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CULTURED MEAT - CONTROVERSIAL INNOVATION IN A CHANGING WORLD

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Abstract

The production and marketing of artificial meat remain contentious subjects, generating ongoing debate. This paper evaluates the topic by presenting a balanced overview of the arguments for and against artificial meat, categorized into four main dimensions: technical, economical, environmental and social. On the scientific front, abundant data from recent studies highlights significant advancements over the past decade. Numerous start-ups have enhanced the original bio fermentation technologies, striving to replicate the natural development of striated muscle tissue. Nevertheless, a critical challenge persists: scaling production from laboratory experiments to industrial-level capacities. Politically, the discourse revolves around the tension between biotechnological innovation and traditional animal husbandry practices. While prior reviews have optimistically addressed environmental sustainability, antibiotic resistance, and ethical considerations, these perspectives often underestimate the socio-cultural challenges associated with this paradigm shift.

Key words*: animal husbandry, artificial meat, consumer acceptance, ethics, muscle tissue.*

INTRODUCTION

The cultured meat is known in scientific literature as artificial meat, fake meat, cultivated meat, lab-grown meat, cell-cultured meat, cell-based meat, slaughter-free meat, in-vitro meat, synthetic meat, nano-pastured meat, meat substitute or cultivated muscle fibers (Bryant & Barnett, 2019; Hallman & Hallman, 2020).

Cultured meat represents a specialized area of cell-based agriculture with significant potential to mitigate the negative effects associated with conventional meat production by generating meat in vitro (Reiss et al., 2021).

While cultured meat is often regarded as a promising technological innovation, its ability to address challenges related to food security and environmental sustainability, especially in the context of rising global meat demand, as projected by the FAO, is difficult to prove.

The transition of cultured meat from a laboratory concept to a commercially viable product requires substantial further advancements. These include refining its composition, optimizing large-scale production, replicating the natural aging process of meat, and obtaining regulatory approval - processes that are both complex and time-consuming. Additionally, ongoing research efforts aim to replace animal-derived components with more sustainable alternatives and to enhance the product by incorporating elements such as fat tissue to improve its sensory and nutritional properties. In addition to technical and regulatory hurdles, the success of cultured meat in the market will largely depend on consumer acceptance. If it becomes commercially available, cultured meat will enter a competitive landscape that includes conventionally produced meat as well as alternative protein sources such as plant-based meat substitutes, mycoproteins, and insect-derived proteins (Post & Hocquette, 2017).

The alternative protein industry initially favoured the term "clean meat", but consumers have shown a preference for the terms "cultivated" and "cultured" over "cell-cultivated" and "cell-cultured" (Stephens et al., 2018).

Even if the most used denomination is "cultivated meat", from ethical and scientific point of view the so-called "meat" real term should be: "cell cultivated food" (c.c.f.) (Ong et al., 2020). In fact, using a fake term conscientiously, those interested in promoting a certain brand succeed in persuading the public in a fraud, introducing into the subconscious the idea that that food is meat. As a result, the use of the term "meat" has created an ambiguity that benefits proponents of 'cultured meat,' allowing them to dissociate from the negative connotations of conventional meat (animal suffering, environmental deterioration), while still capitalizing on the positive associations that meat holds for consumers (strength, vitality, healthiness, etc.) (Chriki et al., 2022). In this way, the start-ups have succeeded in imposing the name "meat" for these cultivated muscle fibers into the everyday language. It is noteworthy that the predominant keywords featured in press articles are "meat" and, to a lesser extent, "food" (Chriki & Hocquette, 2020).

In Singapore, the consumption of artificial meat has been legalized since 2020. Following the Covid quarantine, the country importing 90% of its meat, the process of producing and marketing synthetic meat – chicken nuggets – has begun.

However, in the last three shops sell 2-3 kg of c.c.f. per day compared to 2-3 tons of chicken meat. Singapore remains a special example, in fact a peripheral one (Jairath et al., 2021).

