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Halal Perspective Review of Cultured Meat Stem Cell Method

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ABSTRACT

Cultured meat is meat made in vitro based on cells or biotechnology meat that can replace animal meat products in general. The halal status of cultured meat is still a matter of debate in society. The aim of writing this systematic literature review is to discuss the halal status of cultured meat. The method used in writing this systematic literature review is based on the results of a systematic literature review; several researchers used Google Scholar, ScienceDirect, and other applications such as Microsoft Excel. SLR is an effort to make the often-subjective literature review more objective to reduce researcher bias. This paper uses a systematic literature review to review published studies on halal perspectives of cultured meat. The relevant material was accessed and sourced from Google Scholar databases with a publication period from 2022-2024 and provide open access journals. Research results show that animal cells taken from animals that have been slaughtered according to Islamic law and rules are said to be halal for consumption. However, if the production of cultured meat comes from non-halal animals or from halal animals but the slaughter is not in accordance with Islamic law and rules, then it is haram for consumption.

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1. INTRODUCTION

Analog meat products have advanced significantly in recent years, with one example being plant-based meat manufactured from nuts and grains (Ching et al., 2022). However, the manufacturing of analogue meat from plant resources has numerous flaws, one of which is its nutritional value. Cultured meat development is thought to be increasingly advantageous as technology advances. Cultured meat is meat produced in vitro using cells or technologies that can replace animal meat products. Cultured meat is gaining popularity among the public and researchers because it may be utilized as an alternative source of meat derived from the slaughter of cows, goats, or chickens (Siipi, 2015). It is currently referred to by a number of names, such as cell-based meat, in clean, synthetic, artificial, lab or factory grown meat, in vitro, even though opinions on the appropriate language are still divided (Lanzoni et al., 2024).

The notion of cultured meat was originally offered by a food technology business in Berkeley, California, USA, which marketed cultured meatballs in 2016. Singapore was the first

country to legalize the sale of cultured chicken meat products (Kashim et al., 2023). Cultured meat may be produced in vast quantities to suit the public's rising need for animal products like meat as the population grows (Treich, 2021). Global meat consumption will rise further in the following decades as the world's population is expected to grow by 70% by 2050. NASA's study on muscle culture with turkey cells and edible carp fillets highlights the possibility of cultured meat manufacturing.

Cultured meat may also be processed into meatballs, sausages, nuggets, and a variety of other items. Plant-based goods are a viable alternative, but they do not yet taste exactly like meat (Waltz, 2021). The cattle sector contributes to global warming by emitting carbon dioxide, methane, and nitrogen oxide gases, which can raise temperatures by 0.5 to 2 degrees Celsius (Kashim et al., 2023). The marketing of cultured meat has various challenges, one of which is the issue faced by the processed meat business in assuring that the cultured meat manufacturing process adheres to the halal concept. The community, particularly Muslims, lays a strong focus on the halal status of cultured meat. The global food sector places a high emphasis on halal food (Kashim et al., 2023). According to the Global Islamic Economy Report 2020/21, consumers' demand for halal food and drinks grew by 3.2% from 2018. The global food business cannot ignore this since the demand for halal food grows year after year, necessitating the development of obviously halal cultured meat to be approved by customers.

This systematic literature review aims to explore the halal perspective on cultured meat by examining existing research and scholarly opinions on the subject. It seeks to address key questions regarding the permissibility of cultured meat consumption among Muslims, the criteria that determine its halal status, and the implications for market acceptance. By synthesizing findings from various studies, this review will provide a comprehensive understanding of the intersection between cultured meat technology and Islamic dietary laws.

Moreover, the review will highlight the ongoing debates among scholars and religious authorities regarding the ethical and religious implications of consuming cultured meat. As the cultured meat industry continues to develop, it is essential to establish clear guidelines and standards that align with halal principles to ensure consumer confidence and acceptance. This research not only contributes to the academic discourse surrounding halal food but also serves as a valuable resource for stakeholders in the food industry, policymakers, and consumers seeking to navigate the complexities of halal certification in the context of innovative food technologies.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this study are 16 previous scientific articles that were used from the PRISMA method from Google Scholar and ScienceDirect databases.

2.2. Methods

Processing previous research is an important part of research. A good review is a strong foundation for contributing to science. A review of previous research helps to develop related theories and research areas and guides the development of future research. Based on the results of a systematic literature review, several researchers used ScienceDirect and other applications such as Microsoft Excel. SLR is an effort to make the often subjective literature review more objective to reduce researcher bias (Priharsari, 2022). This paper uses a systematic literature review to review published studies on halal perspectives of cultured meat.

This journal uses the Systematic review is limited to research in the form of articles. The articles used are articles that are research that has been reviewed and published in English-language journals. More specifically, this paper adopts the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach to identify, select, assess, and

synthesize literature findings that have the potential to produce accurate, complete systematic literature review reporting and thus facilitate evidence-based decision-making. The PRISMA technique is a modified prism method from Mahadi (2023) framework. The following subsections detail the PRISMA stages and process can be seen in Figure 1.

