GFI – Good Food Institute
GHG – Greenhouse Gas
GDP – Gross Domestic Product
GVC – Global Value Chain
IP – Intellectual Property
LCA – Life Cycle Assessment
MEP – Member of the European Parliament
MNE – Multinational Enterprise
NGOs – Non-Governmental Organizations
PETA – People for the Ethical Treatment of Animals
STS – Science and Technology Studies

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1. Introduction

1.1. Meat production and technological development

Human dietary patterns negatively impact the environment, particularly in terms of land use changes, freshwater consumption, and greenhouse gas (GHG) emissions (Smith et al., 2024). The world's population is expected to exceed 9 billion people in the next 30 years, driven by the increase in people surviving to reproductive age, the rise in human lifespan, and other trends with far-reaching consequences (United Nations, n.d.). Therefore, the necessity to support the dietary needs of a growing and aging global population is expected to have significant environmental impacts.

Despite being an essential part of a healthy human diet, proteins are linked to numerous environmental problems. They are critical nutrients for the human body that support growth and development, and they are important for maintaining musculoskeletal health (Smith et al., 2024). Even though animal products (meat, aquaculture, eggs and dairy) constitute only 37% of protein supply, they use 83% of the world’s farmland and account for approximately 58% of food production related emissions. Additionally, the global livestock industry has recently come under scrutiny due to the negative human health impacts, and the conditions in which animals are farmed and slaughtered, deepening the worries about the future of protein production (Ellies-Oury et al., 2022; Fatima et al., 2023).

Considering the projected population growth and the environmental, health and ethical concerns, the current animal protein production and consumption patterns are not compatible with sustainable food and protein systems. The global average per capita meat consumption is on the rise, driven by not only population growth but also increasing average individual income (Godfray et al., 2018). While forecasts indicate a rising demand for conventional proteins up to 2050, climate change necessitates considering non-linear scenarios and the potentially transformative role of alternative proteins in the global and EU protein balance (European Parliament, 2024).

Alternative proteins are proposed as solutions to a number of sustainability issues associated with meat. They refer to novel high-protein foods such as plant-based substitutes, insect-based protein foods, algae, products from microbial fermentation and lab-grown or cultured meat (IPES-food, 2022; Wiesner, 2023). The

different products and technologies are associated with their own benefits and challenges that can be highly controversial and contested. Among novel proteins, cultured meat is the most reported FoodTech innovation and it is distinct due to its revolutionary potential (Chriki et al., 2020). As a Novel Food, cultured meat is yet to receive approval from the European Food Safety Authority (EFSA) to be sold in the European Union (EU). In comparison to other alternative proteins, cultured meat technology is able to create products that are identical to conventional meat and it holds the promise to enable meat consumption while ensuring global food security and sustainability (Stephens et al., 2018, IDTechEx, 2023). However, many of the promises and potential benefits of cultured meat are largely speculative (Olenic and Thorrez, 2023). Therefore, it is strongly linked to future visions as well as promises and expectations.

1.2. Problem statement

Cultured meat is a technology that has received increased attention over the last five years and is rapidly emerging as a new market (IDTechEx, 2023). However, it is also highly controversial, surrounded by different ideas of its potential risks and benefits. Contrary to traditional farming methods, cultured meat is produced by culturing animal cells in a medium outside the living body (Fatima et al., 2023). Due to the radically different production methods a transition towards this type of production would have far reaching consequences for the current food system and the various stakeholders involved in it.

Emergence of cultured meat technology has sparked heated debates and political disagreements. This is due to the different visions various actors hold about the role of cultured meat technology within the society and in the transition towards sustainability. It is also associated with various ideas about its benefits and risks, and the future of technological development. These visions are especially discernible in the European political arena where politicians, national delegations and other stakeholders promote and make their sociotechnical and protein visions public through reports, debates, voting, commentary, articles and other activities.

The future of food and protein systems is central to EU decision-making and visionary claims that frame the protein issue and solutions in various ways. Political speech in general is saturated with statements about good and anticipated futures,

along with proposals that assign responsibilities to various actors and entities to realize those suggested visions (Karhunmaa, 2019). In the EU efforts to transition to sustainability in different sectors is an ongoing challenge unfolding amid what is known as global polycrisis - a combination of economic, social, and environmental crises that collectively pose systemic risks (European Environment Agency, 2024).

Political debates surrounding food and protein systems within the European Parliament make reference to the current geopolitical context and environmental issues, what technologies and policy actions can bring about desired futures, how they could do it and who should be involved ("Verbatim Report of Proceedings - European Protein Strategy (Debate) - Thursday, 19 October 2023," 2023). These debates reflect broader visions; however, they also exclude alternative visions held among stakeholders that do not directly participate in decision-making processes but nevertheless are involved in the food system and have the ability to shape the future of protein production.

When initial 'vanguard visions' (Hilgartner, 2015), visions held amongst individuals or small collectives regarding the future using science and technology, succeed in gaining traction, they can rise to the status of collectively held sociotechnical imaginaries (Jasanoff, 2015). This concept emerged from an increasing awareness that expectations regarding future possibilities are deeply rooted in the organization and practice of science and technology (Jasanoff & Kim, 2009). Initially sociotechnical imaginaries concept was introduced to talk about nation-specific technological goals and projects and later it was broadened making it more universal (Rudek, 2022). As an analytic device, sociotechnical imaginaries can be used to identify the different ways that groups of people collectively imagine their relationship with science and technology and the type of future these relationships can produce (Hughes, 2024).

Numerous sociotechnical imaginaries can co-exist within a society either in tension or in a productive interplay and it is often institutions of power, such as legislatures, courts, and the media that can place certain imagined futures above others, granting them a dominant position for policy purposes (Jasanoff, 2015). Considering that the dominant European sociotechnical imaginary on cultured meat is in-the-making and conflicting imaginaries of the technology exist, there is a degree of uncertainty about the future of cultured meat that is currently widely debated. Therefore, the following research focuses on the emerging cultured meat imaginaries

and contestation before a dominant imaginary is institutionally stabilized, focusing on how the technology is framed among various stakeholders and what it could mean for its future development.

During this time when, after their emergence, imaginaries clash and engage with one another, tensions are especially discernible as imaginaries compete to spread and gain traction. Identifying these sociotechnical imaginaries and their underlying storylines, could help clarify the perceived benefits, promises, fears and risks associated with cultured meat technology and how they are used to bring actors together and advance interests. Additionally, tracing sociotechnical imaginaries and their narratives could point to values and interests involved and therefore reveal how tensions between these imaginaries can be resolved.

This can help distinguish which imaginaries have the potential to materialize and under what circumstances it can be achieved. Furthermore, it can highlight what policy actions and governance activities are necessary to maximize the benefits and minimize the risks of cultured meat technology imagined by various groups. This could further illuminate what actions are necessary for developing sustainable sociotechnical pathways for cultured meat technology and what could be its role in the future of protein production.

1.3. Research objective and research questions

The research objective is to explore cultured meat imaginaries of proponents and opponents in the European political arena using the sociotechnical imaginaries perspective. The study aims to understand what are the futuristic visions in relation to cultured meat that are constructed within the EU, what are the tensions between these visions and how these collectively held visions might influence the future development of cultured meat technology. Following this, the question that the study aims to address is:

What are the sociotechnical imaginaries of proponents and opponents of cultured meat within the European Union and how could they shape the future trajectory of the technology?

The research question is investigated and answered using 4 sub-questions:

- *Who are the relevant stakeholders in the cultured meat debate?*
- *What are the sociotechnical imaginaries and their perceived risks and benefits of cultured meat emerging among stakeholders in Europe?*
- *What are the main points of conflicts and agreements between the imaginaries?*
- *What are the governance solutions proposed by different sociotechnical imaginaries?*

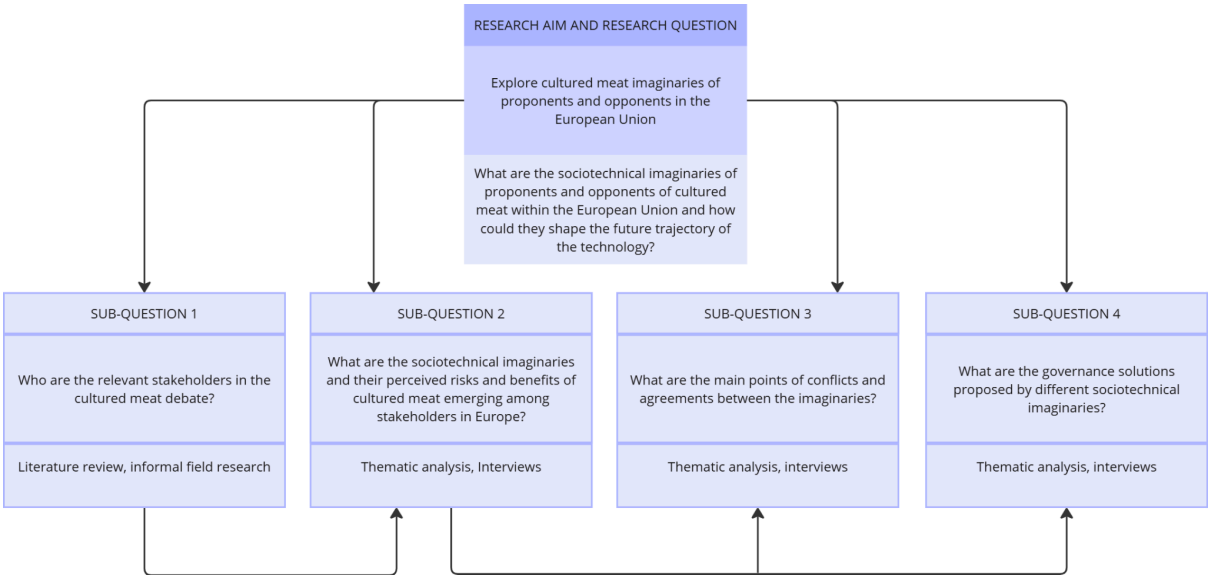

Figure 1. Research flow diagram.

1.4. Scientific and societal relevance

Sociotechnical imaginaries allude to desirable futures and 'how life ought, or ought not, to be lived' (Jasanoff, 2015: 4). These imaginaries not only refer to how technology can bring about desirable futures but they also entail ideas of what is considered undesirable. Sociotechnical imaginaries are not merely ideas as they have material consequences, bringing projects into being and justifying their development (Beck et al., 2021).

Cultured meat is a new potentially disruptive technology whose future is not yet known. It is currently produced on a very small scale and it has not received approval from the EFSA, therefore it cannot be considered part of the current food system. Considering the wide range of negative impacts that result from the food

system, there is an urgency for a sustainable transition, especially regarding meat production. The term sustainability transitions is employed to talk about large-scale disruptive changes in societal systems which are necessary to tackle societal challenges and that emerge over a long period of time (Loorbach, 2017). They pose a threat to existing configurations that are continuously facing sustainability challenges and offer opportunities for a systemic change that cultured meat could potentially achieve.

Even though a transition is necessary, the pathways to sustainability and whether cultured meat could be a solution is unclear. Helping societies to achieve sustainable protein production requires paying close attention to the desires and fears that people have, as well as their values and interests reflected in their protein imaginaries. Therefore, this study can provide understanding of what hopes and concerns are associated with cultured meat technology and how they can be addressed in order to support the development of this technology. The results can be used by decision-makers, technology developers and designers, as well as companies concerned with their communication strategies. Additionally, the research contributes to the field of studies on sociotechnical imaginaries with a focus on food systems and protein transition.

1.5. Relevance to the field of Industrial Ecology

Industrial ecology takes an inter and transdisciplinary approach to understanding (un)sustainability and it encompasses a variety of approaches to researching society-nature relations (Ramos-Martín & Padilla Rosa, 2023). It focuses on concepts, methods and tools that can be used to identify, design and critically evaluate sustainability solutions and their implementation.

Considering that cultured meat is a technology that can have far reaching consequences for the food system, society and the environment, its impacts are not easy to quantify as it is part of a complex network of interactions which are more than numbers. Therefore, as a sustainability solution, cultured meat needs to be critically assessed.

Sociotechnical imaginaries concept provides a lens through which the impacts of the technology can be assessed from the point of view of stakeholders who would be affected by it. Therefore, the findings are relevant for the scientific community that

aims to design a technology that is sustainable from a holistic point of view, taking into account values involved. Additionally, it is relevant for decision makers that are responsible for policies that can help Europe to transition their food systems to more sustainable configurations.

1.6. Thesis Outline

The thesis consists of seven chapters. The first chapter provides a general introduction to the topic which leads to the problem statement. Further research objectives and research questions are outlined and the scientific and societal relevance is explained. In chapter 2 background information on traditional meat and cultured meat are provided. Chapter 3 introduces the theoretical framework on sociotechnical imaginaries. The following chapter 4 explains the methodology used for data collection and analysis providing a detailed explanation of how the thematic analysis was applied. Chapter 5 presents results of the study that are organized to answer the sub-research questions. Chapter 6 provides a discussion on the findings, limitations of the research and recommendations for future research. Finally, chapter 7 offers a conclusion.

2. Background

The following chapter provides background information necessary for the development of the research. In the first half the central topic is traditional meat. It introduces the difficulties associated with changing the production and consumption patterns of meat and the issues related to industrial production regarding environmental, human health and ethical implications. In the second half, the focus is on cultured meat. The chapter provides an introduction to the history and technology of cultured meat and outlines the opportunities and challenges associated with the technology.

2.1. Traditional meat

2.1.1. Meat beyond nutritional value

The significance of meat extends beyond dietary considerations and it plays an important and diverse role in people's lives around the world (Bekker et al., 2017). Meat is not only prepared and consumed for its nutritional value but it is deeply connected to cultural traditions and norms, as well as aspects of identity, gender relations and understandings of 'health, purity, or naturalness' (Nungesser & Winter, 2021). Additionally, meat is considered to be a high status food as people in many countries can afford to consume it only on special occasions (Bekker et al., 2017). Meat consumption has strong symbolic meaning and it is highly ideologically charged. This ideological aspect is illustrated by the fact that most people in the industrialized world do not need to consume animal products for their survival or do not need to consume at a rate it is currently done on average (Broad, 2023). The decades-long high cultural status that meat holds and the resulting daily-meat normative has led to 'a socio-technical protein regime that is highly resistant to change' (Hundscheid et al., 2022).

Food and eating in general are intertwined with cultural conventions and activities relating to daily life (Hundscheid et al., 2022). Oftentimes it can be difficult to introduce dietary changes and alter deeply ingrained food habits because of aspects such as lack of cooking skills and social support (Treich, 2021). When it comes to meat, it is also the strong attachment, its high nutritional value and pro-meat beliefs that are strengthened by various structures. These include existing social norms, values as well as policy (in)actions that create barriers for transition.

The current meat production system has been largely shaped by government policies that contribute to the regime that resists change (UNEP, 2023). The decades-long investments, incentives in the form of subsidies supporting conventional animal farming, as well as pricing that does not account for social and environmental externalities have allowed to keep the price of meat artificially low while the negative externalities are increasingly high.

2.1.2. Environmental concerns

Negative externalities from the meat production are manifold. Livestock industry produces large amounts of GHG emissions which are estimated to range from 12% to 18% globally (Fatima et al., 2023; Ellies-Oury, 2022). Additionally, industrial large-scale meat production is associated with biodiversity loss, pollution, climate change and the disruption of the nitrogen cycle (Fatima et al., 2023; Jahir et al., 2023; Gu et al., 2023). Due to the land requirements for grazing and arable land for the feed production it drives land use change and deforestation, and animal feed is in direct competition with human food (Fatima et al., 2023; Ellies-Oury, 2022). Additionally, livestock farming affects water ecosystems and requires large quantities of freshwater. It contributes to eutrophication of waterways as a result of nitrogen and phosphorous emissions which can potentially lead to oxygen depletion in lakes and seas (Jahir et al., 2023). The overall effect of large scale meat production on the environment is characterized by significant negative impacts

2.1.3. Health concerns

In addition to negative environmental impacts, the production and consumption of meat is also linked to adverse health effects. High levels of meat consumption, especially processed red meat, is connected to increased risk of non-communicable diseases, including cardiovascular diseases, type-2 diabetes, as well as obesity and being overweight. (Fatima et al., 2023, Gu et al., 2023; van Dijk et al., 2023). Additionally, the consumption of red meat is associated with certain cancer developments. The pervasive use of antibiotics in animal agriculture is contributing to the problem of antibiotic resistance in humans (Bryant & Sancturom, 2021).

Human health is also negatively affected during animal farming and the production process. Most animals kept for meat production are raised in concentrated animal feeding operations (CAFOs) that cause animal suffering and bring dirt, chemicals and also disease into the environment (Jahir et al., 2023). CAFO workers are exposed to these harmful impacts experiencing asthma, eye irritation and chronic bronchitis on a regular basis. Being in close contact with animals in agriculture can also increase the risk of zoonotic diseases such as swine flu and bird flu (Bryant & Sancturom, 2021). Animal farming plays a role in the emergence and spread of zoonotic pathogens due to domestic animals being the source of infectious diseases that can reach humans (Espinosa et al., 2020). Intensive livestock farming characterized by genetic proximity and high density create conditions in which pathogens can mutate and evolve. As a result, there is a higher risk of mutation that can be transmitted to humans, such as zoonoses.

2.1.4. Ethical and animal welfare concerns

Intensive livestock farming not only raises human health concerns but also ethical questions. Farming methods and issues surrounding animal welfare are increasingly being called into question. Monogastric farms in particular are being highlighted due to the disconnection between different elements such as the land, the farm, and the living conditions that do not respect the well-being and natural behavior of the animals. (Ellies-Oury, 2022). More that 90% of farmed animals globally are kept in factory farms where they endure high levels of suffering from painful mutilations, inappropriate cage sizes, and frequent abuse (Bryant & Sancturom, 2021). Additionally, breeding strategies that have been implemented over the last five decades aimed at improving animal production have pushed animals to their biological limits, resulting in a loss of natural biodiversity (Ellies-Oury, 2022).

2.2. Cultured meat

2.2.1. History and development

The development of alternative protein sources, particularly cultured meat, has emerged as a promising solution to address problems associated with conventional meat production and consumption. The idea of cultured or in-vitro meat for human consumption is not new and its beginnings can be found already in the essay ‘Fifty Years Hence’ by Winston Churchill published in 1932 in book *Thoughts and adventures* (Zuhaib Fayaz Bhat et al., 2015). Churchill wrote that ‘Fifty years hence we shall escape the absurdity of growing a whole chicken in order to eat the breast or wing by growing these parts separately under a suitable medium’. In the early 1950s Willem Van Eelen of the Netherlands had the idea to generate in vitro meat using tissue culture. However, it wasn’t until 1999 that the theoretical idea was granted a patent (Zuhaib Fayaz Bhat et al., 2015; Ellies-Oury, 2022).

