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REVIEW ARTICLE

Current Trends and Prospects of Halal-Cultured Meat in Malaysia

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ABSTRACT

Cultured meat, sometimes called in vitro, clean or cell-based meat, is an innovative approach to sustainable food production, addressing urgent problems like those surrounding wellbeing, the environment and health. Although the prospects for cultured meat are good, consumer acceptance is a key determinant for successful entry into the market. This paper aims to review the current trend and perspective of halal cultured meat in Malaysia. A review analysis was used in this paper to study the current literature on halal cultured meat with special reference to the evolution, challenges, and potential in Malaysia. The review analysis revealed several current trends and prospects of halal-cultured meat in Malaysia, including: (a) the process of cultured meat; (b) the challenges of the development of cultured meat; (c) the markets of cultured meat; (d) the halal parameters of cultured meat; and (e) the consumers' acceptance of cultured meat. In conclusion, the introduction of halal-cultured meat to the Malaysian market depends upon the intricate negotiation of the dynamics of consumer education, strategic communication, and the larger sociocultural and religious context. Future studies should include longitudinal research to measure behaviour change as a result of educational outreach and cross-cultural comparison of meat perception, religious adherence and product identity.

Contribution/Originality: This study enriches the literature on halal-cultured meat by examining Malaysia's unique religious, cultural, and consumer dynamics. It emphasises the need for tailored strategies that align scientific innovation with Islamic principles to support acceptance, policy development, and sustainable integration of cultured meat into the country's growing halal food sector.

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1. Introduction

Cultured meat, sometimes called in vitro, clean or cell-based meat, is an innovative approach to sustainable food production, addressing urgent problems like those surrounding wellbeing, the environment and health. Cultured meat production is based on the in vitro growth of animal cells, enabling the production of muscle and fat tissues that resemble conventional meat without killing an animal. This sustainable method alludes to the fact that the carbon footprint of cultured meat (CM) can be 90% less harmful in terms of greenhouse gas (GHG) emissions than traditional meat and uses 90% less water and 90% less land (Batini, 2019). One of the major challenges of CM production is the use of a serum-supplemented culture medium, which affects scalability and economy (Takii et al., 2022). Studies have indicated that the production of serum-free media may provide economic and environmental advantages for cultivated meat. Indeed, increasing membrane cholesterol was found to be a crucial requirement for optimal growth of cells in the absence of serum, as indicated by a recent study that suggested a potential for a transition beyond serum-dependent media. This shift is important not only for cost but also to lower the overall carbon emissions associated with the cultured meat production process.

Although the prospects for cultured meat are good, consumer acceptance is a key determinant for successful entry into the market. There has been some evidence that a large proportion of the population shows an unwillingness to accept cultured meat because of unnaturalness and food safety issues (Siddiqui et al., 2022a). Robust marketing strategies and clear information on the health and environmental benefits of cultured meat are crucial to alleviate these issues and increase consumer acceptance of this new source of protein. The halal considerations of cultured meat mirror the complex dynamics of belief, culture and philosophy that underpin patterns of food production in Muslim societies. Following halal standards is the most fundamental requirement for Muslim consumers, who expect that all steps of meat production, from raw material to processing, should comply with halal standards regulated by designated certification bodies like Jabatan Kemajuan Islam Malaysia (JAKIM) and Majelis Ulama Indonesia (MUI) (Ng et al., 2022). The scope of the regulations is wide in that it includes not just what is halal to be consumed but also the ethical aspects concerning animal welfare and food safety, thereby demonstrating the totality of halal as not only a dietary choice but also a model of ethical living influenced by religious injunctions (Mohamed et al., 2020).

Exploring the current trends and prospects of halal cultured meat in Malaysia brings about significant advantages that bridge the gap between technical breakthroughs and religious dietary observance. This analysis seeks to counter a growing trend in scepticism from Muslim consumers about the halal status of lab-grown meat, contribute to the creation of clear Shariah-compliant guidelines, and raise awareness in the public, especially the younger Muslim population, about the ability of cultured meat to address moral, environmental and food security issues (Burhanuddin et al., 2023). This review leads not only to the positioning of Malaysia in terms of being a halal industry leader but also to helping regulators, academia, researchers, and producers in making informed decisions on the feasibility, acceptance, and commercialisation of halal cultured meat in alignment with Islamic rulings and sustainable development goals (Masood & Mohd Soffian Lee, 2024). Monitoring such developments also helps policymakers anticipate regulatory hurdles and create a model in which cultured meat can meet both national food safety regulations and Islamic dietary regulations. Moreover, it supports research

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and innovation in food biotechnology, which advances Malaysia's aspiration to be a halal hub in the world when scientific and technological advancements are merged with religious and cultural backgrounds.

1.1. Research Objectives

This paper aims to review the current trends and prospects of halal-cultured meat in Malaysia.

2. The General Concept of Cultured Meat

Cell-based meat, or lab-grown, cultivated or in vitro meat, on the other hand, is becoming a real alternative to conventional animal-based meat. It is generated through tissue engineering by cultivating animal muscle cells in a lab in a controlled atmosphere. This emerging technology has attracted much attention for its capacity to tackle some urgent problems inherited in the traditional meat industry, such as animal welfare, environmental sustainability and food security. One of the fundamental benefits of lab-grown meat is it helps alleviate the ethical issues related to conventional meat production, such as animals not needing to be killed in the process (Ahmad et al., 2021; Bryant et al., 2019). Unlike livestock farming, cultured meat is the cultivation of muscle cells, which brings up the issue of what this substance is. This was emphasised by Ketelings et al. (2023), who examined the diverse aspects that influence food identity on meat alternatives, suggesting that cultured meat categorisation could still be challenged. Cultured meat eliminates the need to raise and slaughter animals and hence may alleviate some of the ethical issues surrounding traditional livestock.