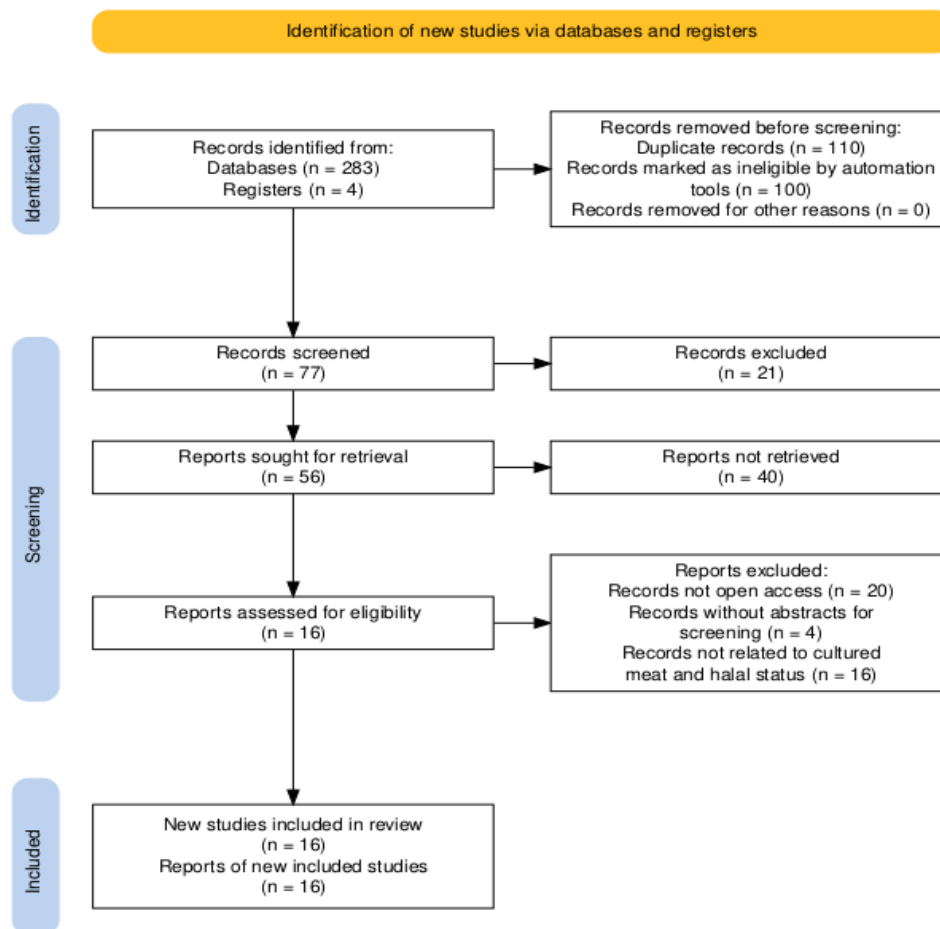


Figure 1. PRISMA flowchart and output.

2.3. Developing Research Questions and Objectives

The purpose of this study is to investigate current cultured meat halal perspective research, as stated in the introduction. The specific objective is to determine the basic pattern in cultured meat halal perspective research from the perspective of SLR. This study addresses the following research questions (RQs) based on the objectives:

RQ1: How far has halal research on cultured meat developed from an SLR perspective?

RQ2: What is the Islamic or Muslim perspective on the acceptance of cultured meat consumption from an SLR perspective?

RQ3: What are the current methods in the perspective of halal research on cultured meat from an SLR perspective?

RQ4: What is the Islamic or Muslim perspective on the acceptance of cultured meat consumption using stem cell methods from an SLR perspective?

2.4. Data Source

The relevant material was accessed and sourced from Google Scholar databases with a publication period from 2022-2024 and provide open access journals.

2.5. Search Strategy

The following search strings were used to look for relevant articles in Google Scholar and ScienceDirect databases:

TITLE-ABS-KEY (“stem cells cultured meat halal status”)

TITLE-ABS-KEY (“stem cells cultured meat, halal status, islamic perspective, muslim”)

TITLE-ABS-KEY (“stem cells cultured meat, halal status, islamic and muslim perspective”)

2.6. Inclusion Criteria

The inclusion criteria for this study are as follows:

- a. Publication year: between the years 2022 and 2024.
- b. Publication type: academic journal articles and review articles.
- c. Publication language: English.
- d. Studies specifically focusing on stem cells cultured meat, halal status, islamic and muslim perspective.

2.7. Exclusion Criteria

The exclusion criteria for this study are as follows:

- a. Journals that do not provide open access.
- b. Book chapters, book series, editorials, and trade publications.
- c. Publications that are not relevant in the stem cells cultured meat, halal status, islamic and muslim perspective.

2.8. Reporting the review

The shortlisted studies from the review were analyzed and discussed in the next section of the report. The literature was categorized and synthesized based on publishing patterns, source, geographic area, and study approach. This section includes theoretical viewpoints, literature-based themes/factors, and a synopsis of chosen investigations.