From 2000 onwards, different scientists began to produce meat by culturing muscle tissue. In 2002, National Aeronautics and Space Administration (NASA) scientists succeeded in culturing muscle tissue from common goldfish in order to explore the possibilities of culturing animal muscle protein for long space voyages initiating research for in vitro meat (Kumar et al., 2021, Zuhaib Fayaz Bhat et al., 2015; Pandurangan & Kim, 2015). In 2013 the world’s first cultured beef burger came out in the laboratory of Professor Mark Post at Maastricht University and it was cooked and tasted by a sensory panel in London that acknowledged its close resemblance to conventional meat (Gu et al., 2023; Zhang et al.,2021, Zuhaib Fayaz Bhat et al., 2015). From 2015 onwards different private companies working with cultured meat have been founded (Zhang et al., 2021). These include Memphis Meat (United States of America) who remains the leader in terms of investment, Super Meat (Israel) and Mosa Meat (The Netherlands).

In 2016 The Good Food institute was created, a non-profit organization that works internationally to accelerate alternative protein innovation and that also promotes cultured meat (Ellies-Oury et al., 2022). In their 2022 State of the Industry Reports they stated that 156 cultured meat companies across 29 countries have been founded (Gu et al., 2023). The year 2023 was a milestone in the history of food and agriculture because meat made without animals was first approved for sale in the world’s largest economy of the United States (US) where cultured meat could be

ordered at two restaurants (The Good Food Institute, 2023). Additionally, cultured meat expanded in Singapore and in 2024 Israel became the third country to advance the approval of cultured meat sales. In the same year French company Gourmey requested a pre-market authorisation for lab-grown meat, specifically foie gras, in the EU, sparking a heated debate on the prospect of cultured meat becoming a reality (Euractive, 2024). Their application was followed by Mosa Meat who announced at the beginning of 2025 that they have submitted their first Novel Food application to the European Commission (EC) for their cultivated beef fat (Mosa Meat, 2025).

2.2.2. Technology

Whether it is foie gras or other types of meat, such as beef or chicken, cultured meat generally is an artificially produced animal flesh product that is not part of a living animal (Pandurangan & Kim, 2015). Cultured meat or in vitro meat is also known as clean meat, lab-grown meat, cell-based meat, cultivated meat and animal-free meat (Gu et al., 2023). The meat is produced outside the living body by culturing the stem cells that are obtained from farm animals inside a bioreactor (Zuhaib Fayaz Bhat et al., 2015). It is done by applying advanced tissue engineering techniques derived from regenerative medicine. This medical field aims to restore dysfunctional or injured organs with functional in vitro-grown tissues.

The production of cultured meat, which is part of the field of cellular agriculture, is based on cell biology and tissue engineering technology (Gu et al., 2023). Considering that the production of cultured meat products is a trade secret for companies, the detailed production process remains unknown to the public. However, the general key technical aspects are known to include cell collection, cell culture, biomass accumulation and food processing (Gu et al., 2023).

Cultured meat production begins with cell harvesting. This step includes cell or tissue biopsy from a live animal or an animal that has been freshly slaughtered or cell isolation from embryos (Lanzoni et al, 2024; Chen et al., 2022) . The subsequent step following cell harvesting involves isolating satellite muscle cells and culturing them to initially promote proliferation and then differentiation within bioreactors where cells need a constant supply of nutrients provided through culture media. In addition to that, they need secondary components such as animal serum, proteins, peptides and other materials that are important to provide cells with signals for their viability,

replication and differentiation. The next step is scaffolding in which biodegradable and/or edible scaffolds are used to provide an environment in which cells can first adhere and proliferate and subsequently differentiate. Cultured meat then goes through maturation before it reaches the final stage. This is due to cell proliferation and differentiation. The product is collected when the desired biomass is accumulated (Gu et al., 2023). The processing aspect depends on what is the desired product.

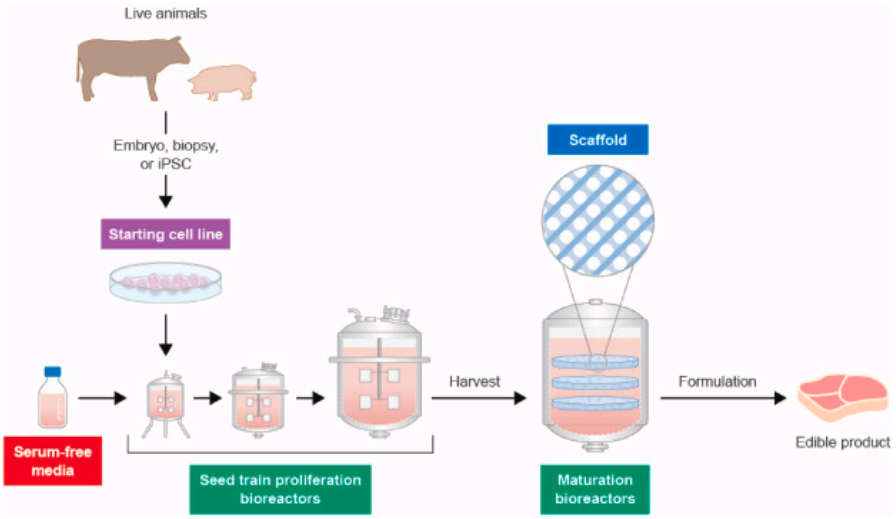

Figure 2. The bioprocess of cultured meat production. The four key technology areas are starting cell lines, culture media, scaffolds, and bioreactors (Chen et al., 2022).

2.2.3. Opportunities

The potential opportunities that can be utilized by cultured meat are manifold. With the global population rising, the demand for protein is growing, making cultured meat a promising solution for meeting dietary needs without the extensive resource consumption associated with traditional livestock farming and therefore addressing the need to reduce the negative environmental consequences of traditional agriculture (Jahir et al, 2023). As a biotechnological innovation, it closely resembles conventional meat while offering substantial benefits not only regarding environmental indicators such as GHG emissions, but also improved animal welfare and enhanced public health and safety (Ellies-Oury et al., 2022).

2.2.3.1. Sustainability

Cultured meat offers significant environmental benefits compared to conventional livestock farming. It could contribute to reduction in water usage, eutrophication potential, as well as land use (Stephens et al., 2018). Cultured meat could drastically reduce water usage (82–96%) and lower overall energy needs compared to conventional meat (Fatima et al., 2023). It requires up to 99% less land and produces 96% fewer GHG emissions, despite higher energy use (Jahir et al., 2023). By reducing reliance on traditional poultry farming, it could also lower the risk of eutrophication.

Livestock occupies a large proportion of arable land and is a major producer of GHG emissions. Therefore, by shifting to cultured meat, which requires significantly less land, competition between food production and climate mitigation efforts could be eased. While many of these findings are based on hypothetical models, life cycle assessments in which cultured and conventional meat are compared showcase substantial sustainability advantages of cultured meat regarding GHG emissions, land use, water consumption and energy requirements (Fatima et al., 2023)

2.2.3.2. Animal welfare and ethics

Cultured meat could also offer opportunities to improve animal welfare. It could significantly reduce the number of animals used in meat production (Jahir et al., 2023). It allows people to consume traditional meats like hamburgers and steaks without harming animals, making it a more ethical alternative (Schaefer & Savulescu, 2014). Since the cultured meat production process, in which muscle tissue is grown from a small number of cells, is likely to require significantly fewer animals, it is considered more animal-friendly than conventional meat production (Ellies-Oury, 2022).

Furthermore, cultured meat could potentially help tackle extinction and decline in the wild population of numerous species. Their struggles are linked to the traditional worldwide exchange of exotic meats from animals that are either uncommon or endangered (Zuhaib Fayaz Bhat et al., 2015). Cultured meat could be produced from the cells of endangered animals or even extinct species, providing a sustainable way to create exotic meats without threatening biodiversity.

2.2.3.3. Health and safety

Cultured meat could potentially offer several health and safety benefits compared to conventional red meat. It has a healthier lipid profile, with lower concentration of saturated fatty acids and no dietary cholesterol, making it a better alternative for nutrition, health and well-being (Fatima et al, 2023).

Additionally, its standardized production together with known composition could help prevent diseases associated with red meat consumption. Unlike traditional meat, cultured meat production is less exposed to chemical hazards such as pesticides, fungicides, and antibiotic residues, as well as harmful bacteria like Salmonella and E. coli and viruses such as Avian and Swine flu (Pandurangan & Kim, 2015).

Proponents argue that cultured meat is safer because it is produced in a fully controlled environment, free from pathogens (Ellies-Oury et al., 2022). The term ‘clean meat’ reinforces this perception, emphasizing its sterile nature and that it is free of any health hazards compared to conventional meat (Ong, Choudhury, & Naing, 2020).

2.2.3.4. Food security

Cultured meat plays a crucial role in supporting food security and sustainability, with its sustainable development closely linked to the safety of cultured meat (Jairath et al., 2021). In Europe, policymakers recognize new technologies as essential for ensuring stable and resilient food systems, as emphasized in the European Commission's Communication on food security (Lanzoni et al., 2024). By reducing reliance on traditional livestock farming, cultured meat can address global food demand, particularly as populations grow. Its efficient production methods require fewer resources and the controlled production environment enhances food safety. As a result, cultured meat presents a tool for improving food security.

2.2.4. Challenges

Even though cultured meat is expected to be a more sustainable alternative to the current factory farming practices on a number of environmental and also social indicators, its implementation on a larger scale poses a challenge. These challenges are multifaceted, ranging from uncertainty regarding its environmental impacts, cost

reduction, ethical concerns, technical and sensory challenges, religious and cultural status, societal acceptance as well as regulatory and political challenges.

2.2.4.1. Environmental impacts

Although life cycle assessment studies of cultured meat are characterized by high uncertainty due to the nature of these studies that are based on modeling and assumptions, they indicate that the production of cultured meat is linked to high energy use due to the production of necessary ingredients and bioreactor use (Jahir et al., 2023).

2.2.4.2. Cost

The cell cultured medium constitutes the largest marginal cost of the production on industrial scale. In order for the cell-cultured meat to be able to compete with livestock meats, the cost of the media needs to be reduced to a point that encourages large-scale production (Hamlin et al., 2022).

2.2.4.3. Animal welfare

An important question relates to the design of a cultured medium and how to avoid using foetal bovine serum (FBS) which is considered unethical as it is obtained after slaughtering pregnant cows (Ellies-Oury et al., 2022). In addition to being considered unethical, FBS is also expensive, inconsistent in its composition and quality, as well as limited in its suppliers. However, it is possible to run production without FBS, proven by many cultured meat companies (GFI, 2024)

2.2.4.4. Technology

Cultured meat is also associated with technological challenges that include process technology as the limitation for the production scale. Technologies that are necessary for the production process are derived from pharmaceutical production and scale up for the production of food is a central research theme (Diaz, 2023). Another major challenge that cultured meat is grappling with is the primary sensory determinants such as flavor, color and texture that need to be equivalent to livestock meat (Jahir et al., 2023). The design of bioreactor has a large effect on the flavor, texture and cost of the production of cultured meat. Therefore, it will be necessary to

develop novel bioreactors with ‘low shear and consistent perfusion over huge capacities’ (Jahir et al., 2023) that could improve the flavor and texture of the final product.

2.2.4.5. Cultural and religious status

Some challenges are related to the ambiguous status of cultured meat. For example, the religious status of cultured meat and whether it can be classified as either halal or kosher is still debated among both Islamic and Judaic authorities (Hamlin et al., 2022; Ellies-Oury et al., 2022). Food and eating are closely tied to cultural conventions and daily activities, and frequently perceived as part of individual freedom (Hundscheid et al., 2022). What is considered meat and how the concept is operationalized may be culturally dependent and therefore heterogeneous across consumers from different countries and with different backgrounds (Bekker et al., 2017).

2.2.4.6. Social acceptance

In most countries the consumption of cultured meat has not been approved (Jahir et al., 2023). A large number of people are not in favor of the concept of cultured meat when they hear about it (Jahir et al., 2023). One of the most significant obstacles to public acceptance is the perceived unnaturalness of cultured meat, seeing it as artificial instead of actual meat. The perceived unnaturalness and unpleasant feelings associated with the concept of cultured meat are recognized as having a larger influence on willingness to eat cultured meat than the motive to improve animal welfare (Ellies-Oury et al., 2022). A major concern that people have is the impact this technology could have on farming traditions and livelihoods (Hamlin et al., 2022).

2.2.4.7. Regulatory landscape

Cultured meat faces a range of regulatory challenges. According to a recent study done by European Parliament Research Service (2024) on alternative protein sources for food and feed there are a lot of uncertainties and it is unclear whether evidence on cultured meat would be enough to satisfy EU regulatory requirements. The regulatory approval is lengthy and complex because cultured meat is classified

as a Novel Food product. Novel Food is ‘food that had not been consumed to a significant degree by humans in the EU before 15 May 1997, when the first Regulation on Novel Food came into force’ (European Commission, n.d.)

Prior to entering the food market foods recognized as Novel Foods have to undergo authorisation on the basis of food safety risk assessment carried out by scientific food authorities (Lanzoni et al., 2024). The regulation that entered into force in 2018 reformed the previous authorisation procedure where now both the risk assessment phase and the risk management phase are entirely centralized.

The current legislative framework with its ‘precautionary approach’ is centered around the assumption that a prior careful risk assessment is necessary for innovative foods in order to ensure the highest standard of consumers’ health protection. Cultured meat is a highly debated Novel Food in the EU territory, not only by the scientific community but also civil society and national policy makers and legislators. Some EU Member States are considering banning the production and marketing of cultured meat which might further affect sector growth (European Parliament Research Service, 2024). However, the European regulatory framework is directly enforced in each Member State. Therefore, any future authorisation in relation to cultured meat obtained at EU level would also have a binding effect in countries imposing a ban and they might be unable to maintain the legitimacy of a national ban.

3. Theoretical framework

The following chapter introduces the concept of sociotechnical imaginaries. It first introduces the reasoning behind using the concept of sociotechnical imaginaries, outlines the theoretical foundation of this concept and its relationship with science and technology studies. The chapter continues by explaining other concepts important for understanding the sociotechnical imaginaries framework and how the sociotechnical imaginaries concept relates to innovation and policy. It then goes into the relationship between the concept, actors and their interests after which it turns to how sociotechnical imaginaries have been used in research and the problems associated with it. In the final section of the chapter, the sociotechnical imaginaries concept and its dimensions are explained focusing on how it is used for this study.

3.1. Introduction

Visions of the future play a crucial role in shaping actions in the present, as these ideas of what the future can be are woven into decisions that influence the sociotechnical fabric of society (Delina, 2018). Consequently, future imaginaries serve as the foundation for designing, developing, deploying, marketing, and regulating technologies, ultimately influencing how they are accessed and adopted (Kao, 2024).

The concept of sociotechnical imaginaries elaborates on the relationship between these imagingins and the material and practical expressions that attempt to bring them into existence (Kao, 2024). Cultured meat is strongly linked to ideas of what the future of meat production should look like, which has consequences for how the development, marketing, and regulation process is carried out. Therefore, sociotechnical imaginary can be used as an analytic device to uncover what are the collectively imagined relationships between social groups, science and technology that exist in relation to cultured meat and what are the futures these relationships might bring about (Hughes, 2024).

3.2. Science and technology studies and sociotechnical imaginaries

The material aspect of technology development is often viewed as separate from the social, as if the design of technologies was not intricately connected to and influenced by the social structures that enable and sustain their production (Jasanoff, 2015). Technological objects are deeply entangled with society and exist as part of social order requiring a broader contextual understanding beyond the technology itself.

The imagination of technology-driven futures is a fundamental aspect of state foresight planning and frequently influences policies of the present (Csernatoni, 2022). By emphasizing the societal dimensions of technology and science developments, the field of science and technology studies (STS) provides various approaches to studying how conceptualization of the future shapes present day policy decisions.

The concept of sociotechnical imaginaries used by STS scholars draws attention to how visions of future developments in science and technology are linked to broader visions of social futures and what is considered collective good (Jasanoff, 2015). It emerged from an increasing recognition that expectations regarding future possibilities are integral to the organization and practice of science and technology (Jasanoff & Kim, 2009). Sociotechnical imaginaries differ from broader use of the term ‘imaginary’ because of their distinct relationship between collective imagination, science, and technology (Jasanoff, 2015).

3.3. Sociotechnical imaginaries concept

Jasanoff and Kim (2009) proposed the use of the concept of sociotechnical imaginaries as a method to encourage STS research on national and state technoscientific policies and politics. This has proven to be a productive line of investigation influenced by the study on national imagined communities carried out by Anderson (1991), as well as the studies of modern political structures shaped by social imaginaries done by Castoriadis (1987) and Taylor (2004).

The term sociotechnical imaginaries as initially introduced by Jasanoff and Kim allows exploring how national political orders and technoscientific projects co-produce each other (Felt, 2017). According to Jasanoff and Kim, the production

and reproduction of nations is closely linked to sociotechnical imaginaries. The national is continuously reimagined through sociotechnical imaginaries that are projected, produced, implemented, and uptaken. Jasanoff and Kim explain the central role of state power that sociotechnical imaginaries are associated with. The active exercise of it is crucial in filtering and selecting the discursive framings that become dominant, integrated into the goals and priorities of state and public action.

Later Jasanoff and Kim (2015) redefined and extended the concept of sociotechnical imaginaries in order to account for the numerous ways that 'scientific and technological visions enter into the assemblages of materiality, meaning, and morality that constitute robust forms of social life' (Jasanoff, 2019: 4). Thus, they define sociotechnical imaginaries as:

'*collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology' (Jasanoff, 2015: 4).*

Sociotechnical imaginaries tend to be more stable when institutionalized (Völker et al., 2020) and they are performative in the way they can mobilize resources, justify certain costs (Rudek, 2022), convince new actors and gradually reshape the idea of a technology's future potential, embedding it with additional purposes beyond the initial idea (Korsnes, 2016). The three conditions that constitute sociotechnical imaginaries are 1) they are collectively held 2) different imaginaries can co-exist 3) they are at the same time normative and material (Senna & Macnaghten, 2021).

3.4. Expectations and visions

Sociotechnical imaginaries emphasize the politics and power of deeply ingrained collective ideas that shape expectations and visions. Expectations are 'statements about future conditions or developments that imply assumptions about how likely these are supposed to be and that travel in a community or public space' (Felt, 2017). They are connected to particular technological development or future state, whereas visions often are linked to 'more or less coherent packages of

potential future states (Felt, 2017). Expectations have the ability to materialize, demonstrating a commitment to a particular future, which can be reflected in investments in a technology. They are seen as important in shaping innovation trajectories and sociotechnical transitions (Bakker et al., 2012).

Most of the time expectations are not presented as neutral but instead serve as promises or concerns and warnings that have underlying positive or negative valuation. Promises are linked to optimistic expectations while concerns or warnings are linked to expectations about potential problems and risks regarding the development and application of a technology (Felt, 2017). Expectations, visions, and other forms of anticipation not only describe but have an impact on what may or may not happen in the future. When technologies are still in the making, promises and concerns surrounding them mobilize and also legitimate the activities of different societal actors, including policy makers (Felt, 2017).