Then the USA authorized the consumption of c.c.f. at the federal level, but in fact each member state has its own legislation. Only in Washington and San Francisco a few eccentric restaurants offer this meat – the peculiarities of the state of California should be mentioned for nonconformity!

Other six states such as Florida have already banned the sale and manufacturing of c.c.f.

In Oklahoma, House Bill 306, enacted on May 19, 2020, provides a legal definition of meat as "any edible portion of livestock or part thereof". The legislation further stipulates that labeling a product as meat, when it is not derived from the harvested production of livestock, constitutes a form of misrepresentation. Kansas state also prohibits the labelling of cell cultured food as meat.

C.c.f., that involves growing meat *in vitro* rather than traditional animal husbandry, offers potential benefits in terms of environmental sustainability as well as improvements in animal health and welfare compared to conventional meat production methods. The production technology of c.c.f. requires many stages, each with potential hazards that need vigilant control and monitoring. Microbial contamination may occur at various stages, including the initial cell collection, the proliferation phase, the differentiation process wherein cells develop into muscle tissue, as well as during the final maturation and harvesting steps (Sogore et al., 2024).

The nutritional value of c.c.f. cannot be objectively assessed because the companies that developed the technology keep the recipe secret (which raises suspicions about the use of growth hormones in the nutrient medium of the bioreactor).

However, this technique is able to produce disorganized muscle fibers which are removed from real muscle, and this is a huge limitation in seeking to reproduce the wide range of meats to feature the variety of animal species and races, as well as different muscles or cuts. Furthermore, the presence and distribution of blood vessels and blood, intramuscular fat, and connective tissue all contribute significantly to the overall flavour profile of meat (Chriki et al., 2022).

Important principles of EU food law, such as the precautionary principle as well as the prior risk assessment, should carefully balance food security needs, the protection of consumer's health, animal welfare, sustainability and the safeguard of agrifood sector's workers and companies (EUR-Lex, 2002).

MATERIALS AND METHODS

In order to carry out this review paper, scientific studies published in specialized literature over the last two decades regarding c.c.f. were analysed, along with promotional materials available online, such as television shows and articles posted on YouTube like "The future of meat" (Vox & Netflix, 2021); "How 'lab-grown' meat is made and will people accept it?" (BBC News, 2023); "The truth about lab-grown meat" (What I've Learned, 2023); "Lab-grown meat: Why are countries banning it?" (BBC World Service, 2023). This methodological approach enables a comprehensive evaluation of the subject, incorporating both the scientific perspective,

based on experimental evidence, and the influence of mass media on public perception.
The selection of materials was carried out based on rigorous criteria to include only credible sources with direct relevance to the analysis of c.c.f. Recognized scientific databases (e.g., PubMed, Web of Science, Scopus) were consulted, considering articles published in indexed journals known for their rigorous peer-review process. Additionally, for media content, the popularity and impact of the materials were assessed based on views, comments, and user interactions.
The analysis was conducted by classifying the identified arguments into two main categories: **pros** and **cons**. Arguments in favour of c.c.f. were extracted from scientific literature supporting the benefits of this product, while opposing arguments came from studies that identified possible adverse effects or limitations. Regarding promotional media materials, the techniques used to highlight the advantages of the product were examined and compared with the available academic research data. This dual methodology facilitates a nuanced understanding of how c.c.f. is perceived both from a scientific standpoint and by consumers exposed to media content.
Thus, this paper provides an objective and balanced analysis of the subject, emphasizing both claims based on experimental evidence and the way media discourse influences public opinion about c.c.f.