3. RESULT AND DISCUSSION

The PRISMA technique was used to select 16 to provide valuable insights into contemporary halal pharmaceutical research in the SLR context. A systematic literature review typically yields only a few papers after screening and filtering. Table 1 provides a summary of 16 scholarly literature selections. Ye et al., (2022) define cultured meat as meat that has been prepared in vitro in a laboratory. According to a market research estimate, the cultured meat industry was worth \$1.64 million in 2021 and is predicted to grow to \$206.6 million and \$2788.1 million by 2025 and 2030, respectively. Scientists all over the world are attempting to manufacture cultured beef in order to reach a shared goal: to create a viable product with high customer acceptance and a reduced price (Choudhary et al., 2023). Current attempts are aimed at making 3D meat with a taste and texture similar to traditional meat on an industrial scale utilizing less expensive plant materials.

Cultured meat is one of the technologies with the potential to address ethical, environmental, and public health concerns associated with traditional meat production, such as greenhouse gas emissions, land and water use, antibiotic resistance, foodborne diseases, and animal slaughter (Bryant & Barnett, 2020). The FAO organization has said that the livestock industry is a significant contributor to climate change. The technique of producing cultured meat entails extracting stem cells from animals so that the cells may grow in a medium with the proper environmental conditions and develop into muscle cells that are physiologically comparable to meat from cattle in general (Ho et al., 2023; Hocquette, 2016). Scent, texture, taste, and appearance are the most important aspects of consumer acceptability of cultured meat

(Siddiqui et al., 2022). One of the issues with cultured meat is that it lacks the myoglobin protein that causes the red color in animal flesh. Natural hues like beetroot and turmeric, as well as hemoglobin derived from animal blood, may be utilized to make cultured meat.

Table 1. Search results for articles that meet the criteria.

No	Author	Title	Discussion
1.	Ye et al. (2022)	<i>Commercialization of cultured meat products: Current status, challenges, and strategic prospects.</i>	<p>Halal research on cultured meat is still in its early stages, but it is gaining attention as the industry develops. To ensure that cultured meat products comply with Islamic dietary requirements, the publication suggests the use of halal stem cell sources and serum-free medium. The reception of cultured meat by Muslim customers is difficult and varies greatly. It is mostly determined by adherence to halal norms, such as stem cell sources and production procedures.</p> <p>There is a strong emphasis on ensuring that cultured meat does not violate Islamic dietary regulations, including the ethical treatment of animals and the avoidance of haram (forbidden) elements. Acceptance may also be influenced by cultural attitudes toward innovative meals and the transparency of the manufacturing process. Current methods in halal research on cultured meat involve exploring the use of halal-certified stem cells and developing serum-free media that comply with halal standards. The focus is on ensuring that all materials used in the production process are halal-certified and that the entire production process aligns with Islamic principles. If the stem cells are sourced ethically and comply with halal standards, there may be a greater likelihood of acceptance among Muslim consumers (Escobar et al., 2021; Mancini & Antonioli, 2019; Thorrez & Vandenburg, 2019).</p>
2.	Yun et al. (2024)	<i>Current Research, Industrialization Status, and Future Perspective of Cultured Meat.</i>	<p>Halal research on cultured meat is exploring whether cell-cultured meat can meet the requirements of halal certification. Key focuses are the sources of the cells (e.g., from halal-slaughtered animals), ensuring that the growth mediums and production methods comply with halal dietary laws, especially by avoiding ingredients like animal-based serum that may not meet halal standards. Some Islamic scholars indicate that cultured meat could be considered halal if derived from halal-slaughtered animals and produced without haram substances. Surveys show a cautious interest in cultured meat among Muslims, with acceptance depending heavily on assurances that it meets religious dietary standards.</p> <p>Stem cell methods raise specific questions for halal compliance. Cultured meat is regulated as a novel food in various regions, with the United States, European Union, and other countries establishing frameworks. For instance, the U.S. FDA and USDA oversee safety and trade aspects, while the EU applies the Novel Food Regulation. Standards focus on food safety, labeling, and environmental impact. The regulatory landscape continues to evolve to ensure consumer safety while addressing ethical and cultural concerns (Hamdan et al., 2018; Ho et al., 2023).</p>

3. Soleymani et al. (2024) *An overview of cultured meat and stem cell bioprinting: How to make it, challenges and prospects, environmental effects, society's culture and the influence of religions.*

Research on cultured meat within halal parameters is progressing, with criteria being established to determine its permissibility. Scientists are currently exploring different types of stem cells, including myoblast or satellite cells, which help muscles heal after injuries. These cells can easily change into myotubes and advanced muscle fibers when grown in large quantities. According to Islamic law, cultured meat could be deemed halal if the cells used originate from an animal slaughtered according to halal methods and if the process avoids using blood or animal-derived serum. The acceptability of cultured meat depends significantly on the source of the cells, making it unlikely for meat derived from prohibited animals, like pigs, to be deemed halal.

