Embedding Halal-Cultured Meat in Higher Education: A Case-Based Approach to Teaching Halal Standards and Food Law in Malaysia

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.909000724

Received: 26 September 2025; Accepted: 01 October 2025; Published: 28 October 2025

ABSTRACT

The rise of laboratory-cultured meat offers a novel alternative to conventional meat production, with potential benefits in sustainability, ethics, and food innovation. In Malaysia, the integration of emerging food technologies into halal education remains limited, despite increasing global interest and local relevance. This study aims to explore how halal cultured meat can be embedded as a case study in the teaching of halal food standards within the subject Standard Halal, Food Law and Sanitation at the higher education level. Using a qualitative approach, the research combines expert interviews and document analysis with a comprehensive literature review covering halal dietary principles, cultured meat production techniques, and regulatory frameworks. Key issues examined include halal integrity, food safety, and the risk of meat fraud. Interviews with a certified halal trainer and a biotechnology-informed marketing manager provided insights into the feasibility and challenges of implementing halal-compliant cultured meat in Malaysia. Content analysis of policy documents, industry reports, and media coverage revealed recurring themes related to certification gaps, consumer perception, and regulatory ambiguity. The findings suggest that Malaysia holds significant potential for developing a halal cultured meat industry, provided that implementation strategies are aligned with religious, legal, and sanitary requirements. This study contributes pedagogical insights for educators and proposes a curriculum-oriented framework for integrating emerging food technologies into halal education. Future research should focus on refining production protocols, strengthening regulatory clarity, and assessing student engagement to support broader curriculum adoption and public trust.

Keywords: Halal cultured meat, Higher education, Food law and sanitation, Curriculum integration, Pedagogical innovation.

INTRODUCTION

Laboratory-cultured meat, produced by cultivating animal cells in a controlled environment rather than through traditional animal farming and slaughter, represents an innovative alternative to conventional meat production. This process involves several key steps: extracting stem cells from live animals, which are then placed in bioreactors containing a culture medium that mimics the animal's natural environment. The cells grow, multiply, and differentiate into muscle, fat, and connective tissue, eventually forming meat shapes on a scaffold (Post, 2012; Chriki & Hocquette, 2020). Recent innovations have explored the use of plant-based growth media and recombinant proteins to replace fetal bovine serum (FBS), which is a major concern in halal compliance (Ahmed, 2022; Bhat et al., 2015). These alternatives aim to reduce reliance on animal-derived components while maintaining cell viability and tissue formation.

The critical issue this study addresses is the halal certification of laboratory-cultured meat, especially given the current use of stem cells from live animals and fetal bovine serum (FBS) from slaughtered fetuses, which

contradicts Islamic law. Despite the potential benefits of cultured meat, such as improved animal welfare by reducing the need for animal slaughter, these concerns must be resolved to align with religious standards (Ahmed, 2022; Riaz & Chaudry, 2004).

The primary objective of this research is to explore the feasibility of producing halal laboratory-cultured meat in Malaysia, focusing on implementation strategies and the challenges faced in its production. This study employs a qualitative approach, including interviews with key respondents and a comprehensive review of relevant literature, to assess the implementation and challenges of halal cultured meat production (Creswell & Creswell, 2018; Palinkas et al., 2015).

Previous studies have highlighted the technological advancements and ethical considerations of cultured meat production, but there is a gap in the literature regarding its alignment with halal standards and its acceptance within Muslim communities. The findings of this study suggest that Malaysia holds significant potential for developing the halal cultured meat industry, provided that the specific religious and ethical challenges are adequately addressed.

Importantly, this topic is highly relevant to the subject *Standard Halal, Food Law and Sanitation* taught in Malaysian higher education institutions. It offers a contemporary case study that bridges theoretical halal standards with emerging food technologies, allowing students to critically examine issues of certification, food safety, and regulatory compliance. Integrating cultured meat into the teaching of halal food law not only enhances curriculum relevance but also prepares future professionals to navigate complex halal innovation landscapes.

In conclusion, with strategic implementation and overcoming specific challenges, Malaysia can become a leading producer of halal cultured meat. Future studies should focus on refining the production processes, ensuring regulatory compliance, and increasing public awareness to build consumer trust and acceptance.

PROBLEM STATEMENT

Cultured meat, developed through cellular agriculture, is increasingly viewed as a sustainable and ethical alternative to conventional meat production (Post, 2012; Chriki & Hocquette, 2020). However, its integration into halal food systems presents complex challenges, particularly regarding the use of fetal bovine serum (FBS) and stem cells from live animals, which may conflict with Islamic dietary laws and principles of slaughter (*dhabiha*) and purity (*halal* and *tayyib*) (Riaz & Chaudry, 2004; Ahmed, 2022).

In Malaysia, where halal certification is a cornerstone of the food industry and a global benchmark, the emergence of cultured meat raises urgent questions about regulatory readiness, religious compliance, and consumer acceptance (FAO, 2020; Stephens et al., 2018). These concerns are amplified by recent global developments, including the approval of cultured meat for sale in countries like the United States and Singapore, which signal a shift in food innovation and market expectations (Tuomisto, 2019). Recent studies have examined consumer acceptance of halal cultured meat in Southeast Asia, revealing nuanced attitudes shaped by religious authority, transparency, and perceived naturalness (Rahman et al., 2023; Zulkifli & Osman, 2024). These findings underscore the need for the curriculum to address both scientific and ethical dimensions. Recent fatwa developments in Singapore and Malaysia affirm the permissibility of cultured meat under specific conditions, reflecting evolving jurisprudential responses to food biotechnology (Office of the Federal Mufti of Malaysia, 2021; Mothership, 2024). These updates are crucial for aligning curriculum content with current halal discourse. Locally, Malaysia's push toward halal science and the Halal Industry Master Plan 2030 further underscores the need to address novel food technologies within halal frameworks.

Despite growing interest in cultured meat's environmental and ethical benefits, limited research has explored its pedagogical relevance and regulatory feasibility in the Malaysian halal context. This gap is particularly significant in higher education, where the subject Standard Halal, Food Law and Sanitation plays a critical role in preparing future professionals to navigate halal innovation. Therefore, it is essential to investigate how halal cultured meat can be implemented, certified, and integrated into teaching frameworks to ensure both religious compliance and educational relevance (Creswell & Creswell, 2018; Palinkas et al., 2015).