Expectations may be contradictory and they may compete to remain relevant (Korsnes, 2016). This is not necessarily a weakness, as scenarios are flexible and can be leveraged to gain support from different groups. Additionally, as noted by various scholars on expectations, some promises are intentionally set unrealistically high to spark interest and create a protected space for a technology. Although these promises may be unrealistic, they are useful for those advocating for the technology, as they may influence how people consider the topic and they are part of strategic games.

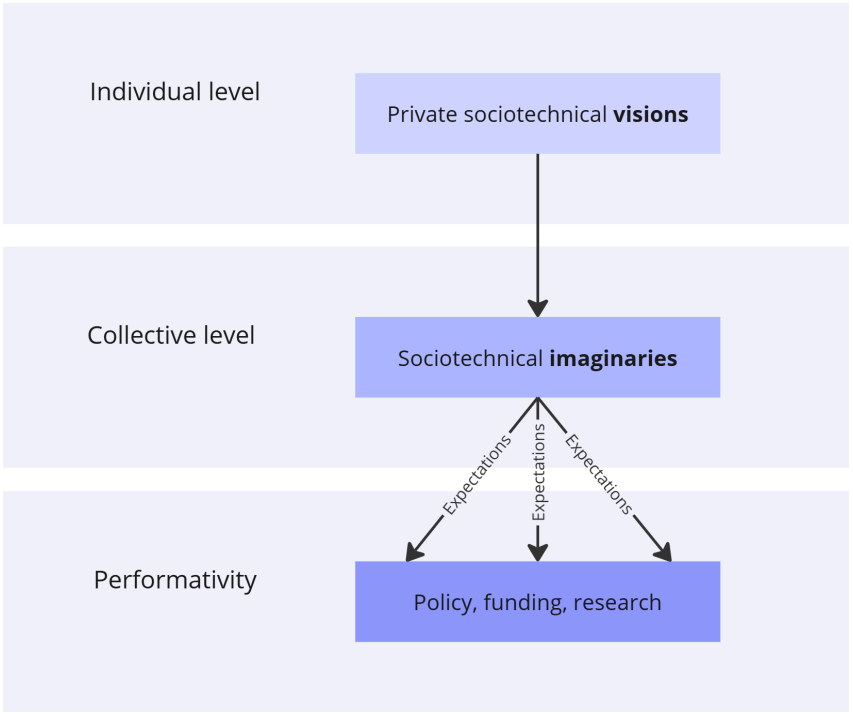

Figure 3. Performativity of the future visions – scope of analysis (Adapted from Rabiej-Sienicka, 2022).

3.5. Innovations and policy

Innovations including novel technologies are closely linked to 'ideas, values and images of what is better, healthier, richer' (van Lente, 2021). Novel technologies are typically accompanied with optimistic images about their usefulness, benefits and overall desirability. However, plans regarding these technologies can also be accompanied with negative ideas of threat and danger (Senna & Macnaghten, 2021). If different ways of anticipating the future produce the present, they also undeniably materially shape the future itself (Felt, 2017). This prompts questions about the politics of how certain future expectations and images become dominant, how the future is experienced in the present and how different ways of constructing the future have important political consequences in the present.

Sociotechnical imaginaries can be understood as underlying rationales and justifications that are rarely made explicit of particular policy choices (Völker et al., 2020). Even though the concept is difficult to capture, and its practical implications for policymaking are not obvious, sociotechnical imaginaries have an essential role

in creating policies (Rudek, 2022). They influence fund allocation, research priorities, the communication of development goals, and other key decision-making processes.

The concept of sociotechnical imaginaries has allowed uncovering how historically rooted visions shape policy practices or how they develop to lock in certain research trajectories (Felt, 2017). Sociotechnical imaginaries go beyond simply imagining alternative ways of living (Hughes, 2024). They actively contribute to materializing those alternatives. By shaping perceptions of both the society that technological innovation can create and the society that is needed for that innovation to occur, they guide collectives along specific technoscientific pathways.

Oftentimes there are many competing technologies and trajectories for a sociotechnical transition (Bakker et al., 2012). And possibly even more competing visions and expectations relating to the innovation trajectories. Due to the restricted resources, only a limited number of paths can be supported. This requires making choices that are not simply based on ‘price and performance’ (Bakker et al., 2012: 1059) but also on the valuation of what the emerging technologies will be able to do in the future. It is not simple facts that the choices between transition paths are based on but it is expectations.

3.6. Actors, interests and sociotechnical imaginaries

The key reasons why complexities arise in policy settings is the diversity of actors that are involved - their interests and politics (Delina, 2018). It is linked to the multiple ways different actors interpret the world resulting from their different experiences, perception, values and interests. Therefore, actors will attempt to advance their preferred visions in order to create and reinforce the future pathways they favor.

The formation of actor groups supporting specific future visions is not neutral or self-evident but it is driven by interests and strategic choices, and it can have an impact on the direction of transition processes (Mast, 2022). The actors who dedicate their various resources, such as material, financial or also network, to a particular vision play a crucial role in opening and closing specific transformation paths and determining which transformation paths are considered feasible, desirable, or misguided.

When it comes to new sociotechnical imaginaries, their success is influenced by various factors such as how well they match ‘existing cultural norms and moral values, social structures and material infrastructure, political institutions and economic systems, hopes and aspirations’ (Sadowski & Bendor, 2019). Narratives often play an important role in this process as they make imaginaries intuitively recognizable, easier to understand, digest and relate. Narratives not only plant beliefs, shape perceptions, and build associations, but they can also act as a powerful call to action that helps to generate the political will or public purpose to attain a sociotechnical imaginary. However, the spread of persuasive narratives does not ensure the smooth and effortless adoption of imaginaries.

3.7. Sociotechnical imaginaries and research

The concept of sociotechnical imaginaries has gained popularity in recent years (Felt, 2017). Social scientists employ it in their research as an analytic device that helps them capture the multiplicity of ways relationships between society, science and technology are collectively imagined and the futures these relationships might bring into existence (Hughes, 2024). Even though the concept is difficult to capture, its importance has increased (Rudek, 2022).

The concept is inherently complex and multidimensional (Cairns et al., 2022). It can overlap with, encompass, or be distinguished from parallel notions such as frames, discourse, narratives, and storylines. In any domain, what might be considered as an instance of a sociotechnical imaginary is likely to be ‘ambiguous, fluid and contestable’ as they are not individually distinct, internally consistent, and mutually separable from one another (and other forms of discourse) in simple, fixed ways (Cairns et al., 2022). In other words, STIs should not be analyzed through a ‘monothetic glance’ (Ritzer, 2000), as though they are defined by a fixed set of necessary or sufficient characteristics on standardized dimensions (Cairns et al., 2022).

3.8. Sociotechnical imaginaries’ research dimensions

Considering that there are no standardized dimensions and characteristics that can be attributed to sociotechnical imaginaries, they are developed based on the research purpose and findings from literature review. The research is concerned with

different sociotechnical imaginaries of proponents and opponents of cultured meat in the EU and what drives these imaginaries. Therefore, the first two dimensions - stance and framing - are developed similarly to the study by Santos Pereira et al. (2017).

Their research is concerned with the evolution of the Portuguese sociotechnical imaginary on nuclear energy and technology. They focus on national parliamentary debates, which according to them shows different ways of framing Portuguese nuclearities. During the individual analysis of each statement they identified the stance of Members of Parliament on nuclear energy as pro, against, or neutral/ undefined along the framings that were used to justify this stance, such as economic, political, social, environmental, and scientific. Following the definition that Santos Pereira et al. use, frames are understood as ‘devices that organize a selective representation of a specific issue (Conrad, 1997), conditioning the formation of public opinion (Gamson and Modigliani, 1989) and social movements (Benford and Snow, 2000). To frame something is to emphasize certain aspects and to overlook others’ (Santos Pereira et al., 2017).

In order to contextualize the stance and framing, further dimensions are established following Longhurst & Chilvers (2019). Their study analyzes diverse visions of energy transitions across different institutional settings in the UK using a new analytical framework that is focused on relational co-productionist perspectives in STS. They comparatively analyze the similarities and differences of these visions in relation to four dimensions of sociotechnical transformation. They distinguish them as ‘meanings, knowings, doings, and organizings’ (Longhurst & Chilvers, 2019).

Considering that the nature of their research is different and the following research is concerned with protein transition instead of energy transition, these dimensions are adjusted to fit the research purpose. Therefore, ‘meanings’ refer to issues motivating the protein transition, ‘organizings’ are linked to proposed governance arrangements, and ‘knowings’ refer to actors whose knowledge and concerns need to be taken into account. Considering that the main technology of interest is cultured meat, ‘doings’ as a dimension refers to other proposed technologies for protein transition. However, this dimension is used to distinguish an imaginary that is generally more supportive of the future with other technologies.

Table 1.

Sociotechnical Imaginaries dimensions

Dimension	Explanation
stance	pro, against, or neutral/ undefined stance in relation to cultured meat
framing	framing of cultured meat, emphasizing certain aspects
meanings	issues motivating the protein transition
organizings	proposed governance arrangements and solutions to protein issues
knowings	actors whose knowledge and concerns need to be taken into account
doings	other proposed technologies for protein transition

4. Methodology

This chapter presents the methods that were used to collect and analyse data in order to uncover sociotechnical imaginaries. It begins by explaining the approach to data collection and the sampling methods that were used. Then, the chapter explains how stakeholders were identified to access material for further analysis. The chapter continues with introducing the interview process. The following section provides an explanation of the thematic analysis method, the use of the method, coding approach and selection of codes. The chapter ends with a description of storylines concept which is used to sort the imaginaries.

4.1. Data Collection

The study is based on data acquired using extensive literature review and 4 semi-structured interviews with experts in the field of alternative proteins, cultured meat, research and development as well as public and regulatory affairs. The research employed a qualitative approach to uncover stakeholders with an interest in cultured meat and/or conventional meat industry and to analyse their sociotechnical imaginaries surrounding cultured meat futures. Stakeholders here are defined as individuals, groups and organizations that ‘share a common interest or stake in a particular issue or system’ (Grimble & Wellard, 1997: 175).

Literature review and an informal field research during *The Future of Protein Production Amsterdam* conference were employed to identify relevant stakeholders or stakeholder groups in the EU and to find potential research participants. The results from these findings and interactions were used to determine whose material would be relevant for thematic analysis. The resulting material includes but is not limited to reports, articles, websites, documents, and press releases (Appendix A). After close reading, specific parts of these texts were selected for thematic analysis that helped to identify common themes within the sample of materials which were then sorted into storylines.

4.2. Sampling Methods

The sampling method used to select material for analysis included purposive sampling. It is one of the most popular non-probability sampling strategies in qualitative research (Ahmad & Wilkins, 2024). Samples based on this method

include context, materials or participants who share specific qualities that can help with answering the inquiry regarding the phenomenon of interest. The criteria for the material selection in the following research included convenience of access, mention of cultured meat and its potential risks and/or benefits from which a sociotechnical imaginary could be derived and a clear link to a relevant stakeholder. Occasionally, texts were also considered relevant because they had emerged in the context of cultured meat.

This sampling method was also used for selecting research participants. The people interviewed are linked to a relevant stakeholder group, have expert knowledge in the field of cultured meat and other converging areas and were available for an online interview. Even though it was purposeful it was also based on convenience of access.

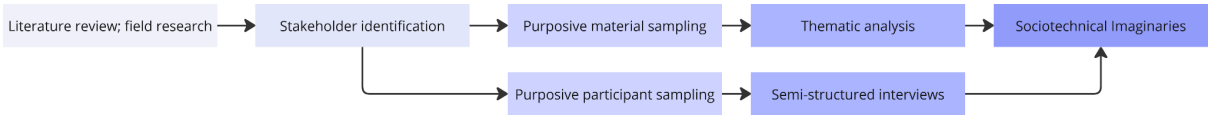

Figure 4. Research methodology diagram.

4.3. Stakeholder identification

Stakeholder identification is a necessary initial step as it allows to distinguish and identify which individuals, groups and organizations constitute stakeholders whose visions are important for understanding the emerging and competing sociotechnical imaginaries in the EU. The identification of relevant stakeholders is based on literature on stakeholders involved in the cultured meat landscape and an informal field research carried out during *The Future of Protein Production Amsterdam* where informal conversations and interactions led to the discoveries of stakeholders.

Góes et al. (2024) identified stakeholders relevant for the cultured meat technology in order to conduct interviews with representatives from these groups and to explore the justifications they employ and their impacts on innovations applying Public Justification Analysis. According to the authors, their literature findings suggest that six key stakeholders can be identified in the field of cultured meat.

These stakeholders can be split into primary stakeholders, whose impact on the development of the industry is direct: startups, investors and conventional meat multinationals; and secondary stakeholders, whose influence on the development of an innovation can be indirect: NGOs, researchers, and the media. However, the authors argue that for nascent innovations, both primary and secondary stakeholders constitute key stakeholders.

The following research extends this list by adding input companies, farmers, political and policy stakeholders, retailers and animal rights activists. These groups figure as stakeholders in the systematic review on stakeholders' beliefs toward alternative protein sources and specifically cultured meat (Amato et al, 2023). Additionally, some of these groups are recognized as stakeholders whose views are important for making decisions on the policy future of cultured meat within the EU. This is reflected in the contribution that they were welcome to provide for the *Draft act prohibiting the production and placing on the market of laboratory-grown meat* by Hungary (2024).

4.4. Interviews

Semi-structured interviews with 4 experts (Appendix B) were used to determine the main sociotechnical imaginaries in the EU, discuss the risks and benefits of cultured meat technology, the necessary governance solutions for maximizing its benefits and minimizing its risks and to validate findings from literature and thematic analysis.

Interviews were held online from November 2024 to January 2025 and the spoken language was English. Prior to interviews, participants were introduced to the research process and gave their permission by signing a consent form (Appendix C). The interviews were different in length ranging from 45 minutes to 90 minutes which had an effect on the number of topics that could be covered. A semi structured interview guide (Appendix D) was used to structure the interviews. The topics of interests included:

1. The future role of cultured meat
2. The main benefits of cultured meat
3. The main risks of cultured meat
4. Necessary governance arrangements
5. People involved
6. Common narratives
7. Validation of findings

However, interview participants had the freedom to divert from the guide and follow-up questions were included depending on the answers that were given, which allowed the conversations to flow freely and for new insights to emerge. After the interviews were done, they were transcribed and shared with research participants for approval. Later they were coded and mined for relevant themes.

4.5. Thematic analysis

Thematic analysis was applied to the research material in order to mine for common themes. However, the sample of material which was analyzed does not include all stakeholders (Table 2). The stakeholders that were not included are conventional meat multinationals, media, farmers, and retailers. The material that is linked to the stakeholder group of investors overlaps with political and policy stakeholders. These stakeholders are not represented in the analysis due to lack of access to any material that would explicitly talk about cultured meat or give any meaningful information about their stance.

Table 2.

Stakeholders for analysis

4.5.1. Theory

Numerous research projects have used thematic qualitative text analysis as their research method (Kuchatz, 2014). Thematic analysis is the most popular qualitative analytic method used across various disciplines, such as sociology, anthropology, and psychology. In comparison to other qualitative text analysis, thematic analysis in particular makes visible the difference between qualitative and quantitative analysis. The goal of quantitative text analysis is to create precise categories from the verbal data and carry out statistical evaluation of the resulting data matrix; however, qualitative text analysis is focused on the text itself. Thematic analysis involves searching for themes that are important for describing the phenomenon under study (Fereday & Muir-Cochrane, 2014). The identification of themes is based on close reading and re-reading of the data. Central to the analysis is recognition of patterns within the data, with emerging themes serving as the categories for analysis.

4.5.2. Coding approach

There are different methods that are used to construct the categories with which thematic analysis can be carried out. These range between inductive methods where categories are created using the data and deductive methods where categories are based on an underlying theory or the guiding research question (Kuchatz, 2014). In the following study the coding approach is guided by ‘hybrid coding’ (Boyatzis, 1998) that combines a priori coding with data-driven inductive coding. Authors doing research on sociotechnical imaginaries have used this coding approach for various reasons, such as to identify emerging imaginaries surrounding negative emissions technologies (NETs) in Sweden and to find similarities and differences between air quality action plans (AQAPs) in London, Hong Kong, and San Francisco and different storylines driving sociotechnical imaginaries of urban futures (Christiansen & Carton, 2021; Gross et al., 2019). This approach allows both existing theories and text data to influence the work. Additionally, it is useful for finding narratives and patterns that point to emerging imaginaries (Christiansen & Carton, 2021).

4.5.3. Selected codes and categories

In the following research a priori categories and some of the codes are developed based on the guiding research questions as well as theory and literature on sociotechnical imaginaries and cultured meat. A distinction is made between categories and codes, defining categories (also called themes in literature) as ‘broad units of information that consist of several codes aggregated to form a common idea’ (Creswell, 2013: 186) where codes are related to each other through their content or context (Erlingsson & Brysievicz, 2017). Meaning that ‘codes are organised into a category when they are describing different aspects, similarities or differences, of the text’s content that belong together’(Erlingsson & Brysievicz, 2017: 96).

The code categories and their respective codes are organized in a code manual (Appendix B). The main coding categories are based on the dimensions that were defined earlier as *stance*, *framing, meanings, organizings, knowings,* and *doings .* In a similar manner to Santos Pereira et al. (2017), the codes used to identify the *stance* of different actors on cultured meat in the EU are *pro, against, or neutral/undefined*. The a priori codes for *framings* were based on narratives found in literature that are commonly used to highlight the potential benefits and risks of cultured meat. These codes are further developed in an iterative manner from the textual data analysed for the research purposes. Similarly, the codes for code categories *meanings, organizings, knowings,* and *doings* that are based on the dimensions found in Longhurst & Chilvers (2019) are also developed in an iterative manner.

4.6. Storylines

After finding common themes and patterns, these themes are sorted into storylines that capture the different cultured meat narratives. A storyline is ‘a condensed statement summarizing complex narratives’ used by people as ‘short hand’ in discussions’ (Hajer, 2006:69). Statements often have a narrative form and facts are told in a story. Even though storylines do not necessarily represent the facts of a problem in an accurate way, it can have an important function for building political coalitions (Hansen & Kolleck, 2023).

Often people use cues to tell complex stories assuming that the message will be read in the same way as the sender intended it to be read (Hajer, 2006).

However, this assumption is false and people ‘do not really or do not fully understand each other’(Hajer, 2006: 69). It can be functional for building coalitions. Storylines can serve as rallying points that brings actors together to form coalitions, even though their individual interpretations of the narratives may vary in practice (Tozer & Klenk, 2018).

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5. Results

The following chapter presents results obtained from literature review, thematic analysis and interviews. The first part introduces the stakeholders that were identified as relevant to cultured meat research. In the second part findings surrounding cultured meat imaginaries are presented, introducing the underlying storylines and narratives of their imagined futures. In the third part these imaginaries are compared and assessed. The final part outlines the governance solutions that opponents and proponents propose to support their imagined protein futures.