A significant proportion of the Muslim population appears amenable to the notion of eating cultured meat. According to survey data, 58% of Muslim respondents are happy to ingest cultured beef, 68% cultured lamb or goat, and 49% cultured chicken, with approval dropping to 28% for cultured pork. This implies conditional acceptance, affected by halal compliance and the perceived benefits of cultured meat production. Halal research on cultured meat focuses on ensuring that the production process aligns with halal guidelines. Additionally, researchers are exploring methods to improve the texture, taste, and color of cultured meat to enhance its appeal and acceptance. This stems from interpretations by Islamic jurists who reference Quranic teachings on dietary laws, emphasizing that the source and processing of the cells play a central role in determining the halal status of cultured meat (Bryant & Dillard, 2019; Smith & Meyer, 2020).
4. Qotadah et al. (2022) *Cultured Meat for Indonesian Muslim Communities: A Review of Maslahah and Prospect.*

Lab-grown meat must consider social issues such as consumer appeal, religious status, regulation, and other factors. Lab-grown meat can be identified in several ways, including the source, manufacturing process, medium, and final product. It must be derived from animal tissue or stem cells, synthesis occurs ex-vivo, is cultivated in an appropriate medium, and is produced using meat culture. Religious concerns, particularly for Muslim consumers in Indonesia, include whether cultured meat is halal and meets halal al-tayyibah principles. Meat produced in a laboratory might originate from living animals, slaughtered animals, or animals that have not been killed. Some Muslim legal experts, such as Nahdlatul Ulama (NU) in Indonesia, argue that cultured meat derived from living animal cells is legally impure and forbidden for consumption.

Abdul Qahir Qamar from the International Islamic Fiqh Academy in Jeddah, Saudi Arabia, argues that lab-grown meat is halal as long as the stem cells used come from animals that Muslims are allowed to eat and the production method does not involve components that Muslims are not permitted to consume. To guarantee cultured meat complies with the halal concept, relevant agencies should collaborate to verify the status based on available information. Lab-based scientists demonstrate the manufacturing process. This ensures cultured meat meets the halal principles (Hamdan et al., 2018).

5. Kashim et al. (2023) *Scientific and Islamic perspectives in relation to the Halal status of cultured meat.*
- Stem cells are placed in a nutrient-rich culture medium that supports cell growth and maturation. Biomaterials in the culture induce stem cells to form muscle fibers, the primary component of meat. The optimal growth medium includes 5–10% blood serum, which contains proteins, hormones, and growth factors essential for cell reproduction. Scaffold biomaterials, such as animal-derived collagen or plant-based polysaccharides (e.g., cellulose, alginates), provide structural support for cell growth and differentiation, helping to shape cultured meat's texture and morphology.
- Cell selection in cultured meat production involves two types of stem cells: embryonic stem cells (ESCs) and adult stem cells (ADSCs/non-ESCs). ESCs are pluripotent stem cells that can multiply in different tissues but lose pluripotency once isolated from blastocysts. ADSCs, or myosatellite cells, are adult stem cells that maintain the ability to self-renew and proliferate but can only differentiate into muscle cells. They can be extracted from adult animal tissues and developed into muscle fibers called myotubes.
- There are three techniques used in cultured meat production: scaffold-based, self-organising, and 3D printing. Scaffold-based techniques involve embryonic myoblasts or MCs proliferating and attaching to scaffolds or carriers, such as collagen meshwork or microcarrier beads. These techniques can be used for producing ground processed meats, such as hamburgers or sausages, but not highly structured meats like steak. Self-organising techniques create structured muscle tissues as self-organizing constructs, which can be used to produce highly structured meat. However, the lack of blood circulation in explants makes substantial growth impossible.
- 3D printing meat involves producing more than one tissue culture meat by inserting billions of muscle cells, fat cells, blood cells, and others into a 3-D printer. The assembly of cells is printed by injecting ink on the surface of the paper that allows the cells to be moved, and the printed cells are then cultured in a medium similar to that used in the scaffolding technique. Cultured meat productivity depends on the medium composition, which determines the final characteristics. Foetal bovine serum (FBS) is sourced from animals, violating ethical principles. Growth factors can support germination. Proliferation of bovine myoblasts in serum-free media, reducing meat production costs. However, start-up culture medium was not serum-free, violating Islamic ethics. Manipulation of biologically sourced materials like collagen should be avoided.
- To allow Muslim consumers to eat cultured meat, three factors must be considered: the type and source of animal cells used, the medium used for culturing stem cells, and the biomaterial used in proliferation. The slaughtering process must adhere to Sharia law, and bleeding should be spontaneous and complete. Cultured meat derived from ESCs and MCs is halal if obtained from halal animals slaughtered according to Shariah law. Scaffolding and biomaterials derived from animals must be halal. The use of microorganisms such as bacteria and fungi are halal as long as the bacteria and fungi are grown in a pure medium.