RESULTS AND DISCUSSIONS

The analysis aimed to integrate both conventional research findings and media-driven narratives to provide a well-rounded perspective on the topic.
Among the pros arguments in support of c.c.f. are: growth of muscle tissue in a lab, as opposed to rearing animals, offers potential advantages in terms of sustainability, animal welfare and health, water footprint, carbon footprint, saving land for feed production, methane production (global warming!???) (Apaolaza et al., 2025). Food safety regarding accidental contamination with *E. coli, Salmonella, Campylobacter* is avoided. One of the strongest arguments in favor of cultured meat is its potential to significantly reduce the reliance on antibiotics, a major issue associated with conventional meat production. In traditional animal husbandry, approximately 80% of the world's antibiotics are administered to livestock, not only to cure infections but also to enhance growth and prevention of disease outbreaks under intensive farming practices. This widespread use has contributed to the alarming rise of antibiotic resistance, a global public health crisis that reduces the effectiveness of life-saving drugs for humans. Cultured meat, produced in controlled environments without the need for antibiotics, offers a promising alternative that could help combat this growing threat. By eliminating antibiotic use in meat production, cultured meat reduces the risk of antibiotic-resistant bacteria entering the food chain, ultimately protecting both human health and the effectiveness of modern medicine.
A significant technical advance in the assembly of muscle stem cells on three-dimensional supports (3-D printing) represents a major breakthrough in the development of cultured meat, addressing key challenges related to tissue structure, texture, and functionality (Barzee et al., 2022; Schätzlein & Blaeser, 2022). Unlike traditional two-dimensional cell cultures, which fail to replicate the complexity of natural muscle tissue, three-dimensional scaffolds provide a more realistic extracellular environment that enhances cell adhesion, differentiation, and maturation.
By mimicking the biological architecture of animal muscle, these advanced support structures promote the alignment and organization of muscle fibers, leading to a more authentic texture and nutritional profile in cultured meat products. Additionally, the improved efficiency in muscle stem cell assembly can accelerate production timelines, making lab-grown meat more scalable and economically viable. This advancement not only enhances the quality of cultured meat but also contributes to sustainability by reducing reliance on traditional livestock farming, decreasing greenhouse gas emissions, and minimizing land and water use.
Ultimately, the refinement of three-dimensional muscle cell assembly brings cultured meat closer to commercialization, improving its acceptance as a viable alternative to

conventional meat while addressing global food security and ethical concerns related to animal agriculture. The technology offers consumers a meat product that is free from pathogens, ethically produced and environmentally sustainable.

In the mirror, the cons arguments are systematized on the following topics: technical, economic, environmental and social.

Technically, taking a muscle fragment from an adult animal and multiplying it in an artificial environment is a process known in the pharmaceutical industry for many decades. The difficulties arise when instead of a population of cells, one moves on to recreating tissues. Trying to create a living artificial organ is a challenge unprecedented in the history of scientific research.

In fact, all this technology tries to imitate a self-sustaining organism. An animal (cow, bird, fish) has evolved for millions of years to reach its present form. It was a complex process of self-regulation based on countless feedbacks. C.c.f. partisans claim that it is not an autonomous organism or even an organ. The presumption is false. To imitate the texture of conventional meat, populations of stem cells (myosatellite cells) must be arranged in a three-dimensional architecture that can be achieved by using organic plant supports or by creating scaffolds using 3D printing using synthetic protein material as raw material (Boland et al., 2003; Barzee et al., 2022).

However, if in experimental laboratory modules these scaffolds can ensure the formation of protein pieces similar to natural meat, in industrial biofermenters the technical obstacle becomes insurmountable. It is about 5 to 15 tons per fermenter. The reproduction of the capillary vascular networks that nourish the muscles, the blood vessels, the nerves and the connective interstices that ensure the organoleptic characteristics specific to natural meat is an almost scientific target, comparable to the difference between the cryopreservation of some cells (e.g. oocytes, spermatozoa, embryos) compared to that of some organs or entire organisms. The key word in these metabolic processes is homeostasis. Sustaining the life of stem cells requires mimicking animal biology, both by bringing in nutrients and oxygen and by eliminating breakdown products. The kidney removes hundreds of harmful substances from the blood. For example: urea, ammonia, uric acid, amino-acids, creatinine, chlorides, phosphates, sulphates, amyloid and certain enzymes. The lung eliminates CO_2 with water vapour. Through perspiration, the skin excretes water, salts, and varying amounts of urea, uric acid, ammonia, amino acids, glucose, and lactic acid. Can the renal, pulmonary, dermal and intestinal function of eliminating metabolic waste be imitated, and if not, then how healthy can c.c.f. be?