5.1. Stakeholders

In the following section stakeholders in the field of cultured meat and conventional meat production are identified. Furthermore, their role, interests and opportunities in the emergence of cultured meat industry are explained.

5.1.1. (Input) companies

The production of cultured meat requires primary ‘ingredients’ that constitute the most significant inputs to the system (GFI, 2017). These include cell culture media and scaffolds, both necessary for cell culturing and both likely produced outside the cultured meat companies. Culture media currently makes up a large share of the production costs (Jahir et al., 2023). Reducing these costs is essential for large- scale production in order for the price of cultured meat to be able to compete with livestock meats. Cell culturing also requires bioreactors that can ensure the right conditions for cell growth in a controlled environment (Soccol et al, 2024). Different companies can act as technology enablers and help overcome challenges that cultured meat companies are facing.

Several larger companies, such as leading global life science company Merck KGaA, large-scale cell culture manufacturing specialist Esco Aster, and multinational suppliers of raw materials, including Nutreco, DSM, have already made strategic moves to position themselves for opportunities in the field of cultivated meat (GFI, n.d.-a). Additionally, companies such as Systemiq that are not necessarily providing inputs for cultured meat, can participate and help enable the emergence of cultured meat technology by focusing on transforming markets and business models and providing strategic advice with high impact.

5.1.2. Farmers

Changing the meat production system and integrating cultured meat into the protein system will have an impact on livestock farming. This could threaten some sectors and cause disruption to others. Concerns about the unintended consequences that cultured meat technology could bring relate to the negative impact that farmers and farming communities could experience, reduced autonomy and control in the food system and the power concentration in companies that control development of new technologies and access to them (Manning et al, 2023). Additionally, small farms could be the most affected producers if cellular agriculture takes a prominent position in the protein market (Soccol et al., 2024).

However, cultured meat will also potentially create opportunities for some farm businesses (Innovation for agriculture, 2023). Cultured meat technology could allow moving away from intense industrial production systems and return to more traditional farming (Manning et al., 2023). Farmers could grow feedstock necessary for cultured meat production or produce it on farms. They could supply other input products such as food-grade ingredients for the growth media necessary for cultured meat production (Royal Agricultural University, 2024). Potential opportunities also include waste valorisation from crop by-products and residues, and animal by-products.

Farmers could also take advantage of their competitive edge in e.g. achieving higher prices for conventional meat. They could also reshape their supply chain relationships by having better contractual agreements and access new markets. Additionally, they could take advantage of freed up land by using it for e.g. energy production, invest in production units and attract new labour and skills. Therefore, farmers are key stakeholders that will be affected by the transition but also have opportunities to benefit from it.

5.1.3. Startups

There is a growing number of cultured meat related startups emerging in different parts of the world. They are important stakeholders due to their role in driving the development, commercialization, and scaling of cultured meat technologies. Over recent years, there has been a surge in cultured meat startups globally, with Europe accounting for 80% since 2017 (Ye et al., 2022). These startups

also lead innovation in areas such as serum-free culture media, more stable stem cell lines, and customized solutions for cell and protein characterization, addressing both technical challenges and ethical concerns, such as those tied to dietary patterns and religious beliefs. Some of the largest cultured meat companies in Europe regarding funding include Mosa Meat, Biotech Foods, Meatable and Gourmey.

Mosa Meat is the first company to hold a public tasting of its cultivated beef. Following the Dutch government's introduction of a Code of Practice in 2023, Mosa Meat, a Dutch startup known for creating the world's first cultivated meat burger, held the first ever public tasting of cultivated beef in the EU (Mridul, 2024). Gourmey, a French startup, is the first company to submit a Novel Food application for cultivated foods in the EU (EIT Food, 2024). It was followed by Mosa Meat who submitted their first Novel Food application for their cultivated beef fat (Mosa Meat, 2025).

5.1.4. Investors

Financing and investment is one of the challenges that cultured meat is facing in regards to its commercialization (Xiang & Zhang, 2023). Contrary to many other innovations, cultured meat has largely developed without public research initiatives that are aimed at sustainability in food and agriculture and it has emerged within an innovation niche that is largely sustained using private investment (Helliwell et al, 2024). Investments in the cultivated segment are necessary to continue research and development of the technology, scale production, and reduce costs (GFI, 2021). Even though investments are continuing to grow every year, cultured meat constitutes a small share of overall investment in food tech. Some of the most active EU investors in 2020 included Blue Horizon, Bell Food Group and EIT Food. Even though the investments are largely private, in 2022 the Dutch government confirmed that it will allocate €60 million to support the formation of an ecosystem around cellular agriculture (Delft University of Technology, 2022). This is the largest public funding into the field of cellular agriculture not only in Europe but also globally. Public funding for cultivated meat could have significant benefits for the food system’s productivity and economic growth (GFI, 2021). Therefore, investors have a significant role to play in the development of cultured meat technology and research more broadly.

5.1.5. Conventional meat multinationals

Considering that cultured meat technology aims to eliminate large scale factory farming, conventional meat multinationals could experience significant negative consequences for their current production systems and businesses. These companies can create additional barriers to commercialization of cultured meat by extensive lobbying. Evidence shows that certain agricultural and meat lobby groups are working in efforts to undermine a transition to a food system with lower meat production and consumption. However, many companies are already involved in the cultured meat industry through investment, acquisitions, partnerships, research development and manufacturing, seizing the promising market opportunities (GFI, 2023). Some of the most high profile companies that are involved in the cultured meat industry include Tyson Foods, Cargill and JBS. In 2021 JBS invested US$100 million in buying cultured meat company BioTech Food and establishing a research centre on cultured meat in Brazil (SEI, 2022). Therefore, these companies can use the opportunity to advance their position in the market by also participating in the emerging industry.

5.1.6. Political and policy stakeholders

Representatives from political and policy stakeholder groups hold a strategic role in shaping societal processes, such as the drafting of laws and regulations at regional, national, and European Union levels. Their efforts often focus on advancing the group's interests through direct and indirect lobbying while also participating in negotiations or mediating between disagreeing stakeholders (Moritz et al., 2022). European Commissions together with member states, are involved in the decision making on the market authorization of Novel Food products and labeling. However, Members of the European Parliament (MEPs) take part in the EU’s decision-making in the plenary sitting which represents the culmination of the legislative work done in committee and in the political groups (European Parliament, -b). Here they express their standpoint vis-a-vis the Commission and Council. When a parliamentary report is put to vote in plenary, generally it is the subject of a debate in which the Commission, the representatives of political groups and individual MEPs express their views.

On 19 October 2023, the European Parliament voted in favor of an own-initiative report by Emma Wiesner, on behalf of the Committee on Agriculture and Rural Development, on a European protein strategy (2023/2015(INI)) (A9-0281/2023), calling for the development of a comprehensive and ambitious EU Protein Strategy that is focused on reducing import dependence from third countries, increasing European protein autonomy, and improving sustainable local protein production (Food Manufacture, 2023; Wiesner, 2023). A debate preceded the voting where different MEPs expressed their views on the current situation of proteins in Europe and their vision on potential solutions and stance in relation to cultured meat. MEPs play an important role in shaping EU rules and representing the interests of EU citizens. Therefore, they can use their position to promote particular future visions regarding cultured meat which requires more than technology that can produce it.

Considering the Novel Food status of cultured meat, it requires approval from the EFSA. They provide the scientific base for any regulatory decisions in order to ensure food safety and protect European consumers from any food related risks. They play a role in providing guidance for applications and updating their guidance in line with advances in food research and innovation (EFSA, 2024-b). The EFSA also provides support to potential applicants that fall into the category of small and medium sized enterprises working in Novel Foods and offer general pre-submission advice service (EFSA, 2024-a). However, the EFSA has no say in the EU decision-making process (EFSA, 2023). Additionally, they don't have a pro or against stance in relation to a new food technology such as cultured meat. However, their assessment provides scientific input on the safety of such products and a solid base for European policies and legislation (EFSA, n.d.).

5.1.7. Animal rights activists

People for the Ethical Treatment of Animals (PETA) shaped the early history of cultured meat alongside university researchers, investors and artists (Jönnson, 2016). Animal rights activists and those concerned with animal welfare are interested in the technology due to its potential to reduce animal suffering and produce meat without slaughtering animals. Cultured meat avoids many of the issues associated with conventional meat production and its moral implications (Zuhaib Fayaz Bhat et

al., 2015). Contrary to other animal welfare improvements such as those relating to more humane housing and killing systems that have been criticized for 'humanewashing' and greenwashing industrial animal agriculture, if developed and promoted in the right way, cultured meat could allow for moderate positive change in the short term and a radical change over a longer period of time (Sebo, 2018).

Due to these expected animal welfare improvements, cultured meat has the potential to be accepted by activists who are typically cautious about changes supported by companies, and by companies that are usually cautious about changes supported by activists. Anima International and Eurogroup for Animals are some of the stakeholders that offered their commentary on the Hungarian ban showing a positive stance and outlining several arguments why banning of cultured meat should not be accepted. Therefore, showing that animal rights activists could support the future of cultured meat technology.

5.1.8. Non-governmental organizations and non-governmental research institutes

Non-governmental organizations (NGOs) and research institutes have the power to influence the transition to more sustainable animal protein production which includes cultured meat. They have proven to have an increasingly important role in solving complex sustainability challenges that require reshaping Global Value Chains (GVCs) led by Multinational Enterprises (MNEs) (Casnici et al., 2024). An example of an NGO that has played an active role in steering the transition toward alternative protein sources to solve sustainability issues related to animal-based agriculture is Good Food Institute (GFI). GFI is an NGO with significant influence on a global scale on the commercial development of cultured meat alongside small firms and MNEs. GFI has actively supported start-ups and entrepreneurs in order to promote innovation in the industry as well as facilitate interconnectivity between companies. Their main activities also include shaping the regulatory landscape to ensure that alternative proteins are part of policy discussions worldwide when it comes to climate change mitigation and global health (GFI, 2020 in Casnici et al., 2024). Additionally, their efforts include determining the most complex bottlenecks regarding the development of alternative proteins and ways to alleviate them. In addition to GFI, New Harvest is a non-profit research institute that is advancing the science behind

cultured meat by financing and strategically conducting research having invested more than $2 million in grants (Fernandes et al, 2022). These stakeholders are therefore important players that can advance the future of alternative proteins and cultured meat.

5.1.9. Retailers

After the manufacturing of the product companies will need to use larger markets and distribution networks to reach consumers (GFI, 2017). This can be done through foodservice, restaurants, supermarkets and other retailers. Food retailers will not only play a role in ensuring that the product reaches the hands of the consumers but also help mitigate concerns consumers might have about the food technology and familiarize them with the product for wider acceptance (Rombach et al, 2022). Curiosity about cultured meat together with increased acceptance could therefore generate significant profit for retail companies. Retailers that are the frontrunners in the retail ‘sustainability race’ (Green Queen, 2024) could offer cultured meat to its customers contributing to their targets and sustainability image.

Lidl is a major retailer aiming to cut its scope 3 emissions which include direct emissions from the supply chain that occur from products that the company sells and it is aiming to shift sales to more plant-based proteins (Green Queen, 2024). By incorporating cultured meat in their sales they could reduce emissions resulting from livestock farming and position themselves as sustainability frontrunners.

5.1.10. Scientists and researchers

Scientists and researchers have been central to the development of cultured meat technology. Even though cultured meat is recently gaining momentum, this innovation has a long history of laboratory research (Goes et al., 2023). Scientists alongside technologists are working on various aspects of cultured meat trying to reach the common goal of creating a product that is commercially viable and accepted by consumers (Yap, 2023). Scientists, including social scientists and psychologists, are also important for researching social acceptance of cultured meat and reasons for its high or low acceptance among various people in different regions of the world (Treich, 2021). Interdisciplinary collaboration between different scientists could help determine what contributes to the positive or negative perception and

consumer attitude towards cultured meat (Kouarfate & Durif, 2023). This could result in an increased level of acceptability.

5.1.11. Media

News media play an important role in not only reflecting public opinion but also shaping it. Media also has an impact on societal norms. By selecting which issues to highlight, the mass media shape the focus of public discourse, impacting public perceptions, attitudes, and, in some instances, people's behavior (Hundscheid et al., 2022). A number of studies show that media plays a central role in shaping societal norms and reflecting cultural changes surrounding meat and its potential alternatives. Some show that media is an institution that supports the current status of meat, whereas others showed that media can also help with campaigns aimed at reducing meat consumption. Therefore, the media could play an important role by informing the public and shaping its opinion towards more acceptance.

5.2. Sociotechnical imaginaries

The sociotechnical imaginaries (Figure 5) that are identified using thematic analysis (Appendix F) are first distinguished based on the stance in relation to cultured meat that is expressed in the material analysed. Following this, opponent and proponent imaginaries are further discussed as broad categories focusing on their framings of the protein issue (meanings), and who should be involved in the transition (knowings). The sociotechnical imaginaries are further distinguished based on how the stances are framed (framing) in relation to cultured meat and their storylines that serve as rationales and drivers for their governance solutions and pro or against position. Imaginary to which other technological solutions (doings) were central is outlined separately from the proponent and opponent imaginaries. Additionally, uncommon imaginaries that emerged during the research are mentioned.

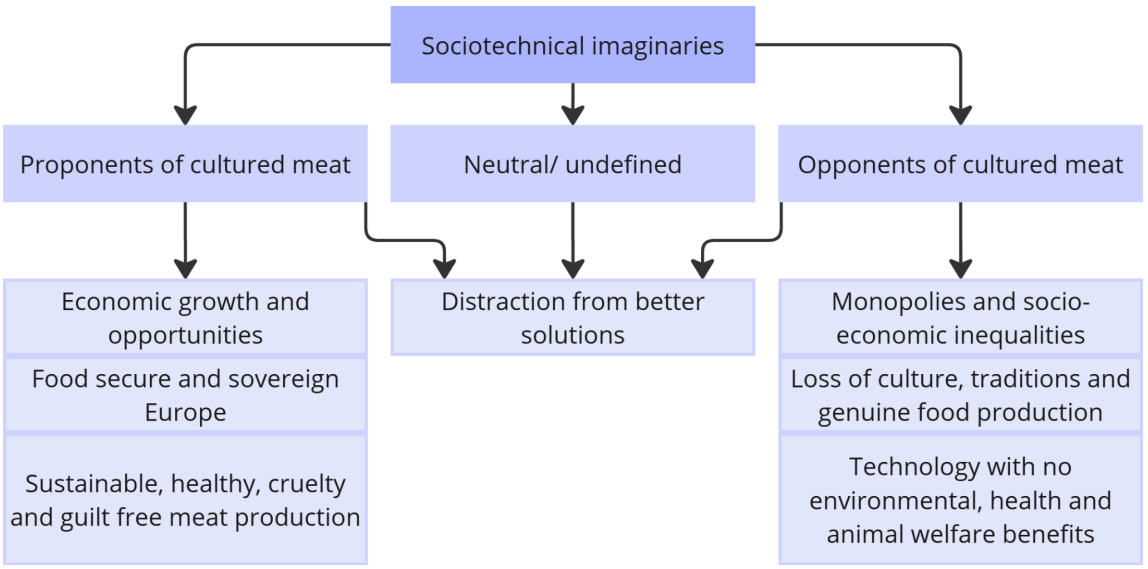

Figure 5. Sociotechnical imaginaries.

5.2.1. Opponent imaginaries

In the following analysis opponents of cultured meat frequently frame the protein issue as an issue of import dependence, food insecurity and environmental impacts that result from agricultural practices in importing countries. In this analysis these framings are largely expressed by MEPs who participated in the protein debate and demonstrated an outstanding level of opposition to cultured meat technology. In addition to the protein strategy outlining the issue of import dependence where only 29 % of the high-protein feedstock originates from the EU (Wiesner, 2023). Numerous members (e.g. Tom Vandenkendelaere, Elena Lizzi, Irène Tolleret) highlighted that Europe is too dependent on third countries for animal feed where growing production of e.g. soy crops results in negative environmental impacts such as deforestation and biodiversity loss.

Europe imports a large share of its plant-based proteins for animal feed leading to high dependence which has negative consequences for European food security and sovereignty. Some emphasize that the dependence is a result of agreements signed by the EU such as the Blair House agreement (Marc Tarabella, Herbert Dorfmann) and stricter rules for farmers in Europe in comparison to those in importing countries which also leads to unfair competition (Daniel Buda). Additionally, some emphasize that it is a larger issue of factory farming that is highly

inefficient as these animals require feed which is imported from third countries (Tilly Metz; Maria Noichl) and could be consumed by humans (Anja Hazekamp). They highlight the need to reduce import dependence to ensure protein sovereignty and security in Europe and to decrease environmental impacts. This is especially crucial for the growing protein demand expected in the future (Sénat, 2023; Anne Sander).

However, they envision a better protein future in Europe without cultured meat and view it in a negative light or as unnecessary in order to solve protein issues in the EU. Several MEPs emphasize that citizens and farmers should be those whose interests are protected in search of a solution for the protein issue (Danilo Oscar Lancini; Tom Vandenkendelaere; Elena Lizzi). They also need to be informed about the dangers of cultured meat and they need to be presented with correct information to avoid misleading customers. In a CAP note from the Austrian, French and Italian delegations supported by nine other delegations they call for a comprehensive impact assessment of the Commission that takes into account different questions and issues linked to cultured meat and they want EU consumers and citizens' views to be conducted and included (General Secretariat of the Council, 2024). They also highlight the role of scientists as they call for a transparent and science-based approach to assess the development of cultured meat, which they do not consider as a sustainable alternative to conventional meat. Decision-makers therefore are expected to work on solutions in which farmers are at the centre of attention and the society can benefit. They are discouraged to direct funds towards innovations such as cultured meat (Dacian Ciolos, Elena Lizzi).

In their sociotechnical imaginaries cultured meat is unable to address European protein issues and it is associated with different types of risks and threats that the future of the technology holds. The following opponent imaginaries are therefore identified and highlights the different concerns each imaginary is based on and the risks their storylines highlight. These imaginaries are identified following shared elements in their narratives and recognizable patterns.

5.2.1.1. Monopolies and socio-economic inequalities

Opponents of cultured meat technology construct meat grown in laboratories within an imaginary of monopolies and growing inequalities. This imaginary is common among stakeholders that oppose cultured meat in the political arena looking for ways to restrict its development and access to market. They view the technology

as another tool for multinationals to gain power that could lead to an emergence of monopolies and oligopolies. The technology is associated with high entry costs (Coldiretti Giovani Impresa, 2021; General Secretariat of the Council, 2024), the use of intellectual property (IP) rights and significant economies of scale that could provide strong incentives for industry consolidation (UNEP, 2023).