6. Guo & Wiwattanadate, (2023) *Sustainable Landscape of Cultured Meat in Developing Countries: Opportunities, Challenges, and Sustainable Prospects.*
- The literature review explores consumer perceptions of sustainable food technologies and cultured meat, focusing on consumer acceptance and attitudes towards cultured meat. China is the most frequent country for research, followed by Brazil, South Africa, Indonesia, Malaysia, Pakistan, and Thailand. The publication years of these studies were mainly concentrated between 2021 and 2023, with 2022 being the year with the highest number of published articles. The literature provides findings on consumer acceptance of new sustainable food technologies and cultured meat, research perspectives from different countries, and the influences of religion and culture on food choices. Research on consumer purchase intentions, attitudes, beliefs, and cognition occupied a large proportion of the collected literature. Studies in multiple countries and regions, including India, South Africa, China, and Africa, have investigated and analyzed consumers' acceptance of cultured meat.
- Cultural and religious factors played different roles in cultured meat research in different countries and regions. In some countries, religious factors play a significant role in the acceptance of cultured meat, such as Shariah and Sufi scholars' assessment of halal cultured meat. However, studies in other developing countries did not specifically emphasize religious factors, possibly because religion would have little influence on the local acceptance of cultured meat.
- Understanding consumer purchase intentions and attitudes and the influence of culture and religion on the acceptance of cultured meat will help us better understand the promotion and adoption of cultured meat in these countries and regions. These findings have significant reference value for developing the cultured meat industry and formulating promotion strategies. Cultured meat technology can contribute to food safety and stability in developing countries, reducing food contamination and disease spread. It offers a more controllable production process, reducing food contamination risks. Cultured meat technology also creates jobs and economic growth, requiring professional and technical personnel.
- The promotion of cultured meat technology can lead to the development of related industrial chains, such as cell culture technology and food processing. Combining tradition and modernity can improve efficiency, reduce resource consumption, and reduce environmental impacts. Community participation, policy support, and scientific and technological innovation are crucial for successful implementation of sustainable meat diets in developing countries (Bryant & Barnett, 2020; Guo & Wiwattanadate, 2023).

7. Yusuf & Setiarto, (2022) *Quality Aspects Related to Meat Analogue Based on Microbiology, Plants and Insects Protein.* This paper highlights the importance of protein in meat analogues. Alternative protein sources can be chosen to minimize environmental impact and ethical concerns. Meat analogue products should provide health benefits, particularly from bioactive chemical content, high dietary fiber, cholesterol-free, and low saturated fat content. To achieve the best correlation between composition, texture, and sensory qualities, meat analogue producers and researchers must address problems such as developing new technologies and ingredients. Consumers are increasingly turning to plant-based meat alternatives (MA) for their nutritional benefits and sensory properties. Popular MA product categories include minced meat, fibrous meat, and emulsion-type products. MA products must contain high protein with complete and easily digestible essential amino acid content, and the selection of protein sources must consider availability, ease of processing technology, and costs. Vegetable protein often requires fortification from outside sources like rice flour or green beans. Studies suggest that traditional meat consumers are increasingly interested in switching to meat analogues (MA) for their nutritional value and similar sensory qualities to real meat. Popular MA products include burgers, nuggets, steaks, and sausages, which need high-quality, easily digestible proteins with balanced essential amino acids. Since plant proteins lack some essential amino acids, fortification with sources like rice or beans is necessary. Additional processing and food additives are required for ideal meat texture and structure, especially when using proteins from sources like fungi, insects, or microalgae. Popular meat analogue product categories include minced meat, fibrous meat, and emulsion-type products. Meat analogue products must contain high protein with complete and easily digestible essential amino acid content, and the selection of protein sources must consider availability, ease of processing technology, and costs. Carbohydrates in MA help with texture and moisture retention, while fats contribute to taste, texture, and nutritional value. Producers commonly use plant oils (e.g., rapeseed, avocado) and fats (e.g., coconut) to achieve a balanced flavor profile and enhance health benefits through unsaturated fats and low cholesterol. Colors from natural sources like beetroot and carrot can mimic red meat tones, while flavors and aromas are improved with spices and herbs. Food additives in MA mimic meat attributes, mask unwanted flavors, and compensate for potential nutrient deficiencies in plant-based diets by adding vitamin B12, iron, zinc, and antioxidants. Transglutaminase enzyme is often used for texture, and antioxidants prevent spoilage, extending shelf life (Bohrer, 2019; Kyriakopoulou et al., 2021).
8. Samad et al. (2024) *Revolutionizing cell-based protein: Innovations, market dynamics, and future* This paper discusses the sustainability and demand for cultured meat, as well as technological advancements, industry trends, obstacles, and prospects. Cultured meat production process stages consist of biopsy, isolation and sorting, expansion on small and large scales, and bioreactor. Technical Advances in Cultured Meat Production such as Scaffolding and Tissue Engineering (advances like 3D bioprinting and specialized scaffolding

prospects in the cultivated meat industry.

materials replicate the microarchitecture of animal tissues), Bioreactor Design and Optimization (recent advancements focus on high-density cell culture in controlled environments, making the shift from lab-scale to industrial-scale production easier), and Cell Line Development (the development of immortalized cell lines allows continuous cell growth without needing fresh animal cells, ensuring genetic stability and enhanced differentiation into desired meat components such as fat and connective tissues). These advances are forming a viable, ethical alternative to conventional meat production.

Consumers are worried about processing conditions, traceability, and the impact of production on animals and the environment. Adopting new dietary habits can be highly difficult, especially when it comes to lowering meat consumption in the face of heightened risks for cardiovascular diseases or type 2 diabetes. This resistance is often attributed to socio-cultural norms. However, in order to encourage a large number of people to change their food habits or significantly reduce meat consumption, a comprehensive approach is needed. This approach should involve a better understanding of the acceptance dynamics of newly developed food products.

Explaining the process of cultured meat production to consumers in various ways can be helpful in understanding the term cultured meat, as many meat consumers are unaware of cultured meat. On the other hand, the physical attributes of cultured meat can also play an important role in attracting consumers to it (Eldesouky et al., 2020; Weiss et al., 2010). Cultured meat's acceptability depends on end-users' adoption, awareness of its benefits, limitations, and sustainability at an affordable cost. However, the feasibility of producing cultured meat commercially and its potential market share are still debated. The future acceptance of in-vitro meat by consumers will be determined by its ability to compete with animal agriculture, rather than solely relying on ethical considerations (Samad et al., 2024).