Environmentally speaking, in vitro meat is a promising substitute with a smaller demand for resources in comparison with conventional meat production. It has a better energy use as compared to conventional livestock farming, which requires high energy for metabolic and operational purposes; in the process of cultured meat production, the resources are used more for tissue growth instead (Thavamani et al., 2020). In addition, it has been argued that the total energy consumption for producing cultured beef might be lower in comparison with that involved in traditional methods, making it a solution for environmental issues such as those related to greenhouse gas emissions and land use inefficiency of livestock farming (Allahverdiyev, 2023). Using cultivated meat further helps prevent the waste of huge agricultural lands and water consumption as in the case of traditional animal farming. This lower environmental footprint helps with the preservation of biodiversity as well as reducing deforestation associated with pasture expansion and feed crop cultivation. With the growing public interest in mitigating climate change worldwide, the sustainable promise of cell-based meat could be deemed a legitimate strategy for mitigating the environmental footprint of meat consumption in the long term.

However, the manufacture of cultured meat is at an early stage, and several technical challenges remain. For example, developing a scaffold that is not only edible and can support cell growth but also simulates the mouthfeel of conventional meat is still an ongoing goal (Bhat et al., 2019). Studies underscore the necessity for new materials, ones that are food safety worthy while appealing to the sensory side (Guan et al., 2023; Tahir & Floreani, 2022). Furthermore, to make cultured meat sustainable for the markets, reliable regulation considering safety, labelling and consumer acceptance has to be established (Simsa et al., 2019). A second major observation would be the design of

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affordable and scalable culture media bursting with animal-originated components, particularly foetal bovine serum (FBS) that is raising ethical and economic issues. In addition, ensuring texture, taste and nutritional content are consistent is crucial to align with consumer demands and compete with regular meat products. Overcoming these technical and regulatory barriers will be important to enable mass adoption and to secure the survival of cultured meat in the global food market.

Consumer acceptance is a crucial aspect of cultured meat. The characteristics of respondents, like occupation in the agricultural sector, have been found to affect attitudes and willingness to pay for cultured meat. Notably, many agricultural employees indicate a much greater willingness to purchase cultured meat products, despite expectations otherwise of job displacement fears (Promtan et al., 2023). This trend indicates that focused communication and education could help counter scepticism and foster acceptance of cultured meat among general consumer groups. Other variables such as how "natural" it is perceived to be, health benefits, and ethical motives also have a strong influence on public attitudes toward cultured meat. Clear communications about the production methods of lab-grown leather and their environmental and ethical benefits can also debunk misconceptions and build trust among consumers. It is also necessary to culturally tailor messages to resonate with values and religious views in these Muslim-majority countries to build trust and market acceptability.

3. Methodology

A review analysis was used in this paper to study the current literature on halal cultured meat with special reference to the evolution, challenges, and potential in Malaysia. The review analysis was performed utilizing search terms including "halal-cultured meat," "cell-based meat and Islam," "cultured meat in Malaysia," and "Islamic dietary law and food technology." Three key academic databases including Semantic Scholars, ProQuest, and ScienceDirect were used to gather peer-reviewed articles on the subject which were published from 2019 to 2025. The inclusion criteria targeted English-language academic articles that dealt with halal compliance, technology-related processes and consumer perception and regulatory concerns. Non-peer-reviewed sources, duplicated records and manuscripts unrelated to halal or cultured meat were removed. The articles selected were screened using a structured approach, that is, title and abstract screening and full-text review. Salient themes were extracted and integrated to illuminate the relationship between halal-based principles and the innovation of cultured meat. The choice of review analysis was made because it permitted the integration of insights from multiple disciplines, providing a comprehensive panorama of the actual domain, without being limited by primary data collection. It also helped identify gaps in the extant literature that may inform future studies on halal food biotechnology and consumer behaviour in Muslim-majority markets.

4. Findings

The review analysis revealed several current trends and prospects of halal-cultured meat in Malaysia, including: (a) the process of cultured meat; (b) the challenges of the development of cultured meat; (c) the markets of cultured meat; (d) the halal parameters of cultured meat; and (e) the consumers' acceptance of cultured meat.

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4.1. The Process of Cultured Meat

The process of producing cultured meat, also known as cell-based meat or lab-grown meat, involves several intricate biological and technological steps designed to replicate the characteristics of conventional meat while addressing environmental and ethical concerns associated with livestock farming.

4.1.1. Cell Culture and Scaffold Development

The first stage in producing cultured meat is the extraction of muscle stem cells (myosatellite cells) from the muscles of a living animal. These cells are cultured in a laboratory, commonly in a culture medium which includes the essential nutrients and growth factors required to support the proliferation and differentiation of the cells into muscle. FBS is a typical supplement but is expensive and inconsistent. Various plant or synthetic alternatives to FBS are being developed for increased cell growth, stabilised production costs and desirable meat properties (Yu et al., 2023). Further work is generating new scaffold materials, such as cellulose acetate nanofibres that stimulate the attachment of the skeletal muscle cells and enhance overall tissue development (Santos et al., 2023). Such developments seek to make cultured meat more efficient and more acceptable from an ethical standpoint, particularly in environments where animal-based inputs are at odds with cultural and religious dietary requirements. As the sector develops, it will be essential to fine-tune these core elements if we are to produce cultured meat products that are sustainable, cost-effective and palatable to consumers.

4.1.2. Bioreactor Utilisation

After reaching an optimum cell density, cells are moved to a bioreactor, where environmental conditions – such as temperature, the amount of oxygen and pH value, among others – are controlled in detail to ensure constant growth. There are already different bioreactor prototypes, and it's possible to estimate a familiar bioreactor that could produce 25,600 kg of cultured meat annually. At this scale, it can provide nutrition for thousands of people per year (Hong et al., 2021). The demand for energy consumption is high for these processes, and although production presents an opportunity for less use of land and water, electricity demand may grow, highlighting the requirement for clean energy solutions for an environmentally friendly approach (Heidemann et al., 2020). To overcome this, scientists are looking for energy-saving bioreactor technology and are adding renewable energy to production. The maintenance of aseptic conditions and prevention of contamination during the culturing process is equally crucial to guarantee the safety and quality of the product. As the bioreactor technology is being further developed, the role of automation, monitoring and scalability will be integral to achieving price parity and reducing the environmental footprint of cultivated meat.