Theoretically, it is possible to go from bioreactors of the order of liters to those of tens of thousands of liters using mathematical calculations. However, the laws of biology do not obey these calculations. The body size of animals (including humans) is the result of the evolution of life on earth and therefore these sizes are the ones perfectly adapted to life on Earth. Taking a few liters of cell suspension and multiplying it a thousand times completely changes the data of the problem. From physical to chemical values, everything changes. Not to mention hundreds of other parameters.

The comparison made by the c.c.f. lobbyists with beer fermenters or with the processes of transforming milk into cheese products is ridiculous. A bioreactor is hundreds of times more demanding microbiologically, physically and chemically than the aforementioned ones.

Another important factor is gravity. It exerts forces on terrestrial animals that are involved in the development of muscle tissues. In the case of bioreactors, this phenomenon cannot be equated.

Connective tissues (branches of fascial tissue) provide a certain consistency to conventional meat involved in the thermal transformations associated with cooking and implicitly the flavour of the meat.

The actin and myosin isoforms expressed in cultured muscle tissue were primarily of neonatal or embryonic origin, rather than characteristic of the adult (Thorrez & Vandenburgh, 2019). This may alter the proteins' response to a potential post-mortem transformation. If these transformations are absent, then muscle is not transformed into meat, which is biochemically dissimilar (Datar & Betti, 2010). The techno-functional characteristics and sensory attributes of traditional meat proteins, such as texture, colour, and flavour, are predominantly influenced by the muscle biochemical composition, the organization of thick and thin muscle fibers, and the post-mortem biochemical processes involved in the transformation of muscle into meat (Post, 2012; Fraeye et al., 2020). In contrast, the expression profile of actin and myosin in cultured cells is dominated by embryonic or neonatal isoforms (Thorrez & Vandenburgh, 2019).

On another hand, such an elevated rate of cell proliferation increases the likelihood of regulatory disruptions, similar to those observed in cancerous cells (Chriki & Hocquette, 2020).

The production process of cultivated cell food (c.c.f.) comprises multiple stages, each associated with specific hazards that necessitate rigorous oversight and control measures. Microbial contamination may arise during the initial harvesting of cells, either from the source animals or the surrounding environment. In the cell proliferation phase, potential risks include the presence of chemical residues from culture media components (i.e. growth factors and antibiotics), as well as microbial threats resulting from insufficient bioreactor sterilization. Throughout the differentiation process leading to muscle tissue formation, potential hazards include residues from scaffold materials, microcarriers, and media components. The final maturation and harvesting steps risk contamination of the media from nonsterile conditions, equipment, or the handling by the worker in the absence of proper aseptic conditions (Sogore et al., 2024).

Finally, another problem is immunity. Microbiological safety (bacteria, viruses) remains a big challenge, considering the scale at which we work. In a bioreactor, antibiotics (which are an argument against conventional meat) can prevent the multiplication of bacteria, but not viruses.

As c.c.f. is considered a novel food. Novel food is defined as food that has no prior history of human consumption before being introduced to the market (Miyake et al., 2023). New regulatory frameworks and oversight mechanisms may need to be developed concurrently with the technology to guarantee its consistent quality and safety (Ong et al., 2021).

As such, in the EU, in order to be authorized for consumption, it must be approved by E.F.S.A. The approval process generally takes several years (Post et al., 2020).

In EU legislation, the term "meat" is defined as the 'edible parts,' including blood, of domestic ungulates, poultry, lagomorphs, wild game, farmed game, as well as both small and large wild game (EUR-Lex, 2004). In the United States, the definition of "meat" as provided by the USDA (United States Department of Agriculture) specifically excludes certain categories of animal products, such as fish, poultry, and wild game (Boler, & Woerner, 2017). This distinction highlights the regulatory and classification differences in the way various types of animal-derived food are categorized for purposes of dietary guidelines, labeling, and food safety regulations. As a result, these products are not considered part of the broader category of 'meat' within USDA standards, which can influence both public perception and policy decisions related to nutrition and food industry practices.