This consolidation of power in the hands of a few powerful actors can influence the price and further marginalize smaller producers (UNEP, 2023) and create pressure on ‘small-scaled family owned farms’ (General Secretariat of the Council, 2024). Instead of tackling the problems associated with industrial livestock farming it could first compete with extensive livestock farming, which provides numerous services to rural areas and landscapes and which already faces substantial challenges (Sénat, 2023).

Price increase or other changes affecting food access and availability without just transition policies could have an adverse effect on low-income and food-insecure households (SEI, 2022). Additionally, it puts jobs and companies at risk. Millions of people worldwide are economically dependent on the meat industry, including groups such as farmers and rural communities that already face considerable socio-economic challenges (SEI, 2022). Rural populations in particular could suffer negative consequences as a result of the shift of production from rural to urban regions (UNEP, 2023). Therefore, cultured meat technology is viewed as a pathway to growing social and economic inequalities and dependencies.

In this imaginary cultured meat is not viewed as a sustainable means to increase access to high quality proteins and feed the growing world’s population, but instead it is viewed as ‘a business for few’ (Coldiretti Giovani Impressa, 2021) and disruptive to the European model of food democracy (Daniel Rondinelli). Additionally, governments that are against cultured meat are concerned with new dependencies and therefore lack of autonomy in the food sector, which can have a negative effect on food security (Sénat, 2023; General Secretariat of the Council, 2024) and the position that hi-tech giants could obtain in the food system (Government of Italy, 2023).

Italy in their prohibition of cultured meat emphasizes the importance of their agri-food heritage in the socio-economic and cultural evolution of the country (Government of Italy, 2023). Cultured meat therefore poses a threat to the national food culture and the ‘Made in Italy supply chain’(Government of Italy, 2023). The ban

from Hungary highlights the positive impact that traditional food production has on agriculture and rural living conditions in general. Introduction of cultured meat would have an effect on global supply chains where both formal and informal workers are employed. Activities along the supply chain include not only those related to farm production, meat processing, and packaging but also provision of animal feed and veterinary support (SEI, 2022). As a result, countries where conventional animal products and feed constitute a significant share of exports or of the economy could experience negative effects resulting from the shift in global demand for agricultural commodities (UNEP, 2023)

5.2.1.2. Loss of culture, traditions and genuine food production

Opponents of cultured meat that frame meat produced using cellular agriculture in stark contrast to traditional farming methods view it as detrimental to food culture, heritage and traditions. This imaginary emphasizes the idea that food cannot be reduced to the sum of its different parts (Danilo Oscar Lancini) but it is a ‘cultural and social fact’ (Sénat, 2023) that requires rising above the utilitarian vision which underlies the development of cellular foods. The Hungary draft ban text emphasizes that cultured meat and other production methods that are not considered part of ‘traditional food production’ pose a threat to fundamental values (which are not made explicit). In this imaginary conventional meat production is seen as a ‘genuine’ food production method in contrast to the ‘lab-grown artificial cell-based food’ (General Secretariat of the Council, 2024).

Report by the French senate highlights that appropriate evaluation is required regarding the consequences of an innovation for society and that innovation should not be achieved simply because it can be achieved. Similarly to the threat posed by emergence of cultured meat industry on livelihoods of farmers, meat production using cellular agriculture threatens food culture and farming traditions by potentially eliminating small-scale farming and rural farming practices. Therefore, instead of tackling industrial farming and issues linked to it, the technology is envisioned as leading to the disappearance of local diets, food culture, knowledge and farming traditions.

This sociotechnical imaginary is central to Italy and Hungary who have taken a strong position against cultured meat. One of the explanations Italy offers to the proposed law aiming at prohibiting the production and placing on the market of cultured meat in Italy is that its purpose is to preserve the agri-food heritage which has strategic importance for the territory (Government of Italy, 2023). Additionally, it is necessary to guarantee the national food culture and the continuity of the 'Made in Italy food supply chain' (Government of Italy, 2023). During the protein debate an Italian MEP similarly highlighted the danger that cultured meat could lead to losing the connection between food and land on which it is produced, local knowledge and cultures (Danilo Oscar Lancini). Another Italian MEP emphasized that by giving power to multinationals and making them the owners of the patents of what people eat, cultured meat could break the long standing bond between men and nature (Daniela Rondinelli).

5.2.1.3. Technology with no environmental, health and animal welfare benefits

The opponents of cultured meat also construct the technology as environmentally unsustainable, bad for nature, human health and animal welfare. Extensive livestock farming in rural areas and areas covered by mountains is viewed as important for shaping the landscape, contributing to biodiversity (Irene Tolleret) and providing environmental services such as carbon storage (General Secretariat of the Council, 2024). Cultured meat technology is therefore viewed as damaging to the environment as it could lead to reduction of livestock and traditional farming practices. Additionally, cultured meat production is envisioned as resulting in further negative environmental impacts because of its energy-intensive processes that could generate up to 25 times more CO2 equivalent per kilogram of meat when compared to meat produced using conventional methods (General Secretariat of the Council, 2024; Coldiretti Giovani Impressa, 2021).

In addition to negative consequences for the climate it could also have an adverse effect on water quality and availability as the production requires more water than traditional meat farms and produces polluting residues (Coldiretti Giovani Impressa, 2021). Contrary to the hyped positive environmental effects it is envisioned as furthering the environmental problems that are currently posing a

threat to planetary health and wellbeing without offering any positive effect neither for the environment, nor health or animal wellbeing (Government of Italy, 2023, Coldiretti Giovani Impressa, 2021, General Secretariat of the Council, 2024).

In the Hungary draft ban they call to prohibit the production and placing on the market of cultured meat based on the recognition of positive impacts of traditional food production and the need to 'enforce the fundamental rights to physical and mental health and a healthy environment as laid down in the Fundamental Law' (Hungary, 2024). Following this, they imagine cultured meat as antagonistic to a healthy environment, physical and mental health. Italy also argues that the purpose of their law is to ensure protection of human health. During the debate on the European protein strategy two MEPs from Germany and Italy highlighted the negative health and environmental aspects by stating that 'cell mush grown in laboratory' is unacceptable from a health and hygiene perspective and not sustainable and by referring to it as ultra-processed foods that are certainly not good for the environment (Sylvia Limmer; Danilo Oscar Lancini). Additionally, there is no guarantee about the safe use of all the necessary chemicals in the context of food consumption (Coldiretti Giovani Impressa, 2021).

Similarly to other imaginaries where cultured meat is envisioned as disruptive to farming traditions that could lead to loss of livelihoods, knowledge systems and cultural heritage, it could affect the farmers and break the connection with nature for which food is important (Dacian Ciolos, Daniela Rondinelli). Additionally, cultured meat technology is envisioned as worse for animal welfare because it requires FBS which is produced by slaughtering pregnant cows and removing the fetus (Coldiretti Giovani Impressa, 2021)

5.2.2. Proponent imaginaries

Proponents of cultured meat largely frame the protein issue in the context of growing population and increased protein demand resulting from the population growth and economic factors such as growing middle-classes (Merck Group, n.d.-a). Additionally, it is framed as an environmental, health and animal welfare issue linked to current animal farming practices (UNEP, 2023; Merck Group n.d.-a). Factory farming which dominates animal protein production is associated with numerous negative consequences. Therefore the protein issue is also viewed as an issue of

factory farming that needs to be reduced. Proponents of cultured meat highlight that conventional meat production and industrial farming systems are detrimental to the environment and responsible for a significant share of anthropogenic GHG (Chemometec, n.d., Eurogroup for animals, 2021). Industrial farming uses large territories of arable land, has high water consumption, drives deforestation and biodiversity loss. Additionally, it causes animal suffering and raises ethical concerns (Chemometec, n.d.).

Proponents of cultured meat also frame current animal production as a public health issue highlighting the use of antibiotics that leads to antibiotic resistance in humans (UNEP, 2023; Eurogroup for Animals, 2021) and potential spread of zoonosis caused by high density and low genetic diversity which creates favorable conditions for spread of viruses that can cross the inter-species barrier and infect humans (Anima International, 2020). Therefore, proponents of cultured meat imagine the technology as a solution to the protein issues Europe is facing linked to intensive factory farming.

Central to these imaginaries are the benefits that the technology can bring for the society whose interest, safety and trust are important. Additionally, it is considered necessary to provide people with freedom of choice. The role of scientists and researchers is important for developing a product that can work on the barriers that hinder the acceptance of cultured meat such as bringing down the costs, as well as improving taste and texture (Mosa Meat, n.d.). While scientific knowledge is essential, the support of chefs can be important for promoting and communicating cultured meat imaginaries (Gourmey, 2024; Interview 4). However, in some places scientists and doctors could have more success communicating to the public what cultured meat is (interview 4). Health experts more generally could have a significant role in supporting the transition away from conventional animal proteins by advising people worried about their health on sustainable diets that are not based on conventional animal proteins (interview 2).

Governments could also play a role in educating the public (interview 2). Additionally, governments play a role in creating a good regulatory environment and potentially providing funding for further development (interview 2; interview 4). Decision-makers are expected to create a more supportive regulatory landscape in which cultured meat can become reality on people’s plates. In the proponent

sociotechnical imaginaries cultured meat addresses protein issues and provides various benefits highlighted by the different sociotechnical imaginaries.

5.2.2.1. Economic growth and opportunities

Proponents of cultured meat envision meat production using cellular agriculture as a new opportunity in the food system that could bring economic growth, new jobs, new revenue streams for farmers, and redistribution of production to new areas and countries (UNEP, 2023). Public funding for research on alternative proteins and cultured meat could contribute to economic growth and result in more skilled jobs (GFI, n.d.-b). Emergence of cultured meat industry could create high-skilled jobs in particular regions (UNEP, 2023). Countries with low domestic animal agriculture could reduce import dependence by increasing domestic production using cultured meat technology and potentially benefit from export opportunities (UNEP, 2023). Cultured meat could therefore enhance local production and benefit the economy while protecting the environment (ProVeg Germany, 2024).

It could help meet the growing market demand for proteins by complementing the production capacity of other sustainable methods which can be achieved by investing in local producers (Cellular Agriculture Europe, n.d.). This would allow farmers to generate additional revenue opportunities alongside conventional production. It could also combine better income with less intensive labor (interview 3). Furthermore, the new knowledge requirements and skill set necessary for working in the production of cultured meat could also make farming more attractive to younger generations (Merck Group, n.d. -b).

Cultured meat could reach price and performance parity with meat making it more accessible to consumers and enable the emergence of cultured meat markets. In these favourable conditions the global cultured meat market could reach up to 170-510 bn by 2050 (SYSTEMIQ, 2024). It could directly and indirectly through suppliers and spending in the economy contribute to EU gross domestic product (GDP) by up to 0.5% of its total value in addition to creating up to 90,000 well-paid jobs.

Additionally, spillover benefits for other sectors could happen. These include unlocking the broader bioeconomy as a result of lowering production costs, and more knowledge in the field of cellular agriculture. Furthermore, if Europe does not work on producing cultured meat it might lose out on the opportunity and the

technology that was first developed in Europe and be flooded with production from China that is heavily investing in cultured meat (interview 3). In China's five-year agricultural plan, cultured meat is featured as a component of national food security and it is linked to expectations of global export (SEI, 2022).

5.2.2.2. Food secure and sovereign Europe

Proponents of cultured meat also envision it in the context of greater food security and sovereignty. The European Protein Strategy Draft report emphasizes the need for an urgent EU action to ensure food security inside and outside the EU (Wiesner, 2023). It highlights the essential role of proteins for humans and animals in food and feed and the issue of import dependence associated with feed protein. This dependence on a single or few suppliers poses a threat to food sovereignty and security and therefore must be reduced. Cell-based agriculture is envisioned as a promising and innovative solution that can increase protein production and support agriculture.

The expected population growth will increase protein demand and pressure on the food system where agricultural production methods already have a devastating impact on the environment and society (Meatable, n.d.-a). In addition, worsening climate could reduce the amount of land and water available for farming (Merck Group, n.d.-a). As a result, the planet will not be able to feed all of humanity and satisfy the animal protein demand using conventional production methods (Biotech Foods, n.d.-a). Cultured meat is therefore imagined as a way to increase protein production and availability for a growing population that requires nutrition and a healthy environment.

This imaginary of increased food security is central to start-ups that imagine the technology as a way to increase access and availability of sustainably produced, nutritious, delicious and affordable meat (Meatable, n.d.-a; Mosa Meat, n.d.; Biotech Foods, n.d.-a). Additionally, in a recent amended motion by two Dutch members of Parliament Meulenkamp and Grinwis adopted by show of hands in the Dutch House of Representatives, cultured meat is envisioned in the context of improved food security (Meulenkamp & Grinwis, 2024). The government was requested, in collaboration with Dutch biotechnology companies and knowledge institutions, to provide an overview of existing obstacles within the European Novel Foods procedures and to inform the House and to make efforts to remove these bottlenecks

in the Novel Food procedures, and to regularly inform the House of Representatives about these efforts.

Cultured meat is also envisioned as a way to diversify protein production, which, integrated into existing agrifood value chains, could contribute to building a resilient food system that can withstand disturbances and become less susceptible to supply chain disruptions (Chemometec, n.d.; Gourmey, 2024). In comparison to conventional meat production, cultured meat is not so reliant on natural resources that are necessary for animal feed and also human workforce (Interview 4). Climate change is exacerbating food security risks which were also highlighted by the Covid-19 pandemic. Cultured meat could make food systems less susceptible to zoonotic diseases that can severely affect supply chains (Chemometec, n.d.).

5.2.2.3. Sustainable, healthy, cruelty and guilt free meat production

Proponents of cultured meat construct the imagination of meat produced using cellular agriculture as an environmentally sustainable cruelty free technology that allows guilt free consumption of animal meat without harming human health. This imaginary is central to startups that emphasize the benefits cultured meat production could have within the current food system where industrial animal agriculture has negative effects relating to animal suffering, antibiotic overuse, zoonotic disease, land-use change, GHG emissions and negative human health effects. This imaginary is also common among animal rights activists that are largely concerned with animal welfare and see the potential of cultured meat technology to reduce animal suffering. It is also relevant for NGOs that support the development of alternative proteins and cultured meat because of its potential benefits as well as companies that see the potential to accelerate the emerging industry and become a ‘technology enabler’ (Merck Group, n.d.-a).

In this sociotechnical imaginary meat production using cultured meat technology is envisioned as more efficient with faster production rate and less land required for animal farming and meat production (Eurogroup for Animals,2021; Meatable, n.d.-a, Biotech.Foods n.d., Gourmey, 2024; ProVeg International, 2020; Merckgroup, n.d.-a, Cellular Agriculture Europe, n.d.). Cultured meat could further benefit the environment and reduce the environmental footprint of meat by lowering

energy consumption, minimizing GHG emissions using sustainable energy sources and reducing water use. This imaginary emphasizes that the science and technology behind cultured meat allows faster and more efficient meat production that makes a better use of natural resources without harming the planet, people, or animals (Meatable n.d.-b; Biotech Foods, n.d.-b).

In addition to environmental benefits that are crucial for transitioning to more sustainable food and protein systems, the technology is envisioned as having a positive impact on animal welfare and human health, with large potential for public health (Interview 2). This is because it does not require a large amount of animals to live in close confinement (GFI, n.d. - c) and it needs fewer animals to meet global meat demand (UNEP, 2023). Cultured meat requires a small sample of cells without the need to slaughter the animal (Cellular Agriculture Europe, n.d.). By producing meat in a controlled environment, the risk of foodborne zoonoses, fecal contamination and the need for antibiotics could be reduced (GFI, n.d. -c). Furthermore, the technology allows maximizing health benefits by using healthy additives and eliminating other disadvantages associated with meat such as high fat content, heavy metals, antibiotics and germs (Merck Group, n.d.-b, Cellular Agriculture Europe, n.d.; Eurogroup for Animals, 2021). Therefore, it can offer a tailor made solution to meat (interview 4).

The technology allows eating nutritious meat without sacrificing and harming animals (Biotech Food, n.d. -b). The future with cultured meat is envisioned as offering a better life for animals and humans (ProVeg International, 2020). Additionally, without having to keep animals for slaughtering, the technology could bring humans into harmony with nature and support people who are concerned about the environment, the climate and animal welfare, providing an opportunity to ‘put their values into practice’ (Merck group, n.d.-b).

5.2.3. Distraction from better solutions

In this imaginary other technological and non-technological solutions are considered as the future of protein production in Europe. These other solutions are envisioned as having a more positive impact on the food system and bringing about the future of food sovereignty in Europe. Actors that promote this vision can be generally against but also in favor or indifferent to the development of cultured meat.

During the protein strategy debate several MEPs emphasized the need to focus on increased plant protein production for animals and for human consumption which currently is associated with import dependence from countries with high environmental impacts. Increased production of protein crops for food and feed and more plant-based diets is seen as beneficial for society, human health and the environment (Anja Hazekamp, Isabel Carvalhais). There is no need for 'fancy technology' to increase production (Tilly Metz).

In this imaginary local production is increased which promotes shorter supply chains and offers new opportunities for farmers (Irene Tolleret; Marc Tarabella). Additionally, livestock is reduced which allows more land to be used to grow food for human consumption and return it to nature (Anja Hazekamp). Therefore, future technologies and non-technological solutions should focus on improving crop production, sustainable animal husbandry and circularity in the agri-food system. In this imaginary protein autonomy could be achieved focusing on plant protein strategy and dedicating funds towards it instead of funding alternatives that are distant and highly uncertain (Sénat, 2023) or making sure that money is not diverted from plant based meat or fermentation based foods that are more likely to work (Interview 2).

5.2.4. Uncommon imaginaries

Several other imaginaries or visions emerged during the thematic analysis and through expert interviews in which the results of thematic analysis were discussed. Some of these imaginaries are either not very widely accepted yet or they are more national. These include:

Space missions and advancing research

The technology is necessary for further advancements and research in other areas because it can be used in space missions and other missions to isolated places that require prolonged food supply and nutrition (interview 1).

Cultured meat for pets and as animal feed

A future in which cultured meat is produced for animal consumption has a potential to appeal to groups of people that might themselves be able to adopt vegan or vegetarian lifestyle; however, their pets require carnivore diet (interview 1).

Cultured meat as part of tradition to innovate.

Innovation is tradition. In Europe there is a long tradition to innovate. Therefore, this technology is not a threat to traditions but is generally a part of the European tradition (interview 1).

The US wants to replace French animal farmers.

In France a relatively widespread imaginary was one in which billionaires from the US were financing an animal welfare association in France, as well as cultivated meat companies to replace all meat or good French meat with American fake meat (interview 2). This was the result of L214, the biggest animal welfare association in France, receiving funding from the Open Philanthropy Project US which also gave money to GFI. People also said that they finance cultivated meat companies. Although it was not true, it gave way for the narrative on which the imaginary is built.