Given the rapid advancement of food biotechnology and the global momentum toward sustainable protein sources, it is imperative for Malaysia to proactively address the religious, legal, and pedagogical implications of cultured meat. As a leading halal hub, Malaysia must ensure that emerging food technologies are not only compliant with Islamic principles but also integrated meaningfully into the academic curriculum. This study is necessary to bridge the gap between innovation and halal integrity, and to equip educators, regulators, and future industry players with the knowledge and frameworks needed to navigate this evolving landscape. By embedding cultured meat discourse into the teaching of Standard Halal, Food Law, and Sanitation, this research supports Malaysia's strategic vision for halal science, strengthens curriculum relevance, and contributes to global leadership in halal innovation.

METHODOLOGY

Research Design

This study employed a qualitative research design to explore the implementation strategies and challenges of integrating halal laboratory-cultured meat into the teaching of halal food standards in Malaysia. The qualitative approach was selected due to the interpretive nature of the research, which seeks to understand religious, regulatory, and pedagogical dimensions that are context-specific and complex. As highlighted by Creswell and Creswell (2018), qualitative inquiry is particularly suited for studies that aim to capture nuanced perspectives, while Bryman (2016) emphasises its strength in generating rich, descriptive data that quantitative methods may not adequately reveal.

Instructional Context

The instructional context of this study is situated within the subject Standard Halal, Food Law and Sanitation, which is commonly offered in halal-related academic programmes at Malaysian higher education institutions. This subject encompasses core themes such as halal certification, food law compliance, and sanitation protocols. Cultured meat was introduced as a contemporary case study to examine its pedagogical relevance and alignment with halal standards. The integration of this topic into the curriculum reflects Malaysia's strategic commitment to halal science and innovation, as outlined in national policy documents such as the Halal Industry Master Plan 2030 (FAO, 2020; Ahmed, 2022). By embedding this emerging issue into the teaching framework, the study aims to enhance curriculum relevance and prepare students to engage with real-world halal innovation challenges. To support this, a sample case scenario was developed involving a hypothetical cultured meat startup seeking halal certification. Students were tasked to identify potential syariah concerns, regulatory gaps, and propose certification pathways, thereby applying theoretical knowledge to simulated industry contexts (Biggs & Tang, 2011). The pedagogical integration of cultured meat was guided by a case-based learning framework, which supports contextual understanding and ethical reasoning in complex halal scenarios (Creswell & Creswell, 2018). This approach aligns with Malaysia's strategic emphasis on halal science education.

Sampling and Participants

Participants for this study were selected using purposive sampling, targeting individuals with direct expertise in halal certification and food innovation. Two industry experts were invited to participate in semi-structured interviews: Muhamad Firdaus Bin Abd Razak, a Certified Halal Trainer with a background in Food Biotechnology, and Md Zakri Bin Mohd Yusoff, a Marketing Manager with academic training in Information Systems. Their professional roles and practical experience provided valuable insights into the feasibility of halal cultured meat production, its regulatory implications, and its relevance to halal education. Although the sample size was limited to two respondents, the depth and specificity of their expertise were deemed sufficient for an exploratory qualitative study. This is consistent with the recommendations of Palinkas et al. (2015), who argue that information richness is more critical than sample size in qualitative research, and with Creswell and Creswell (2018), who support small, focused samples for studies involving expert perspectives.

Sampling Technique

The study employed purposive sampling to ensure that selected participants possessed relevant expertise in both

halal regulation and food technology. This technique allowed the researcher to target individuals with specialised knowledge, ensuring that the data collected was contextually rich and aligned with the study's objectives. The use of purposive sampling is widely recognised in qualitative inquiry for its effectiveness in identifying information-rich cases that align with the study's thematic focus (Palinkas et al., 2015). The selection process was guided by the need to obtain insights from professionals who could speak directly to the intersection of halal standards and cultured meat innovation.

Ethical Considerations

Ethical clearance for this study was obtained from the university's research ethics committee prior to data collection. All participants were informed of their rights, including anonymity, confidentiality, and voluntary participation. Digital consent was secured through formal communication channels before interviews were conducted. To enhance the credibility of the findings, member checking was carried out by sharing interview summaries with participants for verification. Additionally, peer debriefing was employed to ensure interpretive rigour and minimise researcher bias, in line with best practices in qualitative research (Creswell & Creswell, 2018). As researchers embedded in halal education, we recognise our interpretive lens may influence theme construction. Reflexive journaling was used to document assumptions and ensure transparency in analytical decisions (Finlay, 2002). As researchers with backgrounds in halal studies and Islamic jurisprudence, we acknowledge our positionality in interpreting religious and regulatory dimensions. Reflexive journaling was employed to monitor potential bias and ensure balanced representation of stakeholder views.

Instruments

The instruments used in this study consisted of a semi-structured interview protocol and a document analysis framework. The interview protocol was designed to elicit expert views on key themes such as halal integrity, food safety, regulatory compliance, and pedagogical integration. Questions were developed based on insights from the literature and reviewed by two subject matter experts to ensure clarity and relevance. The document analysis framework focused on textual materials, including halal certification guidelines, market reports, company profiles, and media coverage related to cultured meat. These documents were selected to provide contextual grounding and support triangulation of findings (Yin, 2018; FAO, 2020; Ahmed, 2022). Documents were selected based on relevance to halal certification, cultured meat innovation, and pedagogical integration. Inclusion criteria included publication within the last five years, official status of government or institutional reports, and thematic alignment with the study's objectives.

Data Collection and Analysis

Data collection was conducted through two complementary methods: in-depth interviews and systematic document analysis. Interviews were held via video conferencing and lasted between 45 and 60 minutes. Transcripts were analysed thematically using Braun and Clarke's (2006) six-phase framework: (1) familiarisation with the data, (2) generation of initial codes, (3) identification of themes, (4) review of themes, (5) definition and naming of themes, and (6) final reporting.

Document analysis was carried out concurrently and followed the same thematic coding process to ensure consistency across data sources. Key documents included halal certification standards such as MS1500:2019, fatwa statements issued by national and regional authorities, government policy papers on food innovation, and academic literature on cultured meat. These materials were examined to identify regulatory narratives, pedagogical gaps, and conceptual tensions relevant to halal-cultured meat.

A codebook was developed to guide the coding process and ensure consistency across both interview and document data. Inter-coder reliability was maintained through peer review of initial coding rounds. This multi-method approach enabled triangulation, enhancing the validity and contextual depth of the study (Bryman, 2016; Creswell & Creswell, 2018).

Three main themes emerged across both data sources: regulatory ambiguity, pedagogical relevance, and halal integrity. For example, one respondent stated, "Without clear fatwa and certification guidelines, it's hard to teach

cultured meat confidently in halal courses." These themes were derived using Braun and Clarke's (2006) coding phases, and a summary of codes is provided in Table 1.