The term "meat" typically refers to the maturation of tissues within an animal and the subsequent slaughtering process to harvest its muscles and organs. However, in this context, we are not discussing skeletal muscle, nor an animal (Hocquette, 2016).

Economically, bioreactors have a high consumption of energy generated by fossil fuels (if they are not replaced with those from green energy – possible!?). The culture media are made with the addition of foetal bovine serum (f.b.s.) and therefore by slaughter. To obtain a hamburger, between 90 and 333 foetuses are needed. Thus, one litter of f.b.s. costs $800.

Vegans consider c.c.f. if obtained without foetal bovine serum (f.b.s.) acceptable (without slaughtering animals). F.b.s. has the role of preventing cell suicide that naturally under the complex influence of metabolic factors stop multiplying – a phenomenon opposite to neoplastic development (cancer). However, f.b.s. substitutes are extremely expensive. 1g of TGF β growth factor costs a million $. F.b.s. contains 1800 types of proteins and over 4000 metabolites (Messmer et al., 2022).

Livestock contribute not only to the production of meat, milk, and eggs but also to the supply of leather, wool, and fiber. In addition, domestic animals have important social and cultural roles, including their involvement in touristic events, transhumance, equestrian tourism, hippo therapy etc. Moreover, they support the creation of regionally distinctive products, such as cheeses and other goods recognized under the Protected Designation of Origin (PDO) system, which reinforce local identity and the concept of taste (Chriki & Hocquette, 2020).

The c.c.f. industry is confronted with a range of significant challenges that hinder the widespread commercialization of the technology (Ellies-Oury et al., 2022). These obstacles include the need to scale production processes efficiently, ensuring that the output meets the demand for large quantities while maintaining high quality. Additionally, replicating the taste and texture of traditional meat products remains a major hurdle, as these sensory characteristics are very important for consumer acceptance. Furthermore, reducing the overall cost of production and ensuring the affordability of the final products are essential factors for making c.c.f. technology commercially viable and competitive with conventional meat alternative.

Food counterfeiting or food fraud is done with those goods that are expensive, not with the cheap ones!

Environmental issues. The idea of climate change generated by raising animals for meat is tempting for the uninitiated - there is a major confrontation between the interests of those promoting green energy and the resistance of those involved in the meat industry (farmers, slaughterhouses, meat processors, transport chain, retail), as well as that of the vast majority of so-called traditional consumers, along with gourmets who cannot be convinced to change their culinary art. A single parameter: the temperature of 37°C, will create also environmental issues. Huge energy consumption, including for air conditioning in these factories. At the same time, the CO_2 production from biofermentation plants is a quantitatively important one.

Moreover, the anticipated reduction in land use resulting from the development of cell-based meats may be less substantial than what is often reported in Life Cycle Assessment (LCA) studies. While LCA typically highlights a significant decrease in land requirements for producing cell-based meat compared to conventional livestock farming, it is important to consider that land used for livestock feed encompasses both arable land (for crops) and non-arable land (used for grazing) (Mottet et al., 2017). The total land area utilized for livestock feed production is therefore more complex than LCA models may suggest, as it includes diverse land types with varying ecological impacts. As such, the potential land-use benefits of cell-based meats should be reevaluated by taking into account these multifaceted land requirements.

Livestock animals have an essential role in the agricultural system by consuming not only dedicated forage crops but also crop residues and various by-products from food production (Miyake et al., 2023). This means that livestock operations contribute to the management and recycling of agricultural waste, which otherwise might remain unused or pose environmental challenges. Consequently, the shift from traditional livestock farming to cell-based meat production, while reducing the direct demand for agricultural land for grazing or feed production, does not automatically result in a proportional decrease in the overall agricultural land area used for livestock-related activities. This is because land currently dedicated to the production of feed crops or the processing of by-products still plays a significant role in sustaining livestock operations, even if the animals themselves are replaced by lab-grown alternatives.