4.1.3. Harvesting and Processing

Once there is enough tissue grown, muscle cells are collected and made into products, from minced meat to steaks. During the production step, consumer acceptance and nutrient composition of the end products pose challenges. It has been suggested that although fortification of cell-based products with more nutrients could improve their health-promotion value, consumer perception might be negatively influenced by the complexity of the production process (Ho et al., 2023). It is essential that the taste,

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texture and appearance of cultured meat closely approximates conventionally slaughtered meat to ensure consumer acceptance and regular consumption. Food scientists are hard at work developing methods to simulate marbling and fat distribution, two major elements affecting flavour and mouthfeel. Furthermore, the stability and shelf-life of cultured meat products during packaging and storage are important for food safety and consumer acceptance. The collaboration of food technologists, sensory scientists and marketing experts will be key to introducing attractive products, which cater to consumer taste while stressing the nutritional and ethical benefits of cultured meat.

4.1.4. Regulatory and Market Considerations

The cultured meat industry is subject to varying levels of regulatory oversight in each country, with food safety, commodity labelling, and animal rights concerns being addressed. Additionally, it is striking that in the context of developing countries, significant financial and technical obstacles in establishing procurement chains for cultured meat remain, demanding customisation of technical and innovative development in local arenas to be economically viable (Guo & Wiwattanadate, 2023). The cultivation of meat involves advanced biotechnological approaches, including cellular agriculture and tissue engineering, for the sustainable generation of a meat substitute. It offers the potential to combat global food security and ethical issues related to animal agriculture, but addressing cost and consumer acceptance challenges is a key to broader market access. To facilitate this shift, governments and regulatory agencies should implement clear, evidence-based guidelines and offer funding for research and infrastructure, especially in areas with limited exposure to cutting-edge food technologies.

4.2. The Challenges of the Development of Cultured Meat

The emergence of cultured meat, a form of alternative protein produced from animal cells in a laboratory setting, raises technical, ethical, and regulatory challenges. It is of paramount importance for the success and acceptability of biotechnological developments in this direction that cultured meat not only can reproduce the taste and texture of traditional meat but may also provide an alternative in response to ethical and environmental concerns. Such issues must be addressed, taking into account a multidisciplinary perspective, involving food science, biotechnology and ethics in the construction of solutions. Balancing innovation with compliance to both health and religion, particularly in Muslim-majority countries, further complicates the narrative. This is essential for screening forces to inform policymaking decisions and public acceptance through clearly communicating scientific progress.

One of the key technical hurdles in cultured meat is the use of FBS in cell culture media. FBS, obtained from the blood of foetuses during the slaughter of pregnant cows, is ethically challenging and also has issues related to scalability, cost-effectiveness, and consumer safety (Lee et al., 2021). Although there is evidence that bovine myoblasts can be cultured in serum-free media, economically viable replacements that support cell proliferation and differentiation are still a major challenge (Lee et al., 2022). Moreover, cultivation conditions need to be optimised to improve the proliferation and quality of muscle stem cells involved in meat production (Choi et al., 2020). Recent advances in plant-based and synthetic media formulations are promising but need to be further validated and cost. It is also desirable to harmonise culture protocols for various cell

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lines to make it reproducible in repeated use as well as scalable in the same manner with a plurality of production sites. In addition, media which are expended and composed following halal conditions are also necessary to be accepted by Islamic markets.

Another challenge is that of consumer perceptions and regulations. Studies have shown that acceptance of cultured meat is influenced by perceived "unnaturalness" and health concerns (Post et al., 2020). The scepticism surrounding laboratory-grown products is typically the result of unfamiliarity and misunderstanding among the public (Fischer & Loo, 2021). In addition, as cultivated meat moves closer to market readiness, it will need to comply with regulations for safety and quality that are in the process of development around the world (Post et al., 2020). Such regulatory uncertainties can be detrimental to investment and development. Standardisation procedures and halal-compliance certificates may help to promote clarity and trust among consumers. Cultural dogma, dietary traditions and misinformation have powerful effects on forming public opinion and must be tackled through targeted awareness programmes. Harmonisation of regulations between regions would help to foster international trade and investment in cultured meat technologies.

The technological challenges of mimicking the texture and taste of cultured meat to the equivalent of butcher meat are also an issue. Obtaining desirable sensory properties of muscles, in terms of organised muscle fibres and fats, makes advanced tissue engineering methods necessary (Park et al., 2023). The production system should mimic not only the nutritional composition of flesh but also provide flavour and texture, leading to new bioproduction processes (Jiménez Rodríguez, 2023). This involves using co-cultures of muscle, fat and connective tissue cells to better replicate the structure of conventional meat. Current research is being directed to the development of biomaterials and 3D bioprinting technologies for the enhancement of tissue architecture and mouthfeel. Product variety, including both ground and formed products, is also essential in addressing differences in consumer preferences.

Moreover, the sustainability context of cultured meat must consider making sure that the ecological consequences of large-scale production are not causing the replacement of existing farming strategies (Podunavac et al., 2023). Concerns involve the large amount of resources required for cell culture: growth factors and biological reactor operating energy source. While cultured meat may indeed have the potential to lower greenhouse gas emissions and land use when compared to traditional livestock farming, more research is needed to scrutinise the whole environmental impact of the production of cultured meat to maximise sustainability benefits (O'Neill et al., 2021). Life cycle assessment (LCA) studies are also required to determine actual environmental benefits under various production conditions. Implementation of renewable energy resources to operate bioreactors would largely help to decrease the carbon footprint. Sustainable infrastructure development must receive financial support from decision-makers, such as taxes, research grants and green technology subsidies.

4.3. The Markets of Cultured Meat

Cultured meat is one of the most promising developments in the realm of the world's food systems, as this could potentially pave the way for more ethical and sustainable practices and more innovation in the meat industry. Traditionally farmed meat is raised by farming livestock; cultured meat is grown from the cultivation of animal cells in a

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substrate and in an environment outside of an animal. This is a place where food security, sustainability and ethics in food production intersect. It provides a potential answer to the increasing world demand for protein production and minimises the negative consequences of conventional meat production like greenhouse gas emissions and deforestation. As it does not require the killing of an animal, cultured meat also responds to the very real concerns over animal welfare, which is partially why it has appealed to so many ethically minded consumers. It also creates fresh possibilities for food innovation that can also be adapted in terms of nutrition or to minimise the potential hazards. With successive technological developments enhancing its scalability and cost-effectiveness, cultured meat is being promoted as a potentially sustainable alternative to traditional meat in the future of food.