9. Kantono et al. (2022) *Consumer Acceptance and Production of In Vivo Meat: A Review*

The comprehension of cultured meat manufacturing techniques and customer acceptance are covered in this essay. One recent advancement in the production of sustainable food is in vitro meat (IVM). Many proponents view cultured meat as the meat of the future, and it has drawn attention from all across the world. Compared to meat from conventional farming, cultured meat production is more environmentally friendly and produces fewer emissions. Muscles were first cultivated in petri dishes for the production of cultured meat, but more recently, alternative culture conditions, bioreactors, and technologies including scaffolding, self-organising techniques, and micropatterning have been integrated. In a bioreactor, where muscle cells develop into muscle fibres, the cells are subsequently put through phases of cell proliferation and differentiation.

The impact of cultured meat on health, nutrition, flavour, safety, cost, food preferences, individual convictions, cultural identities, religious beliefs, sensory quality, and product nature all influence how consumers perceive it. In general, three key aspects influence public acceptance of cultured meat: sociodemographics, general consumer opinions about food

- technologies, and consumer attitudes on animal welfare and the environment.
10. Kang et al. (2024) *Industrial Research and Development on The Production Process and Quality of Cultured Meat Hold Significant Value: A Review*
As a remedy for the growing issue of food insecurity, cultured meat has been gaining traction. Techniques for producing cultured meat, including growing media serum and scaffolds and culturing fresh animal cells, are the subject of extensive and varied research. By 2050, it is anticipated that the demand for staple meats like beef, hog, and chicken would have increased by an average of 70% due to the ongoing rise in meat consumption. Cultured meat has less ethical, religious, and environmental restrictions than meats produced by conventional cattle husbandry because it is made by in vitro culturing cells extracted from the animal's body in bioreactors. It is possible to improve the nutritional value of cultured meat and add chemicals with different properties, like anti-cancer and antioxidants. Scientists and consumers alike are aware of the strong theological benefits of cultured meat and how these factors affect the criteria for cell selection. For instance, "Does the cultured meat produced follow the halal status?" is a key consideration when choosing meat in the Islamic community. This indicates that cultured meat isn't always appropriate for religious individuals.
 11. Ho et al. (2024) *Examining Muslims' Opinions Toward Cultured Meat in Singapore: The Influence of Presumed Media Influence and Halal Consciousness*
This paper explores how Muslims' opinions and behavioural intentions and behavioural intentions about cultured meat are explained by presumptive media impact models, which are influenced by halal consciousness. Halal consciousness was shown to be positively connected with Muslims' attention to media messages about the advantages of cultured meat, which in turn influenced their expected attention to similar messages from friends, family, and social media influencers, according to a survey of 658 Muslim Singaporeans. This study examines the indirect impacts of media attention on Muslim attitudes and consumption intentions towards cultured meat using the IPMI model.
This study discovered that the religious component of halal consciousness serves as a prelude to people's awareness of media messages about the health advantages of cultured meat, which in turn influences their intents to consume it.
 12. Chodkowska et al. (2022) *Sustainable Future Protein Foods: The Challenges and The Future of Cultivated Meat*
Although the process of creating cell cultures from animal muscles has been understood and effectively used for many years, many scientific groups working with later businesses that aim to produce the best possible product that meets consumers expectations continue to struggle with producing a stable piece of meat with the right texture, flavour, and aroma. The most crucial ones are the culture media (without animal serum), which will offer the best conditions for muscle growth, and sturdy scaffolds for cell growth that are natural or almost natural (but still safe for the consumer).
Today, cultured meat is an alternate protein source that still has a lot of issues. These are primarily ensuring that the product is natural (mostly with regard to the medium and its additions) and has the right nutritional values. These kinds of products lower the microbiological risk and lessen the requirement to breed more

animals that have been killed.

13. Lewisch & Riefler (2023) *Cultured meat acceptance for global food security: a systematic literature review and future research directions*

A new meat substitute based on technology; cultured meat has the potential to supplement the world's expanding protein supply. A growing amount of consumer research has looked into individual characteristics that may contribute to customers' acceptance of cultured meat. However, there is little research on how cultural and economic factors influence customer reactions in different nations. Given this, the purpose of this article is to offer a cross-cultural viewpoint on the acceptance of cultured meat and to direct further empirical studies in this area. Because of its capacity to scale up production, cultured beef may eventually play a role in the world's food supply from a sociological standpoint. Over the past ten years, there has been a steady increase in empirical study on customer acceptability of this innovation. The importance of cultural and economic market elements has been mainly overlooked in this stream of study, despite the fact that human aspects that influence acceptance have gotten special emphasis. In light of these elements' impact on the acceptance of cultured meat in national consumer markets and the future food's practical significance for attaining greater global protein security, this study seeks to stimulate further cross-cultural research. A summary of current research settings is also given in this review, along with a framework and related research questions that link the adoption of cultured meat to national food environments, cultural and economic market issues, and more. Before outlining the work's limits and practical ramifications, we go over potential directions for future research in the sections that follow.
14. Soleymani et al. (2024) *An overview of cultured meat and stem cell bioprinting: How to make it, challenges and prospects, environmental effects, society's culture and the influence of religions*