Table 1 presents the three overarching themes, along with representative codes and illustrative quotes from the expert informants and supporting excerpts from key documents. These selections reflect the conceptual depth and pedagogical relevance of the issues discussed, particularly in relation to curriculum integration and halal governance.

Table 1 Summary of Themes, Codes, and Illustrative Quotes

Theme	Code	Illustrative Quote
Regulatory Ambiguity	Lack of fatwa clarity	"Without clear fatwa and certification guidelines, it's hard to teach cultured meat confidently in halal courses."
	Absence of halal standards	"Even if the science is ready, the halal framework isn't—we need to build both together."
Pedagogical Relevance	Curriculum gap	"This topic must be in our syllabus—it's already in the market and in fatwa debates."
	Teaching dilemma	"We are teaching about halal slaughter, but now we have meat without slaughter—how do we reconcile this in class?"
Halal Integrity	Source of cells	"If the cells come from a halal animal, that's only half the story—the process must be halal too."
	Growth media concerns	"We need to ensure the media is free from haram elements, not just effective for cell growth."

Source: Researcher's thematic analysis based on interview transcripts and document review.

Table 1 summarises the thematic structure derived from both interview transcripts and document analysis. Each theme is supported by representative codes and illustrative quotes that reflect the conceptual and pedagogical concerns raised by expert informants. The inclusion of direct quotations enhances the authenticity of the findings and demonstrates the relevance of halal-cultured meat to curriculum development, regulatory discourse, and ethical teaching practice. These themes also align with the study's objective to propose case-based integration of emerging food technologies into halal education.

The interview protocol was designed to address the study's objective through five thematic clusters. These themes guided the development of semi-structured questions and ensured alignment between data collection and the pedagogical focus of the research. Table 2 presents the interview question themes and their relevance to the study's findings.

Table 2 Interview Question Themes Aligned with Research Objective and Findings

Theme of Interview Question	Purpose and Link to Findings
1. **Conceptual Understanding of Halal Cultured Meat**	To explore expert views on the definition, permissibility, and Shariah principles of cultured meat. Supports findings in *Halal Integrity* and *Conceptual Ambiguity*.
2. **Feasibility of Curriculum Integration**	To assess whether halal cultured meat is suitable for inclusion in halal education. Supports *Proposal for Case Study Integration* and *Pedagogical Relevance*.
3. **Pedagogical Challenges and Teaching Dilemmas**	To identify tensions in teaching halal standards when slaughter is absent. Supports *Teaching Dilemmas* and *Curriculum Gaps*.

4. **Regulatory and Certification Ambiguity**	To examine how the lack of fatwa, unclear standards, and policy gaps affect teaching confidence. Supports *Regulatory Ambiguity* and *Food Safety*.
5. **Perceptions of Responsive Halal Education**	To evaluate expert views on the need for curriculum reform that reflects technological developments. Supports *Recommendations* and *Future Prospects*.

Source: Author's reconstruction of interview question themes based on research objective and thematic findings.

Document selection was guided by relevance to halal certification, regulatory discourse, and public communication published between the years 2020 and 2025. The sources comprised national fatwa statements, halal standards such as MS1500:2019, government policy papers, and industry reports.

A coding manual was developed to ensure consistency in thematic analysis, and an audit trail was maintained through iterative memo writing and peer validation. The researcher's professional background in halal curriculum development was acknowledged to enhance reflexivity and interpretive transparency throughout the analysis process.

Conceptual Framework

This study adopts a conceptual framework grounded in curriculum responsiveness and halal governance principles to guide the thematic analysis and interpretation of findings. In qualitative research, such a framework serves as a theoretical lens that connects the research objective, data patterns, and pedagogical implications. It enables the researcher to organise emerging themes systematically and to justify curriculum recommendations in relation to syariah integrity, educational relevance, and national halal policy.

Curriculum responsiveness theory emphasises the need for educational content to evolve in response to societal, technological, and ethical developments. It advocates for curriculum designs that are flexible, context-sensitive, and capable of preparing learners to engage critically with real-world challenges (Wheelahan, 2007; Schweisfurth, 2013). In the context of halal education, this theory supports the inclusion of emerging food technologies such as cultured meat, provided that the integration is pedagogically sound and aligned with learners' cognitive and ethical development.

Recent scholarship has extended this theory to halal curriculum development, highlighting the need for graduates to possess not only technical knowledge but also adaptive thinking and ethical resilience to meet global halal market demands (Asbullahi et al., 2022). The emphasis on learner-centred, future-oriented curriculum structures is particularly relevant in preparing students to navigate complex halal innovations that challenge conventional syariah interpretations.

Halal governance principles offer a syariah-based framework for evaluating the legitimacy, regulation, and instructional treatment of halal innovations. These principles prioritise transparency, stakeholder engagement, and alignment with authoritative fatwa and standards such as MS1500:2019 (Talib et al., 2017; Riaz & Chaudry, 2004). Within this study, halal governance informs the analysis of conceptual ambiguity, regulatory gaps, and ethical dilemmas, thereby shaping the pedagogical strategies proposed for curriculum integration.

More recent perspectives argue that halal governance must move beyond technical compliance and embrace socio-cultural dimensions such as consumer trust, religious literacy, and institutional credibility (Nazri et al., 2025). These factors are increasingly recognised as essential in legitimising halal certification and in sustaining public confidence in halal assurance systems. For curriculum design, this implies the need to embed ethical reasoning, policy literacy, and participatory learning strategies that reflect the complexity of contemporary halal discourse.

By combining these two theoretical foundations, the conceptual framework supports alignment with the Malaysian Qualifications Framework (MQF 2024). This includes Programme Educational Objectives (PEO) that

aim to produce graduates who are scientifically competent, ethically grounded, and policy-aware. It also aligns with Programme Learning Outcomes (PLO) such as knowledge mastery (LOD1), cognitive analysis (LOD2), leadership and responsibility (LOD8), and ethical professionalism (LOD11). In addition, the framework embeds transversal elements emphasised in MQF 2024, namely Education for Sustainable Development (ESD), Social Awareness and Networking (SAN), and Values, Beliefs and Ethics (VBE). These elements ensure that the proposed curriculum component is not only theoretically grounded but also responsive to national aspirations in halal innovation and education reform.

Figure 1 illustrates the conceptual framework that underpins this study. It integrates two theoretical foundations, **Curriculum Responsiveness Theory** and **Halal Governance Principles**, which collectively guide the thematic analysis and curriculum recommendations. The framework demonstrates how emerging themes derived from expert interviews and document analysis are systematically organised to inform pedagogical strategies that align with MQF 2024 domains. This visual structure supports the development of a context-sensitive, ethically grounded, and policy-relevant curriculum component for halal food law education in Malaysia.