There has been an explosion of investment in cellular meat technologies, exemplified in an analysis by Howard et al. (2021) that found that significant money was being invested in startups that were working on cultured meat and fish technology by leading industry players. These ventures employ the use of animal stem cells or satellite cells to manufacture meat products in vitro, the outcome of which stands to transform meat production and consumption on a worldwide basis (Reiss et al., 2021). Moreover, cultured meat could provide an environmentally friendly alternative to animal-based food, mainly through diminishing greenhouse gas emissions and land and water use, albeit at the expense of energy, although this could be provided by renewable sources. Lynch and Pierrehumbert (2019) also speculated that the energy cost of cultured meat might be substantial, but, again, developments in clean energy could reduce these considerations in future. Further research and infrastructure investment will be necessary as the technology develops to improve the efficiency of production, lower costs, and address sustainability concerns in scaling the production of cultured meat.

The manufacturing process of cultured muscle meat mainly depends on the growth of animal muscle cells, which would require the ideal originality of cell culture technology and the employment of bovine serum. The dependence on serum is also considered to be logistically and ethically disadvantageous by Warner (2019), based in part on the current use of animal-based media for cell culture. Biotechnological approaches are particularly important, as they seek to establish animal-free culture media that have the potential to simplify production processes and reduce ethical concerns associated with animal welfare (Fowler et al., 2019). To the best of our knowledge, no systematic database on the cultured meat segment has ever been published so far that could be used to analyse the development of this promising market segment, especially when taking into account the fact that the challenges for the development of cultured meat are many and with no guarantee of success, neither in terms of economy of scale nor for consumer acceptance (Chriki & Hocquette, 2020). To circumvent these issues, scientists are working to identify plant-derived, recombinant and/or synthetic alternatives that mimic the growth-promoting properties of animal-derived serums. If done properly, transitioning to these alternatives will not only eliminate ethical issues about animal-sourced ingredients, but it can also help cultivate meat production scaling and regulation in global markets.

Consumer perceptions are highly important for the adoption and development of cultured meat. The introduction of a combination of plant-based alternatives alongside cultured meat (hybrid products) has been suggested to lower the resistance of potential consumers with low readiness to accept meat alternatives (Grasso et al., 2022). Promoting cultural and psychological barriers to meat consumption is crucial

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emphasised by Theron and Hagen (2023) regarding the ongoing discussion that meat consumption is embedded in practice and identity (Asioli et al., 2023). Hence, education and communication that focus on the environmental and moral relevance of cultured meat are required to gain broader approval (Chriki & Hocquette, 2020). Adaptation of these strategies to cultural and religious contexts may increase benefits, particularly in communities where food beliefs and traditions are commonly coupled. Retailers promoting consumer acceptance of cultured meat through transparency in labelling, public discourse and participatory innovation may also contribute to the development of more trusting relationships and a culture of openness when it comes to considering consuming cultured meat.

Given the development of the cultured meat market, it is important to know about consumer behaviour and preferences to implement a proper marketing strategy. Evidence suggests that one portion of consumer demand is becoming increasingly influenced by health and environmental concerns—a trend that would benefit the market of cultured meats (Theron & Hagen, 2023). Moreover, involving consumers in the co-creation of products according to their taste and nutritional priorities may increase acceptance, thus stimulating demand (Barone et al., 2021). By combining feedback from various segments of consumers, manufacturers can adjust product characteristics, such as flavour, texture, and appearance, to better meet market needs. Furthermore, an openness regarding the safety, method of production, and advantages of cultured beef may contribute to dispelling myths and garnering confidence among consumers. Partnerships among industry, academia, and regulatory agencies will be crucial to addressing consumer wants and worries in a productive manner during product development and marketing.

4.4. The Halal Parameters of Cultured Meat

Lab-grown meat, even though it is a state-of-the-art product, must comply with strict halal standards to conform to Islam's dietary laws. For meat to be halal, production sources are required to meet Shariah law standards, whereas for animals to be considered halal, all must have undergone a specific slaughter method, with which it must be certified by a legitimate halal body, such as JAKIM in Malaysia (Muhamad et al., 2023). Producing cultured meat has unique issues with halal requirements due mainly to the ingredients and the method. For example, the culture media used in the production of cultured meat should be void of non-halal items (Rahman et al., 2019). Moreover, halal control points (HCPs) should also be implemented in the production line, as is the case in conventional meat systems, to control that the product complies with the halal status. This comprises tracking from the cellular growth phase to the harvesting (Amalia et al., 2021; Abdullah et al., 2019). Due to the complicated halal checking system, several novel approaches, for example, spectroscopy, are being explored to determine the halal authenticity of meat products, thus avoiding issues of deception (Dashti et al., 2021). The analysis of halal compliance is essential to guarantee consumer confidence and marketability of cultured meat (Purwanto et al., 2023).

The source of stem cells is also a key factor in deciding the halal-ness of the cultured meat. According to Islamic law, the first cells to be taken have to come from animals that are slaughtered in a "halal" way. However, if the cells are from an animal (that) was not sacrificed in a halal way or from a haram animal, the produced meat would also be haram despite its production method (Qudsiyah & Tsania, 2024). In addition, the culture media should not add components such as FBS, unless derived from halal slaughter, and

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processed appropriately (Hamdan et al., 2018). Moreover, the extent of halal status must be assured from start to finish through the stages of production, storing and handling until the equipment up to the storing and handling process is not contaminated by non-halal. They have also stressed the significance of traceability and certification by recognised halal bodies to reassure consumers and to comply with religious requirements. Therefore, a clear understanding of the supply chain and compliance with Shariah guidelines is critical for cultivated meat to be declared halal.