Cultured meat is not prima facie climatically superior to cattle; its relative impact instead depends on the availability of decarbonized energy generation and the specific production systems that are realized (Lynch & Pierrehumbert, 2019).

Socially the problem is more complex. The social-religious impact has significant dimensions taking into account the number of potential consumers.

Like any emerging technology, c.c.f. raise numerous questions, not only ethical and philosophical but also religious. Due to its ambiguous status, religious authorities continue

to debate whether cultured c.c.f. is considered Kosher (fit for consumption according to Jewish dietary laws), Halal (permissible under Islamic law), or how to address situations where no animals are available for ritual practices (in the case of Hindu consumers) (Ellies et al., 2022).
Jewish and Muslim religious authorities have not expressed an opinion on the kasher or halal character of c.c.f. According to Jewish dietary law, there is uncertainty about whether such foods can be considered Kosher, as they are produced through biotechnological processes rather than traditional animal slaughter methods.
For the Islamic community, a fundamental question is whether cultured meat is halal, meaning in accordance with Islamic law. Given that the production of cultured meat is a recent scientific development, an invention and innovation not previously addressed by classical jurists ('fuqaha'), contemporary scholars must engage in ijtihad to assess and provide answers regarding the compliance of this technology with the principles of Islamic law (Hamdan et al., 2018).
Furthermore, in Hinduism, where certain religious practices are deeply tied to the use of animals in rituals, there are concerns about what to do if no animals are available for sacrificial or ritual purposes, especially for consumers who observe strict vegetarian or non-violent principles.
The ongoing debate regarding the religious status of c.c.f. seems to be notably less emphasized, or even absent, within Christianity. This is primarily due to the fact that Christianity does not impose dietary restrictions on its followers concerning the consumption of meat. In fact, Christian doctrine generally considers all meat to be clean, aligning with the belief that the distinction between clean and unclean foods, as outlined in certain scriptural texts, no longer applies to Christians (Jagadeesan & bin Salem, 2020). As a result, adherents of the Christian faith are free to consume a wide variety of meats, with no religious prohibition against it, reflecting a more permissive stance on dietary practices compared to other religious traditions.
These debates highlight the need for further engagement between scientific innovation and religious traditions, in order to ensure that new food technologies align with diverse cultural and religious practices.
Food neophobia should be mentioned as a refusal factor (Barrena & Sánchez, 2013; Bryant et al., 2019; Siegrist & Hartmann, 2020). Food neophobia, which refers to the reluctance or fear of trying new or unfamiliar foods, should be acknowledged as a significant factor contributing to food rejection or refusal. This psychological barrier can influence individuals' dietary choices and eating behaviors, and should therefore be considered when assessing factors that impact food acceptance or refusal.
Naturalness or unnaturalness - the perception of cultured meat as unnatural represents one of the most significant barriers to its acceptance by consumers (Wilks et al., 2021). This belief, deeply rooted in cultural and traditional views on food production, often leads to skepticism and resistance, hindering the widespread adoption of alternative meat technologies.
While this view may be justified for certain intensive livestock farming systems, which many consider cruel, it does not hold true for a considerable share of global livestock production, especially in large-scale farming practices in France and select African countries.
A recent review suggests that sustainable intensification and agroecology have the potential to converge through transformative approaches aimed at developing livestock farming systems that are ecologically sustainable, socially equitable, and economically viable (Chriki & Hocquette, 2020).
Ultimately, the future of this product will be determined by consumer acceptance. There is ongoing debate regarding the social, ethical, and environmental implications associated with the production, use, and trade of products derived from modern science (Carlarne, 2007; Mancini, & Antonioli, 2019).
The most important factors influencing consumer acceptance/rejection of c.c.f. include public awareness, perceived naturalness, and food-related risk perception. Ethical and environmental concerns prompted consumers to be willing to pay a premium price for

purchasing meat substitutes, but not necessarily c.c.f.