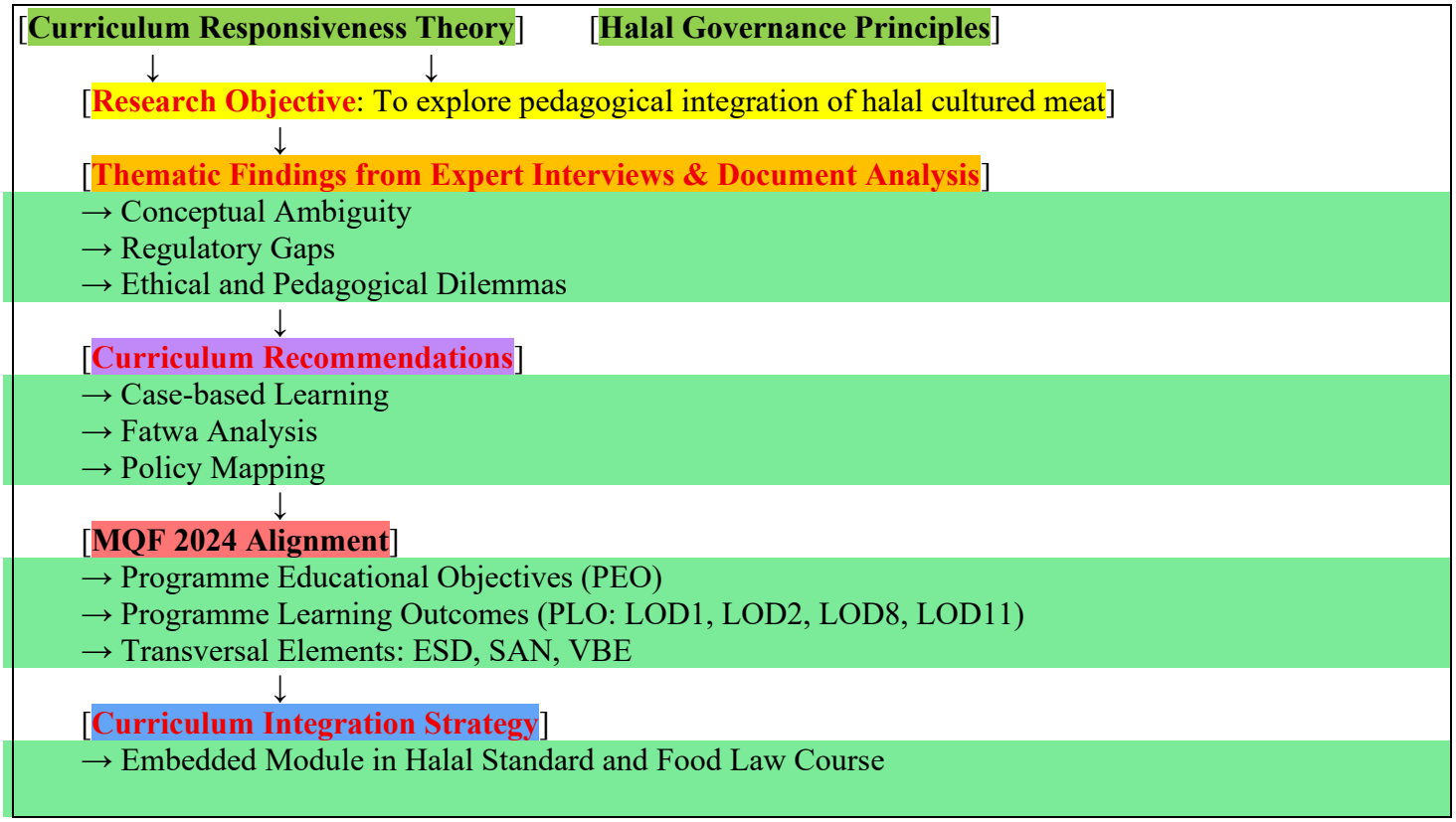

Figure 1 Conceptual Framework for Embedding Halal-Cultured Meat into Halal Food Law Curriculum

FINDINGS AND ARGUMENTS

The Concept of Halal Laboratory-Cultured Meat

The concept of halal laboratory-cultured meat involves the production of meat derived from animal cells, specifically stem cells, obtained through biopsies from halal-certified animals. According to Hafiz M. Ahmed (2022), this meat is produced in a controlled environment using bioreactors to cultivate these cells into muscle tissue that closely resembles traditional meat. For the meat to be considered halal, the cells must originate from animals permissible in Islam. Additionally, the entire production process must avoid any non-halal substances, such as blood or animal-derived growth factors from haram (forbidden) sources. This ensures that the final product adheres to Islamic dietary laws and meets the dietary requirements of Muslim consumers (Ahmed, 2022).

Cultured meat is produced through cellular agriculture, which involves the extraction of stem cells from animal

sources and their proliferation in a controlled environment using nutrient-rich media. One of the most debated components in this process is fetal bovine serum (FBS), which serves as a growth medium but raises significant halal concerns due to its origin and method of extraction. Recent innovations have explored serum-free alternatives and plant-based scaffolding techniques, yet the syariah status of these methods remains under deliberation. Understanding these technical aspects is essential for framing halal cultured meat within both scientific and jurisprudential contexts.

The use of bioreactors allows for precise control over the growth conditions, including temperature, pH, and nutrient supply, ensuring the consistency and safety of the cultured meat. Furthermore, the production process can be optimized to reduce environmental impact by minimizing resource usage, such as land and water, compared to traditional livestock farming (FAO, 2020). This innovative approach not only addresses religious dietary needs but also contributes to sustainable food production.

In Malaysia, the Department of Islamic Development Malaysia (JAKIM) has established protocols for halal meat production, which include guidelines for ensuring that cultured meat meets halal standards. These protocols are periodically reviewed to keep up with industry advancements and ensure compliance with Shariah law. The Malaysian government has also set ambitious goals to support the development of this industry, including financial incentives, grants, and subsidies to startups and companies involved in halal laboratory-cultured meat production (MITI, 2023).

The Issues of Food Fraud in Halal Meat Production

Food fraud in the halal meat production industry is a significant concern, affecting consumer trust, religious practices, and public health. Halal meat fraud manifests in various forms, including adulteration with non-halal substances, substitution of non-halal meat as halal, and incorrect labeling of products without proper certification (Eufic, 2023; Rejeb et al., 2019). Additionally, manufacturers sometimes use expired halal certifications or engage in smuggling and grey market activities, where illegally imported meat that does not meet halal standards is sold in the market. This often results in cross-contamination with non-halal substances such as pork or alcohol during transport (Eufic, 2023; Bonne & Verbeke, 2008).