During the ingredient sourcing, the whole process of production should adhere to the six principles mandatory for halal compliance: the halal animal origin, the correct method of slaughtering, the absence of impurities (*najs*), the total transformation, the public benefit (*maslahah*) and necessity (*darurat*). These guidelines serve as a guide to which cultured meat may adhere to Shariah (Mohd Kashim et al., 2023). Scholars stress the significance of these principles for the integrity not just of the letter of Islamic dietary law but also its spirit, especially as new technologies give rise to new interpretations of religious fatwas. Furthermore, one has to apply each principle holistically, that is, to ensure that the production in no way negates Islamic teachings, whether in terms of ethics in animal welfare or terms of environmental considerations. For instance, the principle of *maslahah* is supportive of innovation relevant to food security and sustainability as long as it does not contradict fundamental Shariah principles. With the rapid developments in technology around cultured meat, continuous ijtihad is essential to offer guidance that reflects modern times yet is rooted in Islamic fiqh.

From a wider perspective, cultured meat can be seen as meeting the maqasid al-shariah goal of protection of life (*hifz al-nafs*) by resolving issues related to food security and the environment. These concerns are subalterns to the primacy of strict adherence to halal but are still part of a broader Islamic discourse and suggest conditional acceptance of cultured meat—so long as all halal regulations are rigorously followed (Reza Adnan et al., 2021). This view seeks to empower Muslim players to take part in the progression of cultured meat technologies from the beginning and have actual halal integrity from lab to shelf. Moreover, this proactive approach enables Islamic ethical principles to be part of scientific and technological development, producing products that are both ethically and religiously acceptable. Joint efforts of Islamic scholars, scientists, and industry players are necessary to address novel bioethical challenges and achieve Shariah compliance in all processes. In this way, the Muslim community can actively participate in dictating the direction of food technology into the future in a manner that conforms to both religious duty and international humanitarian objectives.

4.5. The Consumers' Acceptance of Cultured Meat

Cultural acceptance of cultured meat is conditionally dependent on perceived behavioural control, moral and ethical beliefs and cultural norms. Studies reveal that consumer willingness to taste cultured meat is generally higher than the willingness to integrate it into their habitual diet, which underlines the existence of a considerable acceptance gap, especially in some countries such as France where food culture and tradition are dominant factors shaping consumers' attitudes (Mancini & Antonioli, 2020; Bryant et al., 2020). Differences in how populations and areas perceive such apps should be taken into consideration, as acceptance rates differ as well. For example, consumers in the Netherlands tend to have a more favourable attitude towards cultured meat than French consumers, showing that acceptance may rise with more familiarity (Chriki et al., 2021; Boereboom et al., 2022). Moreover, addressing naturalness and safety

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apprehension regarding cultured meat is important, as these features influence consumer perceptions and purchase intentions substantially (Faletar & Cerjak, 2022). Therefore, market success relies on customised communication strategies for increased acceptance and availability (Siddiqui et al., 2022b; Dupont et al., 2022).

One important reason for acceptance might be due to the people's knowledge or consumer education. Research has found that most consumers are unfamiliar with cultured meat, and that unfamiliarity creates scepticism. But offering clear and positive information, particularly about the environmental and animal welfare benefits, significantly boosts willingness to give it a try. For example, Belgian consumers who were largely unfamiliar with cultured meat (13%) have been informed the willingness to anyway try was at 43%, with sensory expectations and price being the most important barriers (Verbeke et al., 2015). This shows the effect targeted information can have in breaking down resistance and creating interest. Open and transparent communication can help dilute misconceptions, including those of artificialness or health concerns. Also, when people feel that cultivated meat is in line with their values – e.g., it is a sustainable or ethical way to treat animals – they become more favourable. Thus, educational outreach creates a tactical approach to close the knowledge gap and create more market acceptance.

There's also a significant factor in the messaging and framing of the product. Studies show that the category "clean meat", as opposed to "lab-grown" or "cultured" meat, increases purchase intent for the product, given the positive associations it generates. Further, focusing on communication strategies targeted to specific consumer populations—like a segment of meat eaters concerned with sustainability—may enhance effectiveness. Educational interventions focused on consumer food safety personal health benefits and feelings of compassion perform well in raising consumer receptivity, in addition to ethical appeals (Siddiqui et al., 2022c). Positive framing not only affects initial attitudes but can also increase long-term evaluations of the attitude object. Marketers who can speak to fears in a language that is both relatable and aspirational can help to diminish perceived risk. Engaging a key opinion leader or influencer can also increase the acceptability and reach of educational campaigns. Moreover, positioning cultured meat in a way that associates it with tech advancement and future food security may assist in aligning it with future-orientated consumer identity.

Acceptance levels still vary greatly depending on cultural and national context. A comparative study in Belgium, Chile, and China showed that among them, Chinese consumers were the most receptive to cultured meat, with the majority willing to substitute traditional meat and pay a price premium. On the other hand, Belgian and Chilean consumers were sceptical (Escobar et al., 2025). This discrepancy was primarily related to differences in meat attachment, perceived innovation, and openness to novel food technologies. Consumers' receptiveness is affected by cultural narratives surrounding food origin and authenticity. In some areas where traditional food value is high, cultured meat can be considered as a risk instead of an opportunity. On the other hand, societies with high trust in technology and/or more urgent food security needs could be more open to accepting innovative sources of food. Hence, culturally appropriate approaches that recognise and honour the culinary heritage and social ethos in each culture are highly important in the facilitation of acceptability.

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5. Conclusion

In conclusion, the introduction of halal-cultured meat to the Malaysian market depends upon the intricate negotiation of the dynamics of consumer education, strategic communication, and the larger sociocultural and religious context. As much as the proliferation of the cultivated meat-production technology has brought us closer to in vitro meat becoming a commercial product, certain beliefs in society, especially in the Islamofaith community, are playing a pivotal role in the industry. Education focusing on the ethical, environmental, and health benefits tends to increase openness, particularly when paired with culturally tailored messaging and the use of terms such as "clean meat." To be widely accepted, especially in the halal context in Malaysia, innovations need to continue to meet the demands of consumers and religious requirements. Future studies should include longitudinal research to measure behaviour change as a result of educational outreach and cross-cultural comparison of meat perception, religious adherence and product identity. Interdisciplinary collaboration between food technologists, Islamic scholars and behavioural scientists is, importantly, necessary to guarantee that halal-cultured meat is more than technically possible, and is consistent with Islamic values, as well as is considered halal in practice in both content and evaluation.