5.3. Comparison of imaginaries

The imaginaries that were found in reality are not mutually exclusive from one another even though they are presented in this manner. The main characteristics of each imaginary were the result of extensive literature review, thematic analysis, interviews and subjective choices. Even though various stakeholders might borrow elements from multiple imaginaries, interpret narratives differently and align with only some parts of the imaginaries, the comparison of imaginaries is based on the more general difference between how proponents and opponents frame the protein issue, storylines that were identified as overarching drivers of imaginaries and their main characteristics, as well as who proponents and opponents think should be involved in shaping protein futures. Central to different imaginaries are values and interests

as well as assumptions about the future. Therefore, they are critically assessed and analysed in comparison to one another as well as individually.

Table 3.

Sociotechnical imaginaries and their values

Proponent imaginaries	Values	Opponent imaginaries
Sustainable, healthy, cruelty and guilt free meat production	sustainability, healthy environment, wellbeing of humans and animals	Technology with no environmental, health and animal welfare benefits
Food Secure and Sovereign Europe	food security, European sovereignty, socio-economic equality	Monopolies and socio-economic inequalities
Economic growth and opportunities	fair competition, competitiveness, socio-economic equality	
	culture, traditions, heritage	Loss of culture and traditions

5.3.1. Issues motivating the protein transition

Proponent and opponent imaginaries are broadly speaking set apart by their overall positive or negative attitude towards cultured meat technology. Despite having different stances in relation to cultured meat, there are commonalities as well as differences between how they frame the need to transition protein production to a more sustainable system. In both cases current protein production is viewed as problematic. Both sides consider protein issues associated with current production systems as a growing concern due to the increasing protein demand that will continue to rise in the future.

The protein issue is commonly framed in the context of negative environmental impacts linked to climate change, biodiversity loss and other negative consequences. Opposition and imaginaries in favor of other solutions, which are largely reflected in the protein debate, emphasize the indirect environmental impact from animal protein production associated with animal feed in the producing countries outside the EU. According to them, these could be mitigated by more local production of especially plant-based proteins for humans and animals. Therefore, the protein issue is also strongly linked to import dependence and the need to improve food sovereignty and security in Europe.

In the proponents' imaginaries the environmental issue is attributed to industrial farming and meat production more generally. This is because current farming practices require land for livestock as well as feed production, leading to different types of negative environmental effects. Proponent imaginaries also consider food security and ensuring access to proteins as their central motivation. However, in comparison to opponent imaginaries, there is more emphasis on animal suffering and ethical concerns associated with factory farming. Additionally, current animal protein production is framed as a public health issue because of the increased risk of zoonotic diseases and antibiotic resistance. Therefore, even though both proponents and opponents frame the protein issue largely as an environmental problem and a question of food security and sovereignty, proponents are more active in highlighting the moral and human health issues of animal protein production.

5.3.2. Competing imaginaries

Cultured meat technology itself is framed in various ways that were further distinguished based on common themes among different stakeholders and their main characteristics, values and interests. Even though some proponent and opponent imaginaries might position similar values as central, the narratives that surround these values vary. This can be explained by the fact that the imaginaries are used to advance different interests, which are either in support of cultured meat development or against it. Therefore, these imaginaries are compared and assessed based on their values, interests and what storylines drive these imaginaries.

5.3.2.1. Environment, health and ethics

The sociotechnical imaginary 'sustainable, healthy, cruelty and guilt free meat production', which is built on promissory narratives about the sustainability, health and ethical benefits of cultured meat, emphasizes that the technology could lower GHG emissions, water and land use, reduce risk of zoonosis, antibiotic resistance and cancer risks, and eliminate the need for intensive factory farming and slaughtering of animals.

The environmental benefits regarding GHG emissions are based on the assumption that all energy used in production will be from renewable sources. Even though there is scientific evidence that they can be net zero technologies, it largely

depends on the energy source and only with the right energy supply it is possible to have significant positive environmental energy impact (Interview 1; Interview 3). Regarding other promises, there is a strong consensus that cultured meat could reduce land use change (interview 1; interview 2; interview 3). However, according to one interviewee, improvements regarding water use still need to be scientifically proven (interview 1).

Health benefits are another aspect on which the imaginary is built. Although an interviewee highlighted that a race to market can lead to a situation where companies are cutting corners when it comes to safety, it is assumed that the production will be completely safe for human consumption ensured by the EFSA. Therefore, cultured meat products could potentially improve individual health as it can be a tailor made solution with adjusted content to fit the needs of a society (interview 4).

This imaginary also assumes that the reduction of factory farming and antibiotic use will not only improve public health but also animal welfare. The animal welfare aspect has a large potential and for some it goes without saying (interview 3). However, it also depends on how the production process is organized and what ethical considerations are guiding the production. Taking into account that fewer animals would be necessary than the current system requires, it could be considered better for animal welfare if they are believed to have overall negative experience in intensive farms and therefore it is better to replace them with non-existence (interview 2). Additionally, if the production is based on frequent biopsies then, while it can still be considered better in comparison to what animals nowadays endure, the technology is not utilizing its full potential because biopsies can be done without disturbing the animal or taking cells only once (Interview 1; interview 3).

The counter imaginary ‘technology with no environmental, health and animal welfare benefits’ that is in opposition to the imagined environmental, human health and animal welfare benefits, associates the technology with negative environmental impacts because of high energy requirements, loss of environmental services and connection with nature, negative human health effects because of the ultra processed nature of cultured meat products and negative animal welfare implications from using FBS.

The counter imaginary assumes that the high energy demand will not be satisfied in a sustainable way. However, some interviewees pointed out that

opponents often try to oppose cultured meat without addressing actual data (interview 2) and using non peer reviewed Life Cycle Assessments (LCAs) (interview 3). Even though the long term health effects of cultured meat products are not known, Novel Foods in Europe go through a very thorough assessment to ensure their safety. Additionally, the assumption that cultured meat production will require slaughtering of pregnant cows, which therefore is not beneficial for animal welfare, is outdated. The technology keeps developing and it is no longer necessary to use FBS but instead a serum-free media can be used.

The two imaginaries both position sustainability, healthy environment, and wellbeing of humans and animals as their central values. However, they do so using narratives that help advance their different interests which are either to support the development of cultured meat technology by emphasizing its promises and benefits or to undermine it and advocate for conventional meat production.

5.3.2.2. Money, power, jobs and food security

The imaginary ‘monopolies and socioeconomic inequalities’ emphasize the negative impact on competitiveness, consumer welfare, European autonomy, democracy and socio-economic equality that cultured meat technology could have because of monopolies, high entree costs, IPs, new dependences, changes in the social fabric and loss of jobs.

This imaginary is largely concerned with the emergence of monopolies and puts a significant emphasis on this aspect when promoting the imaginary and conventional production methods. It is based on the assumption that only a very limited number of producers will be able to access the market due to aspects such as high entree costs and IPs. However, almost all interviewees highlighted that there are already powerful structures and major producers in the livestock industry that dominate the production and it is not specific to cultured meat (interview 2; interview 3; interview 4). Furthermore, there are industries where monopolies are not addressed, such as pharma, which makes it a very selective effort to single out cultured meat (interview 1). The fear to develop new dependencies, the powerful role of hi-tech giants and reduced food security is also central to this imaginary. However, if this technology develops elsewhere outside the EU, different dependencies could emerge alongside missed opportunities and competitiveness (interview 3).

Central to this imaginary is also loss of jobs and growing inequalities. However, cultured meat technology is far from being able to be implemented on a large scale and viewed as a threat to farmers (interview 1; interview 2; interview 3). As one interviewee mentioned the market is already segmented and the small producers in, for example, Italy are not competing with large pig farmers in countries such as Denmark (interview 4). Additionally, two interviewees highlighted that in Europe there are already problems with workforce on farms (interview 4) and that aging farmers are retiring (interview 2). Therefore, the assumption that jobs will be lost due to cultured meat in reality could be a process that is gradually happening with or without the technology.

Countering this imaginary are two proponent sociotechnical imaginaries identified as ‘economic growth and opportunities’ and ‘food secure and sovereign Europe’. The first of these proponent imaginaries emphasizes the economic benefits, new opportunities and growing European competitiveness that could be achieved with the emergence of cultured meat industry. It could also lead to new research, revenue streams for farmers, more skilled jobs, enhanced local production and potential spillover effects for bioeconomy. Enhanced local production and diversification of protein sources using cultured meat could lead to more security and sovereignty, central to the other proponents’ imaginary, which imagines cultured meat as a way to improve the resilience of food systems and reduce import dependencies.

In the first imaginary of proponents it is assumed that the playing field is not highly uneven and, while there might be more powerful players, monopolies are not dominating the market. Furthermore, farmers are imagined as having access to the technology to produce cultured meat alongside their conventional production and it can take place in locations where meat production is not widely established. Therefore, it could be an opportunity to generate additional income and potentially combine it with less intensive labor which could be more attractive for the younger generation of farmers (interview 3). Additionally, cultured meat is assumed to be able to reach price parity with conventional meat. By doing so, it could be more accessible to consumers as a healthy and sustainable alternative to conventional meat. However, it is yet to be achieved.

This ability to produce in new places without using large amounts of resources that are vulnerable to extreme natural events and climate change, alongside

accessibility and affordability are also central to the second imaginary that is focused on food security and sovereignty. It is assumed that there are no critical dependencies prone to disruptions when meat production is based on cellular agriculture. However, it could largely depend on how the new supply chains are developed as the technology uses materials from pharma and could introduce new tensions in supply chains (interview 1).

Even though fair competition, competitiveness, food security, European sovereignty, and socio-economic equality are presented as central values in both proponent and opponent imaginaries outlined above, these values are surrounded by different narratives that promote cultured meat or impede its development. Additionally, there can be internal contradiction between values and interests when a central value is fair competition but driven by their interests opponents attempt to ban or restrict cultured meat development which goes against fair competition. However, these imaginaries can work to attract those actors who are concerned with e.g. competitiveness and economic growth depending on what are their other interests.

5.3.2.3. Culture, traditions and farmers

The imaginary ‘loss of culture, traditions and genuine food production’ emphasize the negative impact cultured meat would have on food culture, heritage and farming traditions by competing with small, family owned, traditional farms and genuine food production. However, all interviewees highlighted that the aim of cultured meat is not to either completely replace conventional animal farming or eliminate small scale traditional farms. The goal is to stop industrial factory farming which cannot be considered part of local traditions (interview 1).

This imaginary assumes that conventional meat production only means small scale, traditional farms. In addition, traditional foods that require meat products are only considered part of food culture if meat is produced in the conventional way. However, it implies that traditions do not change ignoring the role of evolution. Additionally, it creates a very idealistic image of a small traditional farm, which is not the issue that cultured meat is addressing (interview 2). The small local farms could treat local cuisine while cultured meat could provide everyday proteins (interview 1; interview 4). As one interviewee highlighted there are already significant difficulties to

continue producing in the same way it has been done because of issues such as increased labor costs, feed costs, climate change and other challenges (interview 4).

As it emerges, the main values central to this imaginary are culture, traditions, heritage. These values are driving the imaginary and advancing the interest linked to maintaining conventional meat production and restricting the development of cultured meat production. However, an interviewee argued that tradition and culture are often weaponized to justify some things that are not morally good and to hide other interests, especially economic interests (interview 2). Which further highlights the complex relationship between values and interests in sociotechnical imaginaries.

5.3.3. Who should be involved

Various actors are considered important in the sociotechnical imaginaries that either support or oppose cultured meat. They are essential for various reasons such as to further advance the technology, ensure its uptake or restrict further development, to communicate information as well as protect interests and further advance them.

Society is important for how different imaginaries consider the future. Opponents are largely concerned with protecting the interests of citizens, taking into account their views, informing them about the risks and dangers associated with cultured meat, not misleading them and ensuring their safety when it comes to food consumption. Proponents also consider it important to ensure their safety, inform society about the possibilities of cultured meat, improve their acceptance, and offer freedom of choice. In a similar manner, farmers are considered. Opponents are interested in protecting the interests of farmers, traditions and jobs whereas proponents want to offer them new opportunities, help reorient their activities and generate new revenue streams, as well as maintain traditional production that aligns with the current societal needs. Both proponents and opponents view farmers as important actors who need to be at the centre of attention when considering changes in the food system.

Both sides also consider it necessary to have scientific information and communicate it. Therefore, scientists and researchers play an important role in opponent and proponent imaginaries. In addition to that, proponents consider chefs

to be essential for communicating the possibilities and qualities of cultured meat in addition to other experts such as scientists and doctors. Governments could also play a role in educating society.

In proponent imaginaries, governments and decision-makers are expected to shape the regulatory landscape in support of cultured meat and potentially contribute to its advancement with public funding. Contrary to that, opponents expect decision-makers to introduce barriers to cultured meat and direct funding towards other innovations, refusing to accept it as the future of protein production.

5.4. Governance solutions

These imagined ways of what the future of cultured meat could look like, values and interests that need to be advanced and protected, have implications for what different stakeholders consider relevant governance arrangements for the future. Therefore, the proposed arrangements are distinguished depending on whether they are part of the opponent or proponent imaginaries.

5.4.1. Opponents

The following section outlines the governance solutions that opponents have suggested in order to either restrict or ban the development and emergence of cultured meat industry.

5.4.2. Bans and restrictions

Solutions offered by those who have an oppositional stance towards cultured meat are largely concerned with banning or restricting cultured meat production and marketing. The required activities include fact-based and comprehensive impact assessment prior to any authorization that addresses ethical, economic, social and environmental questions in addition to nutrition, health, safety, food sovereignty and animal welfare concern and a study on EU consumer and citizens' views (General Secretariat of the Council, 2024). They also include prohibiting placing on the market cultured meat and products that contain cultured meat (Hungary, 2024). Prohibiting any marketing until a product has been authorized based on the Novel Food regulations. Stricter regulatory framework for the production of cellular foods in France and at the European level. Prohibit the commercial name 'meat' and make it

mandatory to state the species of origin to ensure correct information of the consumer, particularly regarding allergen risks. Additionally, it is necessary to clearly identify cell-based foods and meat from livestock through labeling. Funding should be dedicated towards accelerating the implementation of the plant protein strategy instead of more uncertain alternatives (Sénat, 2023).

5.4.3. Proponents

Proponents are concerned with governance solutions that support and accelerate the development of cultured meat technology as well as mitigate the potential negative consequences.

5.4.3.1. Monopolies and government funding

A central concern of one of the opposing sociotechnical imaginaries is the possibility of monopolies and the inequalities that it could create. However, instead of banning the technology and going against the free market, governments can put in place regulations that prevent industry consolidation and monopolies (UNEP, 2023; interview 1). They can also implement restrictions on how food products can be valued, how production values can be adjusted and production rates to ensure that companies cannot decide among themselves how much they produce and artificially inflate the price (interview 1).

Support of open-access research can also reduce barriers related to intellectual property (UNEP, 2023; interview 1). Private corporate research oftentimes can be beneficial only for the company that conducted it (GFI, n.d.-). Public funding for research and collaboration can reduce duplicative efforts and advance development and scale up (UNEP, 2023; interview 2). Additionally it can reduce incentives created by private investors' money to race to the market and make unjustified claims (interview 1; interview 2). Government supported research has the potential to find broader application and can lead to important inventions and innovations. Open-access research can advance the whole industry instead of benefiting an individual actor (GFI, 2023). Therefore, public research can address more fundamental questions, support research progress and opportunities for the entire field and focus on areas that serve public interests (GFI, n.d.-; UNEP, 2023).

Commercialization funding offered by governments could provide assistance in establishing facilities, infrastructure and help marketing new products (UNEP, 2023; interview 1, GFI, 2023). Open access pilot scale facilities can help research move forward and start scaling up. It can offer space where companies can go and test their production. Commercialization support such as grants ,investments, loans, and loan guarantees allow products to enter the market at fair and competitive prices aligned with a timeline that supports global climate, sustainability, and human development goals (GFI, 2023). Additionally, government grants could be used to incentivize companies to share technologies with rural communities (SEI, 2022).

Public funding for alternative protein research could contribute to the food system's productivity and economic growth. As a result, more opportunities could be created for farmers as well as more skilled jobs (GFI, n.d.-). Support of small-scale companies and decentralized production could contribute to more resilient supply chains (UNEP, 2023). However, considering that the technology uses specialized materials also from pharma, it is necessary to understand the tension that could arise between the food supply and medical supply (interview 1). It is necessary to have solutions in place for emergencies to ensure that people can access food and medicine without affecting the price of either one of them.

5.4.3.2. Taxes and subsidies

In order to lower meat consumption and minimize barriers for the uptake of alternative proteins, governments could reduce and redistribute subsidies and other types of support for industrial animal agriculture (UNEP, 2023; GFI paper; interview 2; interview 3). This would allow the price to reflect the real costs and internalize the negative externalities in the product price. Instead of subsidizing products that are harmful for the environment, governments could subsidize more sustainable and healthier alternatives such as alternative proteins (interview 1; interview 2). Additionally, subsidizing research and development could be beneficial (Merck Group, n.d.-b; Systemiq, 2024). Governments could also offer tax breaks for new facilities (UNEP, 2023). Subsidizing companies can also be a possibility. However, these subsidies cannot be focused on bailing out investors when they have made mistakes, helping investors get a foothold over everybody and hoarding IP, and generally helping the rich get richer (interview 1).

Going further and taxing meat to incentivize the consumption of alternatives should not be considered as it risks exacerbating social inequalities (UNEP, 2023; interview 1). It would benefit the rich and might not lower the negative impacts as people will rather eat less other foods so that they could continue eating meat and the products they actually want (interview 1). It also raises questions about the allocation of tax money as it could increase the production of other things associated with negative environmental effects. Additionally it could affect animal welfare if meat tax incentivizes consumption of smaller animals (UNEP, 2023). Therefore, any decision to introduce new tax laws requires considering its social consequences.

5.4.3.3. Culture, traditions and social inequalities

In order to avoid inequalities, and support innovation without threatening culinary traditions, inclusive planning and collaborative approach to decision making is necessary (ProVeg Germany, 2024). This approach can offer a more balanced assessment and thorough understanding of the role of cultured meat in the food system. The general aim of the technology is to eliminate factory farming (interview 1; interview 2; interview 3; interview 4). Therefore, there is a minimal risk to culture and traditions unless factory farming can be considered part of culture and traditions (interview 1). Additionally, the technology will not be available on a large scale for at least another decade (interview 1; interview 2). Cultured meat aims to replace factory farming and keep farms that are small-scale, which can provide local production, cuisine, and delicacies while eliminating large scale production for everyday meat consumption (interview 1; interview 4).

Despite posing a minor threat, changes could occur in the distribution and nature of jobs required for the production of meat. Production using cellular agriculture will require highly qualified people and farmers will take on a new role (Merck Group, n.d. -b). Therefore, there is a need for policies that ensure just transition focusing on challenges and opportunities, with particular attention to vulnerable groups of people in order not to further existing inequalities (UNEP, 2023; Cellular Agriculture Europe n.d.). Support and investment in local producers, empowerment of communities and new economic opportunities to farmers alongside their conventional production can contribute to successful integration of cultured meat within current food systems (Cellular Agriculture Europe, n.d.)