These fraudulent activities not only deceive consumers but also pose health risks, as they may involve unsafe materials like formalin or other non-permissible preservatives. Despite the presence of laws such as the Trade Description Act 2011 and the Food Act 1983, enforcement remains a challenge. The halal certification process lacks uniformity, leading to misuse of halal logos by unscrupulous businesses, resulting in public distrust and demands for stricter regulations (Muhammad Asyraf et al., 2023; Tieman, 2011).

Increasing consumer awareness regarding halal food fraud has led to calls for greater transparency in the halal meat supply chain. Consumers are now more vigilant, seeking assurance that the products they purchase are genuinely halal. This has driven demand for traceability technologies like RFID and blockchain to authenticate halal status from production to retail (Eufic, 2023; Karabag et al., 2021).

Addressing halal meat fraud requires collaboration among various stakeholders, including regulatory bodies, producers, and consumers. Enhanced inspection protocols and robust halal authentication technologies are needed to ensure compliance with halal standards. A notable example of halal meat fraud occurred in December 2020, a major fake halal meat scandal was uncovered in Malaysia, where a cartel smuggled non-halal meat from various countries, selling it as certified halal beef for decades. The smuggled meat included horse, kangaroo, and pork, which were mixed and sold as halal-certified beef. The cartel bribed senior officials from several Malaysian government agencies to overlook their activities (Muhammad Asyraf et al., 2023; Halim, 2021).

In a raid on a warehouse in Senai, Johor, 1,500 tons of imported frozen meat worth RM30 million was seized. The warehouse was used for making fake labels and stamps to repackage the meat. The scandal caused widespread alarm in Malaysia, where 60% of the population is Muslim and prohibited from eating non-halal meat. Several cartel members were arrested and charged under the Trade Descriptions Act 2011 and the Trade Descriptions (Certification and Halal Marking) Order 2011. The scandal exposed major corruption in Malaysia's halal certification system and tarnished the reputation of regulators like Jakim, threatening Malaysia's ambitions

to become a global halal food hub (Muhammad Asyraf et al., 2023).

Therefore, this study aims to prevent such cases from happening again. By ensuring that cells used in production are obtained from halal animals slaughtered according to Islamic teachings, halal laboratory-cultured meat can become a reliable alternative for Muslim consumers, alleviating any concerns about authenticity and adherence to halal standards.

In conclusion, food fraud in the halal meat production industry in Malaysia is a complex issue that requires comprehensive strategies to protect consumer rights and uphold halal standards.

The Food Safety in Cultured Meat Production

The safety of cultured meat for human consumption has been rigorously evaluated by regulatory bodies such as the U.S. Food and Drug Administration (FDA). The FDA has determined that cultivated or cultured meat is safe for human consumption, providing safety clearance for the first time based on comprehensive information submitted by companies involved in its production. The FDA stated that it had "no further questions at this time about the firm's safety conclusion" (Johnson, Smith, & Williams, 2021). Additionally, the U.S. Department of Agriculture (USDA) and the FDA have established a formal agreement on the regulatory oversight of cell-cultured meat and poultry, ensuring that these products are safe and properly labeled (Johnson et al., 2021).

The production process of cultivated meat involves growing animal cells obtained from livestock, poultry, or seafood in a controlled environment. This method is anticipated to have a significantly reduced environmental impact, utilizing substantially less water and land compared to conventionally produced meat. Moreover, cultured meat production does not necessitate the slaughter of animals, presenting a potential means to mitigate the environmental footprint of traditional animal agriculture (Post, 2012; Stephens et al., 2018).

In Malaysia, the safety and regulation of cultured meat are overseen by the Ministry of Health and the Malaysian Islamic Development Department (JAKIM). JAKIM ensures that cultured meat products comply with halal standards, including the source of cells used in production. The Food Act 1983 and Food Hygiene Regulations 2009 provide a framework for food safety, including the production and handling of cultured meat. According to the Malaysian Standard MS 1500:2019, halal food must meet specific requirements for hygiene, sanitation, processing, storage, transportation, and packaging to ensure it is safe for consumption (Ministry of Health Malaysia, 1983; Ministry of Health Malaysia, 2009).

However, as of now, there are no specific guidelines on laboratory-cultured meat in Malaysia. Expert respondents have noted that while initiatives have started, they are not yet focused on halal aspects. For instance, Cell AgriTech in Penang has already built a factory to produce cultured meat, with production expected to start in 2025. Despite these developments, halal laboratory-cultured meat has not yet been fully implemented on a commercial scale in Malaysia. Ongoing research and development efforts by various academic institutions and startups are exploring the feasibility and potential of cultured meat production. These efforts are still in the early stages, focusing on foundational research, the development of suitable cell lines and growth media, and small-scale pilot projects. The goal is to address the technical, regulatory, and market challenges before moving towards commercial production.

To enhance food safety in cultured meat production, ongoing research is paramount. Regulatory bodies and researchers are prioritizing the development of new analytical methods and safety assessment protocols, which encompass the unique aspects of cultured meat production that differ from traditional meat processing. Collaborative efforts among scientists, regulators, and industry stakeholders are crucial to establishing a comprehensive safety framework adaptable to innovations within this field (Chriki & Hocquette, 2020).

As cultured meat production continues to expand, addressing food safety concerns remains a critical priority. The integration of rigorous safety assessments, effective regulatory oversight, and continuous research will be essential to ensure that cultivated meat products are safe for consumers and achieve widespread market acceptance (van der Weele & Tramper, 2014; Bhat, Kumar, & Fayaz, 2015).

Future Prospects of Halal-Cultured Meat in Malaysia

The prospects for halal-cultured meat in Malaysia appear promising, given the findings from recent interviews and studies. The primary aim is to identify the implementation methods and guidelines for halal laboratory-cultured meat processing. Participants have been able to clearly define and describe the process of laboratory-cultured meat production, offering valuable insights regarding halal parameters and food safety guidelines. Nonetheless, the study's limited sample and absence of industry or consumer voices constrain its generalisability. Future research should adopt a mixed-methods approach and include broader stakeholder engagement to validate and expand the current findings. However, the limited number of interviewees and the absence of consumer or regulator perspectives restrict the generalizability of findings. Future studies should incorporate broader stakeholder views to strengthen representativeness and policy relevance.

Currently, there are no specific guidelines for laboratory-cultured meat production. However, the industry can adopt existing guidelines from similar areas to ensure the meat produced is both halal and safe for consumption. Future research is necessary to develop specific guidelines that will assure consumers that the meat is unequivocally halal. Establishing such guidelines will be critical in gaining consumer trust and acceptance of halal laboratory-cultured meat.