Stem cells are taken from the animal's muscle tissue during the meat-cultivation process without endangering the animal. Following that, these cells are put in a culture medium that contains foetal bovine serum. They then use either edible or non-edible scaffolds to promote cell proliferation, which is subsequently added to a bioreactor to promote tissue growth. A thin piece of meat normally takes three to five weeks to mature under ideal growth conditions, which include the right amount of oxygen, temperature, nutrients, and growth factors. Currently, the high cost, poor colour and flavour, and lack of acceptance by some religious groups significantly restrict the viability of implementing cultured meat production. This paper explores how people's acceptance of cultured meat may be influenced by their cultural and religious views. For ethical and environmental grounds, some people believe that cultured beef is a better option than conventional meat. Others, however, could be concerned due to their religious or cultural convictions. The environmental benefits of cultured meat can be significant.

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| 15. | Hamdan et al. (2024) | <i>A review of the discussions on cultivated meat from the Islamic perspective</i> | <p>Given the importance of following a halal diet as a divine duty in their lives, one of the main concerns for Muslim consumers is the halal status of farmed meat. Thus, this article aims to conduct a comprehensive assessment of the body of literature on farmed meat from an Islamic perspective as expressed by Muslim scholars, regardless of whether these viewpoints are expressed by a recognised fatwa institution or are the result of individual opinions.</p> <p>The ontological status of cultivated meat, the status and source of stem cells used in the cultivation process, the theological implications of cultivated meat production on changing God's creation, the foundational principles for halal cultivated meat production, and the current necessity of cultivated meat from the standpoint of al-maqasid al-shariah were the five main themes identified through the use of thematic analysis in the discourse among Muslim scholars regarding cultivated meat.</p> <p>Given the growing significance of cultured meat in the food market, prominent figures in the halal business and welfare sectors, including MUIS (The Office of the Mufti of Singapore) and JAKIM (Department of Islamic Development Malaysia), are urged to spearhead this endeavour.</p> |
| 16. | Burhanuddin et al. (2023) | <i>Cultured Meat: An Appraisal from The Fiqh and Sufi Views of Muslim Scholars</i> | <p>Since cultured meat is one of the most recent innovations in the food sector, its existence in modern society necessitates a precise fiqh explanation and process. This study is important since it gives Muslims a better insight and new information. A well-defined approach to fiqh will give society rules for evaluating it as a staple or substitute diet. If not, they might refrain from eating products made from cultured meat as a safety measure against haram and uncertainty (shubhah).</p> <p>The status of cultured meat is regarded as halal according to the main sources of fiqh and sufism, as long as the population's needs are met, there is no harm to eating, and the public benefits.</p> <p>The Qur'an and Sunnah do not address the issue of lab-cultured meat; rather, they discuss how Allah's creation has been altered. According to Islam, a thing's place of origin is acceptable as long as it doesn't hurt people or contravene Shari'ah laws. Therefore, if laboratory-cultured meat is safe for human consumption and aims to address the issue of protein and meat deficiencies, it can be classified as halal.</p> |

According to Siddiqui et al. (2022), cultured meat has grown in popularity after its legalization in Singapore in late 2020, with one manufacturer making nuggets. In 2013, one method for promoting burgers made from cultured meat was to offer a brief explanation of the significance of cultured meat itself, as evidenced by the reaction of customers who had tasted cultured meat, with 58% wanting to buy and consume cultured meat. In terms of religion, most religions support cultured meat as long as the manufacturing procedure adheres to the precepts of the religion.

One of the barriers to public adoption of cultured meat is a lack of public knowledge of 3D food printing due to consumers' unfamiliarity with the technology (Lanz et al., 2024). This barrier can be addressed by disclosing information regarding the improved flavor, health, and naturalness of cultured meat products. Cultured meat produced by 3D printing is regarded as unnatural, innutritious, tastes unpleasant, and has unclear safety.

According to Terano et al. (2023), 44.1% of respondents acknowledged cultured beef as an edible product, while 55.9% questioned its halal character. Their opinions towards cultured meat affected their choice to adopt it. One of the issues that contributed to the acceptability of cultured meat was the prevalence of the Bovine Spongiform Encephalopathy (BSE) outbreak, better known as mad cow disease. This has sparked consumer worry about meat production. Cultured meat is a proposed alternative to conventional meat production.

Because in-vitro meat processing is regulated, it can reduce the occurrence of these issues. This is consistent with Yun et al. (2024), who stated that cultured meat production is safer than conventional meat production against foodborne pathogenic microorganisms such as Salmonella, Campylobacter, *E. coli*, yeast, fungi, and other parasites because it has a closed structure that can control the entry of external substances. The main key to the development of cultured meat is to disseminate relevant knowledge and technology as widely as possible, improve process technology and product quality, reduce product costs, ensure product safety, improve the regulatory system, and achieve perfect market access (Ong et al., 2021).