To minimize the negative social consequences for groups such as rural communities, governments could implement more robust safety nets (UNEP, 2023). Farmers could receive support for providing other public goods such as carbon storage and biodiversity conservation. Governments could also ensure that there is training available for people that might lose their business in order for them to transition to other roles that they are interested in and reorient their activities (interview 1; interview 2). More programs that try to incentivize farmers to stop raising livestock and to instead grow crops such as lentils and pulses could be implemented to help farmers implement more sustainable practices in their farming activities (interview 2).

5.4.3.4. Animal welfare and environmental impacts

Cultured meat could provide real animal welfare benefits. However, realizing these welfare benefits require regulations due to the fact they are not inherent to the technology (interview 1). Considering that it is possible to use production methods that do not require repeated biopsies or even disturbing animals, it is necessary to encourage the most ethical practices available (interview 1). Additionally, it is necessary to have regulations prohibiting producers to use slaughtered animals as material to produce cultured meat while continuing conventional production on a scale that they have done before. Preventative measures should be taken to ensure that cultured meat is not used to amplify production (interview 1). The benefits of cultured meat can only be realized if it replaces animal products instead of being consumed alongside conventional meat (interview 1; UNEP, 2023).

Similarly, the proclaimed environmental benefits of cultured meat cannot be taken for granted. GHG emissions can be reduced as long as energy used to produce cultured meat is decarbonized (interview 2; interview 3). However, it is necessary to have standards and regulations in place to make sure that production is done in an environmentally beneficial way such as using renewable sources to satisfy energy requirements (interview 1). It can be done through measures that ensure the reduction of GHG emissions, such as transitioning electricity grids to renewable sources and encouraging focus on sustainability (UNEP, 2023). However, for a large impact, it is necessary to have a good uptake of the technology all over the world and to make sure that the standards are high everywhere, such as safety standards, and not just prioritize environmental impacts (interview 1).

5.4.3.5. Health, safety and labeling

Health and safety of consumers is the highest priority when it comes to regulating food in the EU. However, globally there are various jurisdictions. Therefore, harmonization of regulatory procedures and high safety standards everywhere would ensure that companies are not able to cut corners regarding product safety because they are racing to market (interview 1). Governments can also proactively address safety and health concerns by supporting research into the nutritional and health consequences of cultured meat (UNEP, 2023).

In addition to safety, clear and fair labeling standards must be implemented. Cultured meat should be labeled transparently to inform consumers while avoiding unnecessary restrictive labeling that could hinder competitiveness (UNEP, 2023). Under EU food law, consumers have the right to accurate information about the food they purchase. Once cultured meat enters the market, it will be subject to Regulation (EU) No 1169/2011, which governs food labeling and consumer information (Eurogroup for Animals, 2024).

Public and political debates continue over whether cultivated meat should be permitted to use traditional meat-related terms such as ‘meat,’ ‘steak,’ and ‘burger’ (UNEP, 2023). Different countries have reached varying conclusions on this issue. However, initial evidence suggests that using these terms for products such as plant-based alternatives does not mislead consumers into believing the products come from animals. On the contrary, such labels may reduce confusion about taste and texture (UNEP, 2023). For cultivated meat, precise labeling will also be critical for individuals with allergies, as some consumers may be allergic to cultured meat components in the same way they react to conventional animal-source foods

5.4.3.6. Regulations

The regulatory pathway in the EU is long in comparison to other jurisdictions where it takes 2 or 3 years (interview 3). Additionally, in Europe there is no pre-submission dialogue for Novel Foods as it is in countries such as Singapore (interview 1; interview 3). This creates uncertainty, making compliance for companies difficult unless they have complete expert knowledge. As a result, companies can end up doing things that are either unnecessary or insufficient and constantly get

stopped (interview 1; interview 3). Additionally, companies can decide to move their production to countries outside the EU (interview 3).

Policies should be designed with a forward-looking approach. They should be approached through backcasting, considering the broader goals of the food system and how innovations like cultured meat fit into that vision (Interview 3). Therefore, the protein system could benefit from Novel Food legislation that is fit for purpose and simplifies as well as speeds up authorisation processes (Wiesner, 2023) which should be collaborative and transparent (Systemiq, 2024).

6. Discussion

The current struggles surrounding cultured meat are highly political, as cultured meat is not yet available in Europe and does not pose an immediate threat to the food system and those involved in it. However, different actors are already positioning themselves in anticipation of a future with cultured meat as part of the protein system. Many promises and benefits, as well as fears and concerns surrounding the technology are speculative, linked to future visions and expectations. Even though these imaginings are associated with the future, they also shape actions in the present as both proponents and opponents use their resources, build coalitions and compete to advance their preferred visions to steer the future towards the pathways that they favor.

Sociotechnical imaginaries are concerned with the relationship between these imaginings and the practical expressions that attempt to bring these imaginaries into existence (Kao, 2024). They are not just means to imagine alternative ways of living but they actively contribute to materializing them (Hughes, 2024). The formation of actor groups that support particular future visions is driven by interests and strategic choices that can have an effect on the transition process (Mast, 2022). Therefore, sociotechnical imaginaries are not neutral as they, driven by certain values and interests, make particular futures possible while foreclosing others.

There are conflicting and competing proponent and opponent imaginaries adopted by powerful stakeholders in the European political arena that make the future of cultured meat technology uncertain. While some support cultured meat technology and therefore promote imaginaries that are based on potentially unrealistic promissory narratives to appeal to certain ideas about desirable futures, others use narratives and political moves that warn about the dangers of cultured meat and its undesirable futures. While these actors that support a certain future vision might interpret narratives differently and tell stories that do not accurately represent facts, their storylines can still be used as rallying points and as a way to bring actors together. Therefore, the research is concerned with uncovering sociotechnical imaginaries, their storylines and narratives that are not necessarily fact based but nevertheless have a function for attracting new actors and rendering imaginaries understandable and relatable.

This study worked to identify common themes among different stakeholders and their sociotechnical imaginaries. Prior to the analysis, 6 analytical dimensions of the sociotechnical imaginaries concept were determined - *stance, framing, meanings, organizings, knowings, and doings*. Considering the lack of standardized dimensions and characteristics, these dimensions were developed based on supporting literature and the research purpose that was set at the beginning of the study. The research focuses on the perceived issues driving the transition according to different stakeholders, the actors they believe need to be considered, how stakeholders frame cultured meat, and the governance solutions they propose to bring these imagined futures into being.

As a result, the research outlines 7 sociotechnical imaginaries, 6 of which are cultured meat imaginaries. The imaginaries are identified as:

<u>Proponent imaginaries</u>

1) Economic growth and opportunities
2) A food secure and sovereign Europe
3) Sustainable, healthy, cruelty and guilt free meat production

<u>Opponent imaginaries</u>

4) Monopolies and socio-economic inequalities
5) Loss of culture, traditions and genuine food production
6) Technology with no environmental, health and animal welfare benefits

<u>Various stances</u>

7) Distraction from better solutions

The imaginaries that are distinguished in reality are not mutually exclusive and their characteristics are distinguished based on the purpose of the research, theory and methods used. Stakeholders might use different imaginaries and their underlying storylines. They might also use particular elements from these imaginaries, interpret narratives differently and align with only some parts of the imaginary. In the material that was analyzed, stakeholders that were generally perceived as proponents, were using narratives that could partly fit into the opponent imaginaries highlighting how these imaginaries do not have clear boundaries but also how proponents can acknowledge the risks associated with cultured meat.

After identifying and sorting the imaginaries and their storylines, their perceived benefits, risks, values and interests were compared and assessed. The different imaginaries frequently express common values, however they are driven and motivated by different interests and therefore based on diverse narratives that are largely related to their rationales for advancing or limiting further development of cultured meat. However, this does not reveal their underlying interests which might be the real reason they are dedicating their efforts and resources to a particular vision and attempting to close a specific technological pathway.

The assumptions that are embedded in some of the imaginaries are not always based on facts or they are outdated. This is especially visible in how statements regarding FBS and loss of farming traditions are used. Despite this, it illustrates how narratives and storylines are used to support certain values and interests and how what people say needs to be taken seriously as it reflects a particular worldview. Additionally, it shows how values such as culture, can be used in storylines that are highly suggestive but very open for interpretation. This reflects in how culture is a concept that although widely used and familiar, can be defined in multiple ways. In addition, occasionally values and interests central to imaginaries can be in tension within an imaginary itself. This internal contradiction becomes obvious when assessing an opponent imaginary where a central value is fair competition but a ban on cultured meat, that can be a preferred governance solution by opponents, goes against this value.

The governance solutions proposed by opponents and proponents are largely aimed at supporting cultured meat technology or prohibiting and restricting its development. Nevertheless, proponents acknowledge the potential risks as well as opponents occasionally acknowledge the potential benefits that can be realized under certain conditions. Proponents can support the technology but still be concerned with risks and only if those risks are addressed, can imagine a future in which the technology actually brings benefits to the society, environment and animals.

This is because the promised benefits of cultured meat are not inherent to the technology. Awareness of the risks that the transition could entail is also expressed by several stakeholders who are generally demonstrating their support for the technology. These risks are associated with the potential monopoly, social inequalities, animal welfare issues, environmental impacts, health and safety

concerns. Therefore, governance solutions are not only concerned with the scale-up of the technology and authorisation but also with mitigating the potential negative unintended consequences. Therefore their governance solutions cut across various policy fields and address the concerns that are also central to the opponent imaginaries.

By tracing the different sociotechnical imaginaries, their tensions and proposed governance solutions, this study contributes to understanding how the future of cultured meat and protein production can be imagined and navigated. Additionally, it adds to the research on sociotechnical imaginaries and the understanding of this concept in relation to food systems and their transitions. This study also shows how different stakeholders, their interests, values, and politics shape sociotechnical imaginaries, the tensions between and within them. Realizing tensions between these imaginaries and why they emerge could be central to the decision making process and effective policies. By tracing the different narratives and storylines that drive the imaginaries, the research attempts to define the most common sociotechnical imaginaries in the EU and their potential role in shaping a direction for their future development. These results can be used across different stakeholders who are concerned with influencing decision-making, building coalitions, designing the technology and its implementation, achieving its social acceptance and influencing the regulatory landscape in order to create a viable pathway for sustainable implementation of the technology.

6.1. Limitations

While the study provides an overview of sociotechnical imaginaries of cultured meat in the EU, the research is associated with several limitations. The first is linked to the lack of standardized dimensions and characteristics of sociotechnical imaginaries concept which has implications for the research. While it makes the concept fluid and flexible, broadening its application, it also makes research in the field highly diverse, its application more difficult and also highly subjective. The concept was therefore the subject of interpretation by the researcher and was used applying logic and knowledge gained from literature review. Additionally, the analysis is applied to a diverse set of material from a limited number of stakeholders. The material differs in length, form and content as the selection was also a matter of accessibility.

The research was further complicated due to stakeholder fatigue which resulted in extremely low interest to participate in interviews. Even though these interviews proved to be insightful, they offer a limited view as all participants have generally a pro attitude towards cultured meat and therefore governance solutions in particular are more extensive when talking about proponent imaginaries.

Another potential barrier to accessing relevant material was language. Material that was originally not in English was mostly discovered through other sources referencing it. Language also had implications for interpretations as the material that was not accessible in English was automatically translated using tools on the internet, therefore potentially losing expressions that are specific to a language and becoming a subject to misinterpretation.

Furthermore, considering that the research process was long and required manual work to process large amounts of data in texts, some parts that are actually relevant to talk about sociotechnical imaginaries could be overlooked and excluded. This can also be due to the high number of codes that were developed in an iterative manner.

6.2. Recommendations

Future research could benefit from more clearly defined dimensions and characteristics of the sociotechnical imaginaries concept for food technologies. While dimensions selected for this research served their purpose, they were also difficult to apply due to the diverse nature of material that was analyzed. For future research, a more thorough analysis would be possible if the material followed a similar template covering different dimensions in more detail. However, this would likely not be possible across different stakeholder groups unless the data analysis is based on interviews in which it is possible to follow a guide and cover all dimensions relevant for the research.

This study was not able to cover all relevant stakeholders, which would have provided a more nuanced view on the sociotechnical imaginaries present in the EU. However, this task might be difficult in a broad setting such as the EU. Therefore, future research could either focus on one stakeholder group or a selection in the EU or various stakeholders on a national level.

In the future, additional research could focus on the timeline of the emergence of the different sociotechnical imaginaries, which imaginaries emerged as counterimaginaries and what prompted them to become more visible, looking at more specific public and political events. Additionally, research could be done on the power dynamics prevalent in the EU and therefore making stronger predictions about which imaginary could become dominant and why.

7. Conclusion

Approached through the sociotechnical imaginaries lens, cultured meat illuminates how the complex relationship between society, technology and science and collective ideas of the future shape present day actions, bring together actors and influence policy decisions. Sociotechnical imaginaries are both descriptive of the future but also normative, as they reveal what the future should or should not be. Therefore, different sociotechnical imaginaries of cultured meat open certain pathways while closing others.

The question that the research aimed to answer relates to how these different ideas of desirable and undesirable futures attainable through cultured meat technology could shape the future trajectory of the technology. Currently the technology is characterized by political disagreements and conflicting ideas about its risks and benefits. Its potential disruptive power could have far reaching influence on the food system and those involved. Therefore, different actors are building coalitions, activating narratives, lobbying and using their power and resources to advance their ideas of the future. Their imaginaries of the future have practical expressions in the present as opponents attempt to ban and restrict the development of cultured meat while proponents take steps to bring cultured meat products to the EU market and increase public acceptance.

The emergence of different sociotechnical imaginaries is the result of these struggles relating to various ideas of what the future of protein production should look like. They are not neutral claims as they are informed by different values and interests. The research identifies a diverse set of stakeholders, each with their own interests and interpretations driving their imaginaries. Some of these stakeholders recognize the potential of the technology. These include start-ups, NGOs, animal rights activists, and also some national governments. While others, farmers, conventional meat multinationals, and countries with strong interest in the farming sector such as Italy, perceive it as a threat. However, these and other stakeholders can have varying stances and their underlying interests are not always obvious.

Considering that powerful actors have taken both proponent and opponent positions there is a level of uncertainty regarding the future of cultured meat. While it is difficult to evaluate the likelihood of a particular imaginary, identified in the

research, to emerge as the dominant European imaginary, the two main trajectories it could take are either further development, supported by policies, research and investment or stagnation and relocation brought by bans, harsh regulations in the EU, lack of funding possibilities and research efforts. This will largely depend on which imaginaries, either opponent or proponent, gain support and traction. It will also depend on how the different storylines and narratives are used strategically in order to appeal to certain values and interests of powerful players. Sociotechnical imaginaries are not mutually exclusive and they can be used in various ways. It can be strategic for building coalitions with actors who, for example, are more interested in the economic implications of a transition than environmental. Additionally, imaginaries that play more on emotions, such as those related to culture and traditions, could gain support due to the values and narratives that are open to broad interpretation and therefore can appeal to many.

The cultured meat debate is more than a discussion about science and technology, it is also a struggle between different values and interests, such as economic, social, environmental and other. Policy will eventually determine which imaginaries prevail through regulatory frameworks, funding mechanisms, and political lobbying that will shape the trajectory of the imaginary. While opponents attempt to ban and restrict the technology, it is more likely it will continue to develop. However, the scale it will be able to reach will depend on various factors such as price, technology, social acceptance. Rather than a binary outcome, future with cultured meat or future with no cultured meat, the most likely scenario is a coexistence of traditional and alternative protein systems. This research provides a foundation for further inquiry into what are the different sociotechnical imaginaries that have emerged, how they can be leveraged, and what concerns need to be addressed to attain particular protein futures and develop a sustainable sociotechnical pathway for cultured meat.

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APPENDIX A

Stakeholder	Stakeholder group	Material used for thematic analysis	Type of source	Source
National delegations	political and policy stakeholders	A note to the EU Council of Ministers	Document	https://data.consilium.europa.eu/doc/document/ST-5469-2024-INIT/en/pdf
Hungarian government	political and policy stakeholders	Draft act prohibiting the production and placing on the market of laboratory-grown meat	Document	https://technical-regulation-information-system.ec.europa.eu/en/notification/26066
Coldretti - agricultural organization	political and policy stakeholders	Consumption: The 5 Lies of Frankenstein Meat (translated from Italian)	Article	https://giovanimpresa.coldiretti.it/notizie/attualita/pub/consumi-le-5-bugie-della-carne-frankenstein/
French government	political and policy stakeholders	Summary of INFORMATION REPORT DONE on behalf of the Economic Affairs Committee (1) on cellular foods (translated from french)	Report	https://www.senat.fr/rap/r22-504/r22-5040.html#toc0
Italian government	political and policy stakeholders	Regulatory impact analysis of bill containing 'Provisions regarding the prohibition of production and placing on the market of synthetic foods' (translated from Italian)	Document	https://www.governo.it/sites/governo.it/files/DDL_CIBO_SINTETICO_AIR.pdf

(various) Members of the European Parliament	political and policy stakeholders	Verbatim report of proceedings - European protein strategy (debate) (translated from different languages)	Verbatim debate	https://www.europarl.europa.eu/doceo/document/CRE-9-2023-10-19-ITM-004_EN.html
Committee on Agriculture and Rural Development (Rapporteur: Emma Wiesner)	political and policy stakeholders	REPORT European Protein Strategy	report	https://www.europarl.europa.eu/doceo/document/A-9-2023-0281_EN.html#_section4
Meatable	startups	The Problem; The Solution; The Science; The Opportunity	company website	https://www.meatable.com/the-solution/ https://www.meatable.com/the-science/ https://www.meatable.com/the-opportunity/
Mosa Meat	startups	The mission: To fundamentally reshape the global food system	company website	https://mosameat.com/the-mission
Bio.Tech.Foods	startups	Bio. Foods.	company website	https://biotech-foods.com/bio https://biotech-foods.com/foods
Gourmey	startups	GOURMEY, THE FRENCH PIONEER IN PREMIUM CULTIVATED FOODS, SEEKS APPROVAL IN FIVE KEY MARKETS, CONFIRMING GLOBAL AMBITIONS	Press release	https://drive.google.com/file/d/17M1C4q_ZLZ6_Zhr9mw6Swxz0JI1U476t/view
New Harvest (researcher Andrew	Nongovernmental organizations and research	Why cultured meat? Through a researcher's lens	Interview article	https://chemometec.com/case-studies/new-harvest/

Stout)	institutes/ scientists and researcher			
Eurogroup for animals	Animal rights activists	Areas of concern - cultivated meat; Briefing - Cultivated meat	organization website; briefing	https://www.eurogroupforanimals.org/what-we-do/areas-of-concern/cultivated-meat 2021_05_20_efa_pp_cultivated meat
Anima International (researcher Włodzimierz Gogłoza)	Animal rights activists/ scientists and researchers	Factory farming is one of the main risk factors of global pandemics. There is an alternative to it	Article on organization website	https://animainternational.org/blog/factory-farming-global-pandemics
United Nations Environment Programme	political and policy stakeholders	What's Cooking? An assessment of potential impacts of selected novel alternatives to conventional animal products	report	https://www.unep.org/resources/whats-cooking-assessment-potential-impacts-selected-novel-alternatives-conventional
Good Food Institute	Nongovernmental organizations and research institutes	2023 State of Global Policy; Introduction to cultivated meat; Ensuring a clear path to market; Benefits of public funding	report, organization website	https://gfi.org/wp-content/uploads/2024/06/The-State-of-Global-Policy-on-Alternative-Proteins-2023.pdf https://gfi.org/science/the-science-of-cultivated-meat/ https://gfi.org/cultivated/ https://gfi.org/ensuring-a-clear-path-to-market/ https://gfi.org/securing-government-funding/
The Dutch government	political and policy stakeholders/	AMENDED MOTION BY MEMBERS	motion	https://www.tweedekamer.nl/kamerstukken/moties/detail?id

	investors	MEULENKAMP AND GRINWIS TO REPLACE THE ONE PRINTED UNDER NO. 19		=2024Z16382&did=2024D39596
ProVeg	Nongovernmental organizations and research institutes	ProVeg Highlights for 2020: accelerating the plant-based sector: commentary on the Hungarian ban	website, commentary on the Hungarian ban	https://proveg.org/news/proveg-highlights-for-2020-accelerating-the-plant-based-sector/ https://technical-regulation-information-system.ec.europa.eu/en/notification/26066
Merck KGaA	Input company	Meeting critical technology challenges; Trendstudy: How cultured meat becomes a game changer	website	https://www.merckgroup.com/en/research/research-and-development-highlights/cultured-meat.html https://www.merckgroup.com/research/innovation-center/en/Trendstudy_EN.pdf
Systemiq	(input) company	The EU cultivated meat opportunity	report	https://www.systemiq.earth/wp-content/uploads/2024/10/EU-Cultivated-Meat-Opportunity.pdf
Stockholm environment institute	Nongovernmental organizations and research institutes	A just transition in the meat sector: why, who and how?	report	https://www.sei.org/wp-content/uploads/2022/11/just-transition-meat-sector.pdf

APPENDIX B

Interview Nr.	Expert description
1	An expert working at a non-profit research institute that is advancing the science behind cultured meat. Background in molecular and stem cell biology and experience working at a Dutch cultivated meat company.
2	An expert who is a PhD candidate from a French university, currently researching the environmental and economic stakes of cultivated meat and other alternative proteins. A background in environmental policy and experience at a French cultivated meat company.
3	An expert from a consultancy working on sustainability topics, Environmental, Social, and Governance (ESG) questions, strategic communication and regulatory affairs. Background in cultural studies and literature.
4	An Expert working at an Estonian governmental organization that advises companies on research and development (R&D) and gives out R&D aid for projects. Experience working at a contract research organization in Estonia focusing on developing innovative solutions in food and biotech.