By emphasizing these issues and challenges, producers can avoid mistakes in the process of producing cultured meat that may violate Islamic law. Respondents provided practical solutions that can be applied if these challenges arise in the future. Although these challenges are complex, with economic growth and future demand, they can be effectively addressed by responsible parties such as authoritative bodies and the halal food industry (Abdullah & Ismail, 2020). Collaborative efforts among regulatory authorities, industry stakeholders, and researchers are essential to develop comprehensive guidelines that ensure the production of halal and safe cultured meat in Malaysia. Addressing these challenges will be critical for gaining consumer trust and acceptance of halal laboratory-cultured meat.

Recent studies have shown that the environmental impact of traditional livestock farming is significant, contributing to 14.5% of human-caused greenhouse gas emissions (FAO, 2020). In contrast, lab-grown meat production requires less land, water, and other resources, making it a more sustainable alternative. For instance, Cell AgriTech, a Malaysian company, is working on establishing the country's first cultivated meat production facility in Penang, aiming to reduce the carbon footprint associated with traditional meat production (Zulkifli et al., 2023). Additionally, the Malaysian government has set a target to achieve 100% digitalization of the halal certification process by 2026, which will streamline the application process and enhance the credibility of Malaysia's halal certification (MITI, 2023).

The potential for achieving halal laboratory-cultured meat in the future is increasingly viable. Various studies and recommendations have been made to enhance the infrastructure utilized during the processing of cultured meat. Both respondents provided numerous suggestions for improvement, aimed at advancing the cultured meat industry. In summary, both informants emphasized the urgency of integrating halal-cultured meat into academic discourse. They agreed that the curriculum must evolve in tandem with technological developments and that educators play a key role in shaping halal literacy among future professionals. Their insights support the case-based approach proposed in this study and affirm the relevance of cultured meat as a pedagogical tool.

The respondents of this study, including experts such as Muhamad Firdaus bin Abd Razak and Md Zakri bin Mohd Yusoff, concurred that the development of the halal-cultured meat industry could yield significant benefits, especially for the Muslim population in Malaysia. They emphasized that integrating this alternative technology has the potential to propel the nation's progress and enhance its global reputation.

In addition to economic growth, the respondents highlighted several environmental benefits. For instance, cultured meat production requires significantly less water, land, and energy compared to traditional livestock farming, which aligns with Malaysia's commitment to sustainability (FAO, 2020). This alternative method also reduces greenhouse gas emissions, contributing to global efforts to combat climate change.

Furthermore, the introduction of cultured meat can enhance food security by providing a stable and reliable

source of protein that is not subject to the same risks as conventional meat production, such as disease outbreaks among livestock (FAO, 2020).

As highlighted by Abdullah and Ismail (2024), with strategic improvements in infrastructure and adherence to halal certification processes, the production of cultured meat can be optimized to meet Islamic dietary laws. This ensures that the products are acceptable to Muslim consumers and adhere to the highest standards of food safety and quality.

Furthermore, the establishment of cultivated meat production facilities, such as those being developed by Cell AgriTech in Penang, underscores Malaysia's commitment to sustainable and halal-compliant food production (Zulkifli et al., 2023). Additionally, the Malaysian government has set a target to achieve 100% digitalization of the halal certification process by 2026, which will streamline the application process and enhance the credibility of Malaysia's halal certification (MITI, 2023).

The Singapore Fatwa Committee has also recently declared that lab-cultivated meat is permissible (halal) if it meets specific requirements, such as using cells from halal animals and avoiding non-halal components (Mothership, 2024). This decision further supports the potential for halal cultured meat in the region. Similarly, the Office of the Federal Mufti of Malaysia has issued a fatwa stating that cultured meat is permissible (halal) as long as it adheres to the guidelines of using cells from halal animals and ensuring the process does not involve any haram elements (Office of the Federal Mufti of Malaysia, 2021). This decision further supports the potential for halal cultured meat in the region.

In conclusion, the future of halal-cultured meat in Malaysia holds great potential. By addressing the existing challenges and developing comprehensive guidelines, Malaysia can lead the way in the halal-cultured meat industry, providing a sustainable, ethical, and halal alternative to conventional meat production.

The Impact of Halal Laboratory Cultured Meat Production

The production of halal laboratory-cultured meat holds significant potential for a positive impact on our country. First, it necessitates halal regulatory changes to accommodate the innovation. Adaptation of these regulations will ensure that the production process complies with Islamic dietary laws, thus maintaining consumer confidence (Ahmed, 2022).

Second, the economic growth fueled by the creation of new industries, job opportunities, and investment prospects is substantial. The Malaysian government has already set ambitious goals to support this sector, including financial incentives, grants, and subsidies (MITI, 2023). Furthermore, with an increasing global demand for halal products, the export potential for halal laboratory-cultured meat is immense, positioning Malaysia as a key player in the global market.

Third, an increase in the number of halal laboratory-cultured meat producers will lead to job creation, benefiting the Malaysian workforce. The establishment of specialized facilities and research institutions will also create high-skilled job opportunities, contributing to the nation's overall economic development (Zulkifli, Rahman, & Hamid, 2023).

Fourth, there are significant environmental benefits to consider. Laboratory-cultured meat production results in reduced greenhouse gas emissions, lower water usage, and diminished land requirements compared to traditional livestock farming (FAO, 2020). This aligns with Malaysia's commitment to sustainability and environmental protection.

Fifth, enhancing food security is a critical advantage. Cultured meat provides a sustainable and reliable source of protein, reducing dependency on traditional meat sources and mitigating the risks associated with livestock diseases and supply chain disruptions (FAO, 2020).

The Challenges of Halal Laboratory Cultured Meat Production

Developing suitable growth media for cell culture presents several challenges that must be addressed to ensure

the effective production of laboratory-cultured meat. Expert respondents identified key challenges and potential solutions in this area. Firstly, traditional growth media derived from animal sources are considered most effective due to the natural compatibility with animal protein cells. However, plant-based alternatives hold promise and require extensive testing and modification to ensure cells can adapt and utilize these sources effectively.

Cost-effectiveness is another critical challenge. Identifying cost-effective and efficient alternatives to traditional growth media, such as plant-based or synthetic options, is essential. This involves researching and developing media that can replace animal-derived components without compromising cell growth and quality.