Cultured meat has greater production costs than normal beef when it initially hits the market. Cultured meat sold in restaurants is pricey because it is meant to increase nutrients or improve certain qualities (Hamdan et al., 2018). This limits the availability of cultured meat to upper-class customers, but it may become more prevalent as prices decline. Furthermore, producers of cultured meat must address the interaction between numerous phenomena, social institutions, and cultures (Zhang et al., 2020). Furthermore, there is much confusion about legislation, religious classification, and economic impact (Briones Alonso et al., 2018).

Halal slaughter strives not just to decrease animal suffering, but also to provide cultured meat that is permissible for consumption in Islam (Post, 2014). This is strongly tied to the adoption of cultured meat by Muslim customers. Muslim consumers are willing to ingest cultured meat created from halal animal cell sources (Bryant et al., 2019). Meanwhile, food rules in the European Union do not allow cultured beef to be used as food since it has the potential to trigger allergies in consumers. Cultured meat adoption differs among nations, impacted by cultural values including religion, environmental concerns, and willingness to pay for food innovation (Briones Alonso et al., 2018; Lewisch & Riefler, 2023). Cultured meat producers must address religious, technological, and social obstacles to ensure that their products are accepted by the larger society (Bonny et al., 2015).

This review presents 16 halal perspectives on cultured meat from various researchers, demonstrating that the majority of researchers allow the production of cultured meat as long as the cell source used is from halal animals, the culture media for its growth is from halal materials, the slaughtering method is by Islamic law, no prohibited substances are used in its production, and there is no cross-contamination with haram products. However, numerous researchers believe that its halalness is determined by each individual's views and the norms of each country, implying that cultured meat presents a societal problem in terms of ethics and market acceptance. Furthermore, based on the stem cell approach with the isolation and cultivation methodology of black-bone chicken embryonic stem cells (ESC) and 3D bioprinting stated earlier, it is possible to infer that it is halal as long as it fits the conditions stipulated by Islamic law. The 3D bioprinting process also produces a limited number of biomaterials for ingestion.

Toxicity testing assesses food safety by analyzing genotoxicity, reproductive toxicity, hematotoxicity, hepatotoxicity, and allergenicity. Standardization of five processes: cell acquisition, preparation, muscle differentiation, culture muscle acquisition, and meat product manufacturing may be required. Several countries have established regulations and classification guidelines for cell-based foods, namely Australasia (Cultured quail as a novel food (food standards code-Applications No. A1269)), EU (European Parliament and of the council No. 2015/2283), Korea (Temporary standards and recognition standards of

specification for food No. 2023-507), Singapore (Requirements for the safety assessment of novel foods and novel food ingredients), UK (Cell-cultivated products), and US (FSIS responsibilities in establishments producing cell-cultured meat and poultry food products No. 7800.1) (Yun et al., 2024). Regulations are overseen by national bodies in each country.

The only marketable cultured meat that has been officially confirmed as safe by the US Food and Drug Administration (FDA) is cell-cultured chicken meat from Upside Foods and GOOD Meat (Yun et al., 2024). Aleph Farms, an Israel-based company, applied for regulatory certification from the Swiss Federal Office for Food Safety and Veterinary Medicine in July 2023. In January 2024, the Israeli Ministry of Health approved the sale of cultured beef from Aleph Farms, becoming the third country to do so and the first for a bovine species (Aleph Farms, 2024). In October 2023, CellMEAT applied for certification from the Republic of Korea's Ministry of Food and Drug Safety (MFDS) for Dokdo shrimp (*Lebbeus groenlandicus*) cell cultures as a temporary food additive (CellMEAT, 2023). In December 2023, Food Standards Australia New Zealand (FSANZ) revealed a new revision to Vow's application for licensing of cultured quail. The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) refer to them as cell-based foods, while the United States Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS) calls them "cell-cultured meats." The U.S. Food and Drug Administration (FDA) uses the term cultured animal cell material.

4. CONCLUSIONS

The systematic literature review conducted on the halal perspective of cultured meat reveals several critical insights regarding its acceptability within the Muslim community. The halal status of cultured meat is primarily contingent upon the source of the cells used in its production and the adherence to Islamic slaughtering practices. Cultured meat derived from cells taken from animals that have been slaughtered according to halal guidelines is deemed permissible for consumption. Conversely, if the cultured meat originates from non-halal animals or from halal animals that have not been slaughtered in accordance with Islamic law, it is classified as haram. Furthermore, the review highlights the importance of the growth mediums and production methods employed in the cultivation of meat. The use of animal-derived serum or other haram substances in the production process raises significant concerns regarding the halal status of the final product. Islamic scholars and halal certification bodies are urged to establish clear guidelines and standards to ensure that cultured meat products meet halal requirements. The acceptance of cultured meat among the Muslim population appears to be cautiously optimistic, with many expressing a willingness to consider it as a viable alternative to traditional meat, provided that it adheres to halal principles. This indicates a potential market for cultured meat within the Muslim community, contingent upon transparency and assurance regarding its halal compliance. In conclusion, as the cultured meat industry continues to evolve, it is imperative for stakeholders, including researchers, producers, and halal certifying bodies, to collaborate in addressing the ethical, cultural, and religious concerns surrounding this innovative food product. By doing so, they can facilitate the integration of cultured meat into the halal food market, ultimately contributing to food security and sustainability while respecting the dietary laws of Islam.

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