APPENDIX C

Informed Consent Form Interview **17/11/2024**

Delft University of Technology

HUMAN RESEARCH ETHICS

INFORMATION & INFORMED CONSENT

You are being invited to participate in a research study titled Exploratory Study of Sociotechnical Imaginaries Surrounding Cultured Meat: Visions of Proponents and Opponents in the European Union. This study is being done by Anna Paberza, a master's student from the TU Delft and Leiden University.

The purpose of this research study is to explore the different future visions actors have in relation to cultured meat technology within the European Union and the tensions between them. The interview will take you approximately 45 minutes to complete. The obtained data will be used for the completion of master's thesis for the study Industrial Ecology. You will be asked to answer a series of semi-structured interview questions related to cultured meat technology, its relationship with current animal protein production and consumption, your envisioned future for this technology, and proposed policy actions.

As with any online activity the risk of a breach is always possible. To the best of our ability any confidential information will be safely stored in TU Delft secure server and only be accessible to Anna Paberza, and her supervisors Lotte Asveld and Jaco Quist.

The interview will be recorded, and afterwards a written transcript will be produced. The transcript will be shared with you for an approval before any further analysis. It will then be analysed to identify elements of imaginaries including values, expectations and perceived risks and benefits associated with cultured meat technology.

The transcript and the recording will be deleted within 2 years after the end of the study. The conclusions resulting from the analysis of all interviews conducted during the research will be made publicly available in an MSc thesis. Only anonymised data will be included in the final project.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions and request any data that you have shared to be deleted.

Privacy declaration:

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information provided above. I have been able to ask questions about the study and my questions have been answered to my satisfaction.		

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.		
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
4. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) such as name and associated personally identifiable research data (PIRD), such as occupation and political beliefs and views with the potential risk of my identity being revealed.		
5. I understand that the following steps will be taken to minimise the threat of a data breach, which include anonymisation, secure data storage and limited access.		
6. I understand that personal information collected about me that can identify me, such as name, will not be shared beyond the study team.		
7. I understand that the (identifiable) personal data such as name I provide will be destroyed maximum 2 years after the end of the project.		
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
8. I understand that after the research study the de-identified information I provide will be used for completion of a master's thesis for the study Industrial Ecology at TU Delft and Leiden University.		
9. I agree that my responses, views or other input can be quoted anonymously in research outputs		
10. I agree that my occupation can be used for quotes in research output		

If you have any questions or complaints, please contact:

Anna Paberza (a.paberza@student.tudelft.nl)

Lotte Asveld (supervisor) (L.Asveld@tudelft.nl)

Signatures

_____	_____	_____
Name of participant	Signature	Date

APPENDIX D

Interview Guide	
Introduction	Can you tell me more about yourself and what you do?
The future role of cultured meat	Howw would you describe cultured meat technology? What is the role of cultured meat technology in the future of protein production?
The main benefits of cultured meat	What would be the benefits of cultured meat production within our current protein system?
The main risks of cultured meat	What would be the risks of cultured meat production within our current protein system?
Necessary governance arrangements	What governance arrangements are necessary to maximize the benefits and mitigate the risks associated with cultured meat production? What governance arrangements are necessary to achieve the implementation of cultured meat into the European food system?
	Subsidies/tax
	Regulations
	Social
	Culture and traditions
	Health and safety
	Monopoly
	Supply chain
	Animal welfare

	Funding Research Labelling Consumer acceptance
People involved	Who should be involved in the process of transitioning to sustainable meat and protein production?
Common narratives	What are the most common narratives you have observed in the field in favor and against cultured meat?
Validation of findings	Introduce to research findings and discuss them
Closing	Thank you for your participation. After transcribing, the interview will be sent to you for approval

APPENDIX E

Stance	
Label	***Pro***
Definition	In support of further development of cultured meat technology and investments, its authorization and entering the food market
Description	Showing support for the technology, mentioning the benefits of cultured meat, focus on the positive aspects of the technology
Label	***Against***
Definition	Against the further development of cultured meat technology and investment, does not support its authorization and entering the food market
Description	Explicitly demonstrating the negative stance, highlight the negative aspects of cultured meat technology and risks associated with it
Label	***Neutral/ undefined***
Definition	The stance in relation to cultured meat is neither positive, nor negative or it is not made known
Description	Neither implicitly or explicitly mention their position in relation to the cultured meat technology, mentions it without having a strong opinion on its positive or negative potential, mentions both benefits and risks

Framing	
Label	*Environmental positive*
Definition	Cultured meat is envisioned as a solution to the rising global demand for meat alongside its negative environmental effects such as water pollution, zoonotic disease, biodiversity loss, greenhouse gas emissions and soil depletion (Castle, 2022).
Label	*Environmental negative*

Definition	The environmental benefits are uncertain and life cycle assessment studies indicate that the production of cultured meat is linked to high energy use (Jahir et al., 2023). The environmental services from livestock farming, such as plant and animal biodiversity in grasslands and landscape maintenance will be lost (Hocquette et al., 2024)
Label	*Nature positive*
Definition	Cultured meat offers a shift away from hybridized breeds of livestock that have a higher yield to a more traditional livestock, potentially contributing to the retention of the genetics of traditional breeds (Stephens et al., 2018). It could also allow human and nature relationships to be restored.
Label	*Nature negative*
Definition	Cultured meat will lead to the disappearance of the relationship between humans and animals. It reduces animals to their useful parts and food distanced from its place in world-ecology (Williams, 2021: 153). Cultured meat is viewed as unnatural and humans are evading nature (Hamdan et al., 2021)
Label	*Social positive*
Definition	Cultured meat is a socially acceptable, guilt free and cruelty free alternative to conventional meat. It allows consuming meat and at the same time improve human health, animal welfare and environmental sustainability (Hocquette, 2016). It will also make high quality and sustainable proteins available to different people.
Label	*Social negative*
Definition	Food is a social fact, cultured meat will negatively affect society and increase inequalities
Label	*Cultural negative*
Definition	Food and eating are closely tied to cultural conventions and daily activities, and frequently perceived as part of individual freedom (Hundscheid et al., 2022). There are concerns about the impact this technology could have on farming traditions and livelihoods (Hamlin et al., 2022). Therefore, cultured meat poses a serious threat to traditional farming practices, cultural values, and rural livelihoods.
Label	*Culture positive*
Definition	Cultured meat can help maintain culinary traditions while looking into the future (Gourmey)

Label	*Economic positive*
Definition	It is possible for cultured meat to achieve price parity with conventional meat when produced at an industrial scale (Specht, 2020). It can produce new revenue streams, contribute to national GDP, provide new job opportunities, economic growth
Label	*Economic negative*
Definition	Cultured meat causes concerns about the impact on the livelihoods of animal farmers and the consolidation of food production under large corporations, as well as how the relative price of cultured meat could have an effect on inequality. There is a potential for a monopoly (Treich, 2021)
Label	*Health and safety positive*
Definition	Cultured meat could potentially offer an ideal composition of the meat product that can satisfy the physiological needs of humans and eliminate health risks (Hocquette et al., 2024). The highly controlled environment might also reduce the risk of food borne pathogens or contaminations.
Label	*Health and safety negative*
Definition	There are uncertainties and concerns about the health and safety issues of cultured meat. Due to the technology being new, the long-term health effects of cultured meat consumption on human health are unknown and could be damaging to health (Shaw & Mac Con Iomaire, 2019). It is also a highly processed food
Label	*Animal welfare positive*
Definition	Cultured meat can have a positive effect on animal welfare and farming practices due to the need to keep fewer animals without slaughtering them. If animals are no longer kept for the purpose of slaughtering, cultured meat could finally allow the loving relationship with animals that are eaten to emerge (van de Weele, 2021).
Label	*Animal welfare negative*
Definition	Cultured meat will require less animals and lead to the disappearance of the relationship between humans and animals and possibly even the disappearance of animals themselves (van de Weele, 2021; Treich, 2021). Animals that are kept will be regularly subjected to biopsies to provide stem cells raising questions about the welfare of these animals (Chriki et al., 2022)

Label	*Food security positive*
Definition	The main goals of cultured meat include food security and sustainability (Jairath et al., 2021). As climate conditions are unstable, cultured meat might enhance food security due to its different production methods which are located indoors (Treich, 2021). It will also make meat available everywhere.
Label	*Food security negative*
Definition	Cultured meat will lead to new dependencies and inequalities (note from countries)
Label	*More efficient*
Definition	Meatable - faster production, no unusable byproducts, more efficient feed conversion

Meanings, issues, and framings of the protein transition	
Label	*Growing population*
Definition	Growing population will put more pressure on protein supply
Label	*Increased protein demand*
Definition	Factors such as growing population, rise in income and others will lead to increased protein demand
Label	*Import dependence*
Definition	The EU has a deficit in protein-rich plants and the EU is heavily dependent on imports of high-protein plant-based products from non-EU countries (from report)
Label	*Food (in)security*
Definition	Sustainably produced plant- and animal-based proteins are strategically important for European food security (report) Say smth about currently lack of security

	Undernourishment of large share of population (Meatable)
Label	*Environmental impacts*
Definition	Import dependency often leads to environmental problems in the producing countries and contributes to climate change (report)
Label	*Factory farming*
Definition	Factory farming has negative consequences and is a major issue in the current animal protein production (debate)
Label	*Inefficient consumption and production rate*
Definition	Food crops are produced (outside the EU) for animal consumption instead of human consumption (debate)
Label	*Problematic International agreements*
Definition	International agreements lead to more imports from third countries and its negative consequences (debate)
Label	*Unfair competition*
Definition	EU farmers are facing unfair competition due to the stricter rules that they are subject to in comparison to some non-EU countries that import to the EU (debate)
Label	*decline in animal husbandry*
Definition	Decline in animal husbandry leads to negative consequences for farmers and consumers (debate)
Label	*Illegal migrants*
Definition	Population growth due to illegal migrants leads to higher protein consumption and its negative consequences (debate)
Label	*Zoonotic disease*

Definition	Zoonotic disease from livestock farming poses a threat to public health

Governance solutions
Incentives for farmers
Government funding
Less bureaucracy
Impact Assessment
Banning
Marketing prohibition
Incentives for farmers
Subsidies/tax
Supply chain
Research
Labelling

Who should be involved
farmers
Scientists and researchers
NGOs
Retailers
Conventional meat multinationals
Startups
Investors
Media
Input companies
Decision-makers
Regulatory authorities
Animal rights activists
Consumers/society

Other solutions
More plant-based proteins
Diversifying diets
Diversification of supply
Pasture-based animal husbandry
Fishing
Mediterranian diet
Equal animal and plant protein production

APPENDIX F

Code/Theme	Imaginary	CAP note	Hungary draft ban	Coldiretti. 5 lies	French report	Italy ban
Pro cultured meat	Proponent					
Against cultured meat	Opponent	v	v	v	v	v
Neutral/ undefined	None/ Other solutions are better					
Animal welfare negative	Technology with no environmental, health and animal welfare benefits	v		v		
Environmental negative		v	v	v		v
Nature negative						
Health and safety negative		v		v		v
Threat to farming	Loss of culture, traditions and genuine food production	v	v	v	v	v
Cultural negative		v	v		v	v
Economic negative	Monopolies and socio-economic inequalities	v	v	v	v	v
Social negative		v	v	v	v	
Food security negative		v			v	

Code/Theme	Imaginary	Maria N MEP	Dacian C MEP	Elena L MEP	Herbert D MEP	Irene T MEP
Pro cultured meat	Proponent					
Against cultured meat	Opponent	v	v	v	v	v
Neutral/ undefined	None/ Other solutions are better					
Animal welfare negative	Technology with no environmental, health and animal welfare benefits					
Environmental negative						v
Nature negative						
Health and safety negative						
Threat to farming	Loss of culture, traditions and			v		
Cultural negative						

	genuine food production					
Economic negative	Monopolies and socio-economic inequalities					

Code/Theme	Imaginary	Gilles L MEP	Marlene M MEP	Daniel R MEP	Sylvia L MEP	Anne S MEP
Pro cultured meat	Proponent					
Against cultured meat	Opponent	v	v	v	v	v
Neutral/ undefined	None/ Other solutions are better					
Animal welfare negative	Technology with no environmental, health and animal welfare benefits					
Environmental negative				v	v	
Nature negative				v		
Health and safety negative					v	
Threat to farming	Loss of culture, traditions and genuine food production	v		v		
Cultural negative						
Economic negative	Monopolies and socio-economic inequalities					
Social negative						
Food security negative						

Code/Theme	Imaginary	Isabel C MEP	Danilo O L MEP	Daniel B MEP	Franc B MEP	
Pro cultured meat	Proponent					
Against cultured meat	Opponent	v	v	v	v	
Neutral/ undefined	None/ Other solutions are better					
Animal welfare negative	Technology with no environmental,					
Environmental negative			v			

Nature negative	health and animal welfare benefits		v			
Health and safety negative			v			
Threat to farming	Loss of culture, traditions and genuine food production				v	
Cultural negative		v	v			
Economic negative	Monopolies and socio-economic inequalities		v		v	
Social negative						
Food security negative						

Code/Theme	Imaginary	MEATABLE	MOSA MEAT	BIO.TECH. FOOD	GOURMEY	NEW HARVEST Andrew S
Pro cultured meat	Proponent	v	v	v	v	v
Against cultured meat	Opponent					
Neutral/ undefined	None/ Other solutions are better					
Environmental Positive	Sustainable, healthy, cruelty and guilt free meat production	v	v	v	v	v
Nature positive						
Social positive		v	v	v	v	
More efficiency		v	v			
Health and safety positive		v		v	v	v
Animal welfare positive		v	v	v	v	v
Economic positive	Economic growth and opportunities	v	v		v	
Food security positive	Food secure and sovereign Europe	v		v	v	v
Cultural positive					v	

Code/Theme	Imaginary	Eurogroup fro animals	Anima International	UNEP	GFI	SEI
Pro cultured meat	Proponent	v	v	v	v	v
Against cultured meat	Opponent					
Neutral/ undefined	None/ Other solutions are better					v
Environmental Positive	Sustainable, healthy, cruelty and guilt free meat production	v	v	v	v	
Nature positive		v				
Social positive		v				
More efficiency				v	v	
Health and safety positive		v	v	v	v	
Animal welfare positive		v	v	v	v	
Economic positive	Economic growth and opportunities			v	v	v
Food security positive	Food secure and sovereign Europe		v	v	v	v
Cultural positive						
Animal welfare negative	Technology with no environmental, health and animal welfare benefits			v		
Environmental negative						
Nature negative						
Health and safety negative						
Threat to farming	Loss of culture, traditions and genuine food production			v		
Cultural negative				v		
Economic negative	Monopolies and socio-economic inequalities			v		v
Social negative						
Food security negative				v		

Code/Theme	Imaginary	ProVeg	MerckGroup	CA Europe	Prot Strat	Dutch Parliament
Pro cultured meat	Proponent	v	v	v	v	v
Against cultured meat	Opponent					
Neutral/ undefined	None/ Other solutions are better					
Environmental Positive	Sustainable, healthy, cruelty and guilt free meat production	v	v	v		
Nature positive						
Social positive		v	v			
More efficiency						
Health and safety positive		v	v	v		
Animal welfare positive		v	v	v		
Economic positive	Economic growth and opportunities	v		v		
Food security positive	Food secure and sovereign Europe				v	v
Cultural positive						

Code/Theme	Imaginary	Izsaskun B MEP	Janusz W MEP	Tom V MEP	Tilly M MEP	Bert Jan R MEP
Pro cultured meat	Proponent	v				
Against cultured meat	Opponent					
Neutral/ undefined	None/ Other solutions are better	v	v	v	v	v

Code/Theme	Imaginary	Anja H MEP	Marc T MEP	Clara A MEP	Benoit B MEP	Krzystof J MEP
Pro cultured meat	Proponent					
Against cultured meat	Opponent					

Neutral/ undefined	None/ Other solutions are better	v	v	v	v	v

Code/Theme	Imaginary	Ladislav I MEP	Mathilde A MEP	Sean K MEP		
Pro cultured meat	Proponent					
Against cultured meat	Opponent					
Neutral/ undefined	None/ Other solutions are better	v	v	v		