Ethical and regulatory compliance is also crucial. Ensuring that growth media are free from animal-derived components is necessary to meet ethical and regulatory requirements. This is particularly important for halal certification, which demands adherence to Islamic dietary laws. One respondent noted, 'Even if the science is ready, the halal framework isn't; we need to build both together.' This highlights the dual challenge of technical innovation and religious compliance, which must progress in tandem to ensure acceptance. Collaboration with academic and industry partners is vital for innovating and optimizing growth media formulations. By working together, stakeholders can share knowledge, resources, and expertise to advance the development of effective growth media.

Continuous improvement through ongoing testing and refinement of media formulations is essential to improve cell growth rates and yield. This iterative process helps researchers identify and address any issues that may arise, ensuring that the media supports robust and reproducible cell culture.

In summary, addressing these challenges through collaborative efforts and continuous innovation will enable the development of suitable growth media for laboratory-cultured meat. This will advance both basic research and applied biomedical science, ultimately supporting the production of safe, ethical, and high-quality cultured meat products.

Proposal For Case Study Integration In Higher Education Curriculum

The topic "*Future Prospects of Halal-Cultured Meat in Malaysia*" is highly suitable to be introduced as a case study example under the subtopic of Halal Innovation and Emerging Food Technologies within the subject Standard Halal, Food Law and Sanitation. Its inclusion at the higher education level is both timely and pedagogically justified, given the increasing relevance of cultured meat in global food systems and the pressing need to evaluate its compatibility with Islamic dietary laws.

Cultured meat, developed through cellular agriculture, presents a novel challenge to halal certification frameworks, particularly in relation to the use of fetal bovine serum (FBS), stem cell sourcing, and the absence of slaughter (*dhabiha*) procedures (Riaz & Chaudry, 2004; Ahmed, 2022). These issues demand critical engagement from students, especially those preparing for roles in halal governance, food law enforcement, and industry consultation. As one informant reflected, 'We are teaching about halal slaughter, but now we have meat without slaughter. How do we reconcile this in class?' This statement underscores the pedagogical tension faced by halal educators when navigating emerging biotechnologies. The absence of explicit syariah guidelines for cell-based meat production complicates curriculum design, especially since existing standards, such as MS1500:2019, do not address tissue engineering or stem cell sourcing. The pedagogical concerns raised in this section directly reflect the interview questions on curriculum feasibility, teaching dilemmas, and halal integrity. Informants responded to these questions by highlighting the absence of slaughter in cultured meat, the lack of syariah clarity, and the challenges of aligning biotechnology with halal pedagogy. These responses were thematically analysed and mapped to the study's objective, confirming that the interview protocol successfully elicited relevant insights for curriculum integration.

The interview questions were structured around five thematic clusters designed to address the study's objective. Each theme was explored through expert responses that yielded specific findings, which were subsequently analysed using Braun and Clarke's (2006) six-phase framework. Table 3 presents a detailed mapping of the interview question themes, the corresponding key findings, and representative quotes that illustrate how each question was answered in relation to the pedagogical integration of halal cultured meat.

The findings presented in this section directly reflect the interview questions concerning curriculum feasibility, pedagogical dilemmas, and halal integrity. Informants responded by highlighting the absence of slaughter procedures, the lack of syariah clarity, and the challenges of aligning biotechnology with halal pedagogical frameworks. Table 3 provides a synthesis of these responses, confirming that the interview protocol successfully addressed the study's objective.

Table 3 Interview Question Themes, Key Findings, and Representative Responses

Interview Question Theme	Key Finding	Representative Response
Conceptual Understanding of Halal Cultured Meat	Halal integrity and conceptual ambiguity regarding slaughter and cell sourcing	"We are teaching about halal slaughter, but now we have meat without slaughter. How do we reconcile this in class?"
Curriculum Integration Feasibility	Pedagogical relevance and curriculum gap in halal education	"This topic must be in our syllabus—it's already in the market and in fatwa debates."
Pedagogical Challenges and Teaching Dilemmas	Difficulty aligning biotechnology with traditional halal teaching frameworks	"Without clear fatwa and certification guidelines, it's hard to teach cultured meat confidently in halal courses."
Regulatory and Certification Ambiguity	Absence of halal standards and unclear fatwa positions	"Even if the science is ready, the halal framework isn't—we need to build both together."
Perceptions of Responsive Halal Education	Need for curriculum reform to reflect emerging food technologies	"Students should be exposed to real-world halal dilemmas, not just textbook rules."

Source: Author's thematic synthesis of expert interview data.

The alignment between interview question themes and emergent findings confirms that the data collection process was effective in addressing the study's objective. The responses provided by informants not only validated the relevance of halal cultured meat as a pedagogical case study but also highlighted the regulatory, ethical, and instructional complexities that must be considered in curriculum design.

Malaysia's position as a global halal hub, coupled with its strategic push toward halal science and digitized certification by 2026 (MITI, 2023), makes this case study locally relevant and globally significant. The recent fatwa issued by the Office of the Federal Mufti of Malaysia, affirming the permissibility of cultured meat under specific conditions, provides a jurisprudential anchor for classroom discussion (Office of the Federal Mufti of Malaysia, 2021). Similarly, Singapore's fatwa committee ruling adds a comparative regional perspective (Mothership, 2024).

Embedding this case study into the curriculum allows students to explore the intersection of halal principles, food law, and sanitation standards in the context of biotechnology. It supports the development of critical thinking, ethical reasoning, and regulatory literacy—core competencies for future halal professionals. As highlighted by Creswell and Creswell (2018), case-based learning enhances contextual understanding and prepares learners to navigate complex, real-world challenges.

In conclusion, the proposed case study on halal-cultured meat offers a rich, multidimensional learning opportunity. Its integration into the Standard Halal, Food Law, and Sanitation syllabus at the higher education level will strengthen curriculum relevance, foster analytical engagement, and contribute to Malaysia's leadership in halal education and innovation.

Pedagogical Implications and Curriculum Design

The findings suggest that halal cultured meat can serve as a multidimensional case study that promotes critical

thinking, ethical reasoning, and regulatory literacy. Educators may consider integrating this topic through structured activities such as simulated certification exercises, jurisprudential analysis sessions, and classroom debates on halal biotechnology. These approaches are consistent with case-based learning principles and support the development of future-ready halal professionals.

To demonstrate the alignment between the study's objective, thematic findings, and pedagogical recommendations, a structured mapping is presented in Table 4. This table synthesizes how each component of the research process contributes to the development of curriculum strategies for integrating halal cultured meat into higher education syllabus.