Ethics Approval and Consent to Participate

The researchers adhere to the research ethics guidelines established by the Research Ethics Committee of Universiti Teknologi MARA (RECUiTM). All procedures performed in this study did not involve human participants.

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Conflict of Interest

The authors reported no conflicts of interest for this work and declare that there is no potential conflict of interest concerning the research, authorship, or publication of this article.

References

Abdullah, F. A. A., Borilova, G., & Steinhauserova, I. (2019). Halal criteria versus conventional slaughter technology. *Animals, 9*(8), 530. https://doi.org/10.3390/ani9080530

Ahmad, K., Lim, J. H., Lee, E. J., Chun, H. J., Ali, S., Ahmad, S. S., Shaikh, S., & Choi, I. (2021). Extracellular matrix and the production of cultured meat. *Foods, 10*(12), 3116. https://doi.org/10.3390/foods10123116

© 2025 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

Allahverdiyev, E. (2023). Innovative approaches in the field of meat production. *E3S Web of Conferences, 376*, 02021. https://doi.org/10.1051/e3sconf/202337602021

Amalia, P., Handayani, N., Apriza, M., & Kusrini, E. (2021). Risk analysis in halal fast food supply chain restaurant using risk map method. *International Journal of Mechanical Engineering Technologies and Applications, 2*(1), 61. https://doi.org/10.21776/mechta.2021.002.01.9

Asioli, D., Banovic, M., Barone, A. M., Grasso, S., & Nayga Jr, R. M. (2023). European consumers' valuation for hybrid meat: does information matter?. *Applied Economic Perspectives and Policy, 45*(1), 44-62. https://doi.org/10.1002/aepp.13283

Barone, A. M., Banovic, M., Asioli, D., Wallace, E., Ruiz-Capillas, C., & Grasso, S. (2021). The usual suspect: How to co-create healthier meat products. *Food Research International, 143*, 110304. https://doi.org/10.1016/j.foodres.2021.110304

Batini, N. (2019). Transforming agri-food sectors to mitigate climate change: The role of green finance. *Vierteljahrshefte Zur Wirtschaftsforschung, 88*(3), 7-42. https://doi.org/10.3790/vjh.88.3.7

Bhat, Z. F., Morton, J. D., Mason, S. L., Bekhit, A. E. D. A., & Bhat, H. F. (2019). Technological, regulatory, and ethical aspects of in vitro meat: A future slaughter-free harvest. *Comprehensive Reviews in Food Science and Food Safety, 18*(4), 1192-1208. https://doi.org/10.1111/1541-4337.12473

Boereboom, A., Mongondry, P., de Aguiar, L. K., Urbano, B., Jiang, Z., De Koning, W., & Vriesekoop, F. (2022). Identifying consumer groups and their characteristics based on their willingness to engage with cultured meat: A comparison of four European countries. *Foods, 11*(2), 197. https://doi.org/10.3390/foods11020197

Bryant, C., Anderson, J., Asher, K., Green, C., & Gasteratos, K. (2019). Strategies for overcoming aversion to unnaturalness: The case of clean meat. *Meat Science, 154*, 37-45. https://doi.org/10.1016/j.meatsci.2019.04.004

Bryant, C., Nek, L., & Rolland, N. (2020). European markets for cultured meat: A comparison of Germany and France. *Foods, 9*(9), 1152. https://doi.org/10.3390/foods9091152

Burhanuddin, I. H., Muhamad Shukri, A. S., Abu Bakar, M. B., Shahid, M. M., & Adam, A. R. (2023). Cultured meat: An appraisal from the fiqh and sufi views of Muslim scholars. *Malaysian Journal of Syariah and Law, 11*(1), 14-30. https://doi.org/10.33102/mjsl.vol11no1.373

Choi, K. H., Yoon, J. W., Kim, M., Jeong, J., Ryu, M., Park, S., Jo, C., & Lee, C. K. (2020). Optimization of culture conditions for maintaining pig muscle stem cells in vitro. *Food Science of Animal Resources, 40*(4), 659-667. https://doi.org/10.5851/kosfa.2020.e39

Chriki, S., & Hocquette, J. F. (2020). The myth of cultured meat: A review. *Frontiers in Nutrition, 7*, 7. https://doi.org/10.3389/fnut.2020.00007

Chriki, S., Payet, V., Pflanzer, S. B., Ellies-Oury, M. P., Liu, J., Hocquette, É., Rezende-de-Souza, J. H., & Hocquette, J. F. (2021). Brazilian consumers' attitudes towards so-called "cell-based meat". *Foods, 10*(11), 2588. https://doi.org/10.3390/foods10112588

Dashti, A., Müller-Maatsch, J., Weesepoel, Y., Parastar, H., Kobarfard, F., Daraei, B., AliAbadi, M. H. S., & Yazdanpanah, H. (2021). The feasibility of two handheld spectrometers for meat speciation combined with chemometric methods and its application for halal certification. *Foods, 11*(1), 71. https://doi.org/10.3390/foods11010071

Dupont, J., Harms, T., & Fiebelkorn, F. (2022). Acceptance of cultured meat in Germany—Application of an extended theory of planned behaviour. *Foods, 11*(3), 424. https://doi.org/10.3390/foods11030424

© 2025 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

Escobar, M. I. R., Han, S., Cadena, E., De Smet, S., & Hung, Y. (2025). Cross-cultural consumer acceptance of cultured meat: A comparative study in Belgium, Chile, and China. *Food Quality and Preference, 127*, 105454. https://doi.org/10.1016/j.foodqual.2025.105454

Faletar, I., & Cerjak, M. (2022). Perception of cultured meat as a basis for market segmentation: empirical findings from Croatian study. *Sustainability, 14*(12), 6956. https://doi.org/10.3390/su14126956

Fischer, A., & Loo, E. (2021). Social acceptability of radical food innovations. In C. M. Galanakis (Ed.), *Food technology disruptions* (pp. 325-361). Elsevier. https://doi.org/10.1016/b978-0-12-821470-1.00002-1

Fowler, W. C., Ting, J. M., Meng, S., Li, L., & Tirrell, M. V. (2019). Integrating systems thinking into teaching emerging technologies. *Journal of Chemical Education, 96*(12), 2805-2813. https://doi.org/10.1021/acs.jchemed.9b00280