The key factors influencing consumer acceptance or rejection of c.c.f. are multifaceted and include elements such as public awareness, the perception of naturalness, risk perceptions associated with food, ethical and environmental concerns (Pakseresht et al., 2022). Research indicates that the general public's understanding of these novel food products plays a significant role in shaping their attitudes and willingness to adopt them. Furthermore, the perceived naturalness of c.c.f is often a critical determinant, as consumers tend to favour foods they deem closer to nature or traditional agricultural products. In addition, concerns related to food safety and potential health risks heavily influence consumer decisions. Ethical and environmental considerations also emerge as significant motivators for consumers, especially those who are inclined to support alternatives to conventional meat production. Many individuals express a readiness to pay a premium price for meat substitutes that align with their values regarding animal welfare and sustainability. However, it is important to note that while these concerns contribute to the acceptance of meat substitutes, they do not necessarily translate into the same level of enthusiasm for cultured cellular foods. This discrepancy suggests that factors beyond ethical and environmental considerations, such as trust, familiarity, and perceived technological risks, also play a pivotal role in shaping consumer attitudes toward c.c.f.

Currently, with all the advertising made about this product, the general public does not have enough samples available to express their opinion for, or against (Heidemann et al., 2020). On the other hand, the terms used for these products do not help the consumers to make the difference between c.c.f. and conventional products.

Sensory studies are few and inconclusive. It should be noted that the sensory is composed of image, smell, taste, umami (the taste of savoury), tactile (tenderness). All combined and originating from an ancestral heritage imprinted in the human genetic code (Egolf et al., 2019).

However, this technique leads to the formation of disorganized muscle fibers that deviate significantly from the structure and composition of natural muscle. This represents a major limitation in efforts to accurately reproduce the wide variety of meats that reflect the diversity of animal species, breeds, muscle types, and specific cuts. Additionally, key physiological components such as blood vessels, blood, nerve tissue, intramuscular fats, and connective tissue play an essential role in defining the sensory properties of meat, particularly its texture, juiciness, and flavour profile. The absence or improper integration of these elements in cultured meat production remains a significant challenge in achieving a product that closely resembles conventional meat.

The nutritional value of c.c.f (cell cultivated food) cannot be objectively evaluated because those companies that developed the technology keep the recipe secret (which generates suspicions regarding the use of growth hormones in the nutritional environment).

However, there remain numerous techno-social, economic, and other challenges that have yet to be resolved and which play a critical role in the survivability and viability of *in vitro* technology (Jairath et al., 2021). These unresolved issues significantly impact the long-term sustainability, effectiveness, and overall viability of *in vitro* technologies, influencing their potential for widespread application and integration into various fields. The interaction of these factors is fundamental to the success of *in vitro* systems, requiring continuous research and innovation to overcome the barriers they present.

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CONCLUSIONS

Each type of meat substitute will have its own benefits and weaknesses.

For new food products to be successful,

whether originating from the traditional meat industry or the "FoodTech" sector, they must be competitive, sustainable, and aligned with consumer preferences and cultural norms. As the global demand for food continues to grow, the balance between innovation and tradition will play a critical role in determining the success of these new food options. Furthermore, they must fit within broader societal shifts toward environmental responsibility, health consciousness, and ethical considerations surrounding food production.

The viability of cultured meat as an alternative to conventional meat production remains a topic of debate, especially regarding its potential to reduce the need for animal slaughter. While proponents argue that cultured meat could improve animal welfare by eliminating the need for farming and slaughtering animals, the scientific community has yet to fully validate these claims. The technical, ethical, and environmental implications of cultured meat are still uncertain, and its widespread acceptance depends on resolving these complex issues. Additionally, consumer acceptance and cultural attitudes toward lab-grown meat continue to evolve, with varying levels of scepticism across different societies. Therefore, further research is necessary to assess whether cultured meat can genuinely offer a sustainable and ethical solution to the challenges posed by conventional meat production.

To properly inform the public, a holistic, objective and transparent presentation of the numerous aspects created by the introduction of this food on the market is necessary.

To have a balanced term between the pro and contra opinions is recommended to use the term "cell cultivated food" instead of "cultured meat".

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