Grasso, S., Asioli, D., & Smith, R. (2022). Consumer co-creation of hybrid meat products: A cross-country European survey. *Food Quality and Preference, 100*, 104586. https://doi.org/10.1016/j.foodqual.2022.104586

Guan, X., Yan, Q., Ma, Z., & Zhou, J. (2023). Production of mature myotubes in vitro improves the texture and protein quality of cultured pork. *Food & Function, 14*(8), 3576-3587. https://doi.org/10.1039/d3fo00445g

Guo, W., & Wiwattanadate, D. (2023). Sustainable landscape of cultured meat in developing countries: Opportunities, challenges, and sustainable prospects. *Meat Technology, 64*(3), 119-133. https://doi.org/10.18485/meattech.2023.64.3.5

Hamdan, M. N., Post, M. J., Ramli, M. A., & Mustafa, A. R. (2018). Cultured meat in Islamic perspective. *Journal of Religion and Health, 57*, 2193-2206. https://doi.org/10.1007/s10943-017-0403-3

Heidemann, M. S., Molento, C. F. M., Reis, G. G., & Phillips, C. J. C. (2020). Uncoupling meat from animal slaughter and its impacts on human-animal relationships. *Frontiers in Psychology, 11*, 1824. https://doi.org/10.3389/fpsyg.2020.01824

Ho, S. S., Ou, M., & Ong, Z. T. (2023). Exploring the general public's and experts' risk and benefit perceptions of cultured meat in Singapore: A mental models approach. *PloS One, 18*(11), e0295265. https://doi.org/10.1371/journal.pone.0295265

Hong, T. K., Shin, D. M., Choi, J., Do, J. T., & Han, S. G. (2021). Current issues and technical advances in cultured meat production: A review. *Food Science of Animal Resources, 41*(3), 355. https://doi.org/10.5851/kosfa.2021.e14

Howard, P. H., Ajena, F., Yamaoka, M., & Clarke, A. (2021). "Protein" industry convergence and its implications for resilient and equitable food systems. *Frontiers in Sustainable Food Systems, 5*, 684181. https://doi.org/10.3389/fsufs.2021.684181

Jiménez Rodríguez, A. (2023). Cultured meat, clean meat,… queer meat? A vegan queer ecofeminist perspective on the implications of cellular agriculture. *Frontiers in Sustainable Food Systems, 7*, 1104731. https://doi.org/10.3389/fsufs.2023.1104731

Ketelings, L., Havermans, R. C., Kremers, S. P., & de Boer, A. (2023). How different dimensions shape the definition of meat alternative products: A scoping review of evidence between 2000 and 2021. *Current Developments in Nutrition, 7*(7), 101960. https://doi.org/10.1016/j.cdnut.2023.101960

Lee, S. Y., Kang, H. J., Kang, J. H., Ramani, S., Park, S., & Hur, S. J. (2021). Principal protocols for the processing of cultured meat. *Journal of Animal Science and Technology, 63*(4), 673-680. https://doi.org/10.5187/jast.2021.e40

Lee, S. Y., Yun, S. H., Jeong, J. W., Kim, J. H., Kim, H. W., Choi, J. S., Kim, G. D., Joo, S. T., Choi, I., & Hur, S. J. (2022). Review of the current research on fetal bovine serum and the

© 2025 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

development of cultured meat. *Food Science of Animal Resources, 42*(5), 775. https://doi.org/10.5851/kosfa.2022.e46

Lynch, J., & Pierrehumbert, R. (2019). Climate impacts of cultured meat and beef cattle. *Frontiers in Sustainable Food Systems, 3*, 421491. https://doi.org/10.3389/fsufs.2019.00005

Mancini, M. C., & Antonioli, F. (2020). To what extent are consumers' perception and acceptance of alternative meat production systems affected by information? The case of cultured meat. *Animals, 10*(4), 656. https://doi.org/10.3390/ani10040656

Masood, A., & Mohd Soffian Lee, U. H. (2024). Securing halal integrity resilience of halal meat ecosystem for Society 5.0 needs through IR4.0 technologies. *International Journal of Religion, 5*(12), 541-557. https://doi.org/10.61707/64t65s36

Mohamed, Y. H., Abdul Rahim, A. R., & Ma'aram, A. (2020). The effect of halal supply chain management on halal integrity assurance for the food industry in Malaysia. *Journal of Islamic Marketing, 12*(9), 1734-1750. https://doi.org/10.1108/jima-12-2018-0240

Mohd Kashim, M. I. A., Abdul Haris, A. A., Abd. Mutalib, S., Anuar, N., & Shahimi, S. (2023). Scientific and Islamic perspectives in relation to the Halal status of cultured meat. *Saudi Journal of Biological Sciences, 30*(1), 103501. https://doi.org/10.1016/j.sjbs.2022.103501

Muhamad, N., Ghazali, S. A. M., Abdullah, P. S., Ibrahim, A. S., & Latiff, Z. A. A. (2023). The perception on halal label of MAMEE products among consumers in Selangor. *BIO Web of Conferences*, 73, 03013. https://doi.org/10.1051/bioconf/20237303013

Ng, P. C., Ahmad Ruslan, N. A. S., Chin, L. X., Ahmad, M., Abu Hanifah, S., Abdullah, Z., & Khor, S. M. (2022). Recent advances in halal food authentication: Challenges and strategies. *Journal of Food Science, 87*(1), 8-35. https://doi.org/10.1111/1750-3841.15998

O'Neill, E. N., Cosenza, Z. A., Baar, K., & Block, D. E. (2021). Considerations for the development of cost-effective cell culture media for cultivated meat production. *Comprehensive Reviews in Food Science and Food Safety, 20*(1), 686-709. https://doi.org/10.1111/1541-4337.12678

Park, S., Park, G., Oh, S., Park, Y., Kim, Y., Kim, J., & Choi, J. (2023). Investigating proliferation and differentiation capacities of Hanwoo steer myosatellite cells at different passages for developing cell-cultured meat. *Scientific Reports, 13*(1), 15614. https://doi.org/10.21203/rs.3.rs-2906778/v1

Podunavac, I., Knežić, T., Djisalov, M., Omerovic, N., Radovic, M., Janjušević, L., Stefanovic, D., Panic, M., Gadjanski, I., & Radonic, V. (2023). Mammalian cell-growth monitoring based on an impedimetric sensor and image processing within a microfluidic platform. *Sensors, 23*(7), 3748. https://doi.org/10.3390/s23073748

Post, M. J., Levenberg, S., Kaplan, D. L., Genovese, N., Fu, J., Bryant, C. J., Negowetti, N., Verzijden, K., & Moutsatsou, P. (2020). Scientific, sustainability and regulatory challenges of cultured meat. *Nature Food, 1*(7), 403-415. https://doi.org/10.1038/s43016-020-0112-z

Promtan, P., Panatuk, J., Kongbuntad, W., Amornlerdpison, D., Nanta, Y., Pripwai, N., Thaworn, W., & Pattanawong, W. (2023). Growth and development of black-boned chicken embryonic stem cells for culture meat using different serums as medium. *Tropical Animal Science Journal, 46*(3), 354-360. https://doi.org/10.5398/tasj.2023.46.3.354

Purwanto, E. H., Tampubolon, B. D., Anggundari, W. C., Dewantoro, A., Anggraeni, P., & Ayuningtyas, U. (2023). Potential technical parameters for the authentication of carrion meat (tiren): A review. *International Food Research Journal, 30*(1), 46-62. https://doi.org/10.47836/ifrj.30.1.03

© 2025 by the authors. Published by Secholian Publication. This article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).

Qudsiyah, U. S., & Tsania, A. A. (2024). Halal perspective review of cultured meat stem cell method. *Journal of Agri-Food Science and Technology, 5*(2), 102-119.https://doi.org/10.12928/jafost.v5i2.11923

Rahman, H. U. U., Sahar, A., Khan, M. I., & Jamil, A. (2019). Discerning microbial and quality attributes of differently slaughtered and dead poultry meat. *Journal of Food Safety, 39*(3), e12622. https://doi.org/10.1111/jfs.12622

Reiss, J., Robertson, S., & Suzuki, M. (2021). Cell sources for cultivated meat: applications and considerations throughout the production workflow. *International Journal of Molecular Sciences, 22*(14), 7513. https://doi.org/10.3390/ijms22147513

Reza Adnan, M. R. A., Fadzil, S. M., & Harun, A. B. M. W. (2021). Cultured meat as halalan toyyiban food: A Maqasid review in the preservation of life (hifz an-nafs). *Food Research, 5*(5), 174-178. https://doi.org/10.26656/fr.2017.5(5).161

Santos, A. E. A. D., Cotta, T., Santos, J. P. F., Camargos, J. S. F., Carmo, A. C. C. D., Alcântara, E. G. A., Fleck, C., Copola, A. G. L., Nogueira, J. M., Silva, G. A. B., Andrade, L. D. O., & Jorge, E. C. (2023). Bioactive cellulose acetate nanofiber loaded with annatto support skeletal muscle cell attachment and proliferation. *Frontiers in Bioengineering and Biotechnology, 11*, 1116917. https://doi.org/10.3389/fbioe.2023.1116917

Siddiqui, S. A., Zannou, O., Karim, I., Kasmiati, K., Awad, N. M. H., Gołaszewski, J., Heinz, V., & Smetana, S. (2022a). Avoiding food neophobia and increasing consumer acceptance of new food trends—a decade of research. *Sustainability, 14*(16), 10391. https://doi.org/10.3390/su141610391

Siddiqui, S. A., Alvi, T., Sameen, A., Khan, S., Blinov, A. V., Nagdalian, A. A., Mehdizadeh, M., Adli, D. N., & Onwezen, M. (2022b). Consumer acceptance of alternative proteins: A systematic review of current alternative protein sources and interventions adapted to increase their acceptability. *Sustainability, 14*(22), 15370. https://doi.org/10.3390/su142215370

Siddiqui, S. A., Khan, S., Farooqi, M. Q. U., Singh, P., Fernando, I., & Nagdalian, A. (2022c). Consumer behavior towards cultured meat: A review since 2014. *Appetite, 179*, 106314. https://doi.org/10.1016/j.appet.2022.106314

Simsa, R., Yuen, J., Stout, A., Rubio, N., Fogelstrand, P., & Kaplan, D. L. (2019). Extracellular heme proteins influence bovine myosatellite cell proliferation and the color of cell-based meat. *Foods, 8*(10), 521. https://doi.org/10.3390/foods8100521

Tahir, I., & Floreani, R. (2022). Dual-crosslinked alginate-based hydrogels with tunable mechanical properties for cultured meat. *Foods, 11*(18), 2829. https://doi.org/10.3390/foods11182829

Takii, S., Wu, J., & Okamura, D. (2022). The amount of membrane cholesterol required for robust cell adhesion and proliferation in serum-free condition. *PloS One, 17*(7), e0259482. https://doi.org/10.1371/journal.pone.0259482

Thavamani, A., Sferra, T. J., & Sankararaman, S. (2020). Meet the meat alternatives: The value of alternative protein sources. *Current Nutrition Reports, 9*(4), 346-355. https://doi.org/10.1007/s13668-020-00341-1

Theron, E., & Hagen, S. (2023). Psychological barriers to climate-friendly food choices. *Psychology in Society,* (65), 81-100. https://doi.org/10.57157/pins2023vol65iss1a5816

Verbeke, W., Sans, P., & Van Loo, E. J. (2015). Challenges and prospects for consumer acceptance of cultured meat. *Journal of Integrative Agriculture, 14*(2), 285-294. https://doi.org/10.1016/S2095-3119(14)60884-4

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Warner, R. D. (2019). Review: Analysis of the process and drivers for cellular meat production. *Animal, 13*(12), 3041-3058. https://doi.org/10.1017/s1751731119001897

Yu, I. S., Choi, Y. R., Choi, J., Kim, M. K., Jung, C. H., Um, M. Y., & Kim, M. J. (2023). Discovery of novel stimulators of Pax7 and/or MyoD: Enhancing the efficacy of cultured meat production through culture media enrichment. *Biosensors, 14*(1), 24. https://doi.org/10.3390/bios14010024

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