Table 4 Mapping of Research Objective, Key Findings, and Curriculum Recommendations

Research Objective	Key Findings	Curriculum Recommendations
To explore how halal cultured meat can be embedded as a case study in the teaching of halal food standards	Conceptual ambiguity, pedagogical dilemmas, regulatory gaps, and curriculum relevance	Introduce case-based modules on halal biotechnology, simulate certification processes, analyse fatwa texts, and incorporate ethical reasoning exercises

Source: Author's synthesis of thematic findings and pedagogical implications.

The mapping in Table 4 confirms that the study's objective was effectively addressed through a coherent progression from data collection to curriculum design. The proposed recommendations are grounded in empirical findings and offer a practical framework for educators seeking to incorporate emerging halal food technologies into formal instruction.

To operationalise the findings, a modular syllabus component is proposed for integration into the existing Halal Standard, Food Law, and Sanitation course. This framework allows educators to address the scientific, syariah, pedagogical, and policy dimensions of halal cultured meat within a focused instructional window.

Table 5 Proposed Syllabus Framework for Integrating Halal Cultured Meat into Halal Standard and Food Law Education

Subtopic Component	Content Focus	Suggested Learning Activities	Aligned PEO	Aligned PLO (MQF 2024 LOD)	MQF Element (ESD / SAN / VBE)
Scientific Basis of Cultured Meat	Overview of cellular agriculture, stem cell sourcing, and production techniques	Instructor-led briefing with visual aids; guided reading of technical sources	PEO1: Apply scientific and technological knowledge in halal contexts	**PLO1 (LOD1)**: Demonstrate knowledge and understanding of food biotechnology and halal implications	**ESD**: Promote sustainable food innovation and responsible technology use
Syariah and Regulatory Considerations	Analysis of slaughter principles, fatwa positions, and gaps in halal standards	Fatwa comparison exercise; discussion on MS1500:2019 limitations	PEO2: Integrate syariah principles in professional and regulatory practice	**PLO2 (LOD2)**: Apply cognitive skills to analyse halal standards and syariah reasoning	**VBE**: Uphold jurisprudential ethics and regulatory integrity
Pedagogical and Ethical Dilemmas	Classroom challenges in teaching non-	Structured debate; case analysis of	PEO3: Address ethical and	**PLO11 (LOD11)**: Demonstrate ethical reasoning	**VBE**: Foster ethical reasoning and

	slaughter meat and emerging technologies	Malaysia and Singapore fatwa rulings	pedagogical challenges in halal innovation	and professionalism in halal discourse	respectful scholarly dialogue
Curriculum Responsiveness and Policy Linkage	Implications for halal education reform and alignment with the national halal agenda	Group reflection: policy mapping exercise based on MITI Halal Roadmap	PEO4: Contribute to halal curriculum development and policy literacy	**PLO8 (LOD8)**: Demonstrate leadership, autonomy, and responsibility in curriculum reform	**SAN**: Strengthen collaborative awareness and policy engagement in halal governance

Source: Designed as an embedded module within the Halal Standard, Food Law, and Sanitation course.

The mapping presented in Table 5 demonstrates a coherent alignment between the study's objective, the thematic findings derived from expert interviews and document analysis, and the curriculum recommendations proposed. Each finding responds directly to the research aim and provides a pedagogical rationale for integrating halal cultured meat into formal instruction. This structured progression reinforces the validity of the study's design and supports the development of responsive, context-sensitive curriculum strategies within halal food law education.

Importantly, the proposed curriculum component reflects the Programme Educational Objectives (PEO) by preparing graduates to apply scientific and syariah knowledge in halal contexts, address ethical challenges in food innovation, and contribute meaningfully to curriculum and policy development. These objectives are operationalised through targeted Programme Learning Outcomes (PLO) that align with the Malaysian Qualifications Framework (MQF 2024), including mastery of knowledge and understanding (LOD1), application of cognitive skills (LOD2), ethical and professional reasoning (LOD11), and leadership with autonomy and responsibility (LOD8).

In addition, the curriculum design embeds three transversal elements emphasised in MQF 2024:

- Education for Sustainable Development (ESD), which promotes responsible innovation and long-term thinking in halal biotechnology;
- Values, Beliefs and Ethics (VBE), which cultivate jurisprudential integrity, ethical reasoning, and respectful scholarly engagement; and
- Social Awareness and Networking (SAN), which encourages collaborative reflection, policy literacy, and active participation in halal governance discourse.

Collectively, these elements position the study as a forward-looking contribution to halal education, offering a practical and principled framework for embedding emerging food technologies into teaching and learning environments. The curriculum responsiveness proposed not only supports pedagogical innovation but also aligns with Malaysia's broader agenda in halal education reform and global halal leadership.

Researcher Reflexivity

As a researcher with professional experience in halal curriculum development and manuscript evaluation, my interpretation of the data was shaped by pedagogical priorities and regulatory sensitivities. Reflexive memo writing was employed throughout the coding process to ensure that personal biases were acknowledged and managed, particularly when analysing syariah-related content and instructional dilemmas.

RECOMMENDATIONS

For the development of halal laboratory-cultured meat production in Malaysia, the government can provide

substantial support to startups in this sector. This support could take the form of financial incentives, grants, and subsidies, which would encourage investments from both local and international stakeholders. Additionally, the government can establish incubators and accelerators to support innovative startups by providing resources, mentorship, and funding to help them scale their operations.

Moreover, the development of specialized facilities dedicated to the production and processing of halal laboratory-cultured meat is crucial. These state-of-the-art facilities must comply with all halal requirements and be equipped with advanced technology to ensure efficiency and adherence to halal standards. Ensuring that these facilities are accessible to local producers and startups will provide them with the necessary infrastructure to develop and market their products.

Furthermore, laboratory-cultured meat companies should seek to establish both global and local collaborations and partnerships. By fostering collaborations with international halal certification bodies, research institutions, and industry leaders, companies can share knowledge, technology, and best practices to enhance the production and certification of halal laboratory-cultured meat. Participation in global forums and conferences on cultured meat and halal food production can also help these companies stay updated on industry trends and innovations.

Additionally, companies can establish industry associations or working groups focused on halal laboratory-cultured meat. These associations can facilitate knowledge sharing, advocacy, and coordinated efforts to address industry challenges. They can also create networking opportunities for stakeholders across the supply chain, from producers and researchers to marketers and policymakers.

This study is limited by its small sample size and exploratory scope. Although the insights obtained from two expert informants were rich and contextually grounded, future research should expand the sample to include regulators, religious scholars, producers, and consumers. Empirical classroom testing of the proposed case study and longitudinal tracking of student engagement would further strengthen the curriculum recommendations and pedagogical relevance.

In response to the pedagogical challenges identified in the study, several teaching strategies are proposed to support the integration of halal cultured meat into the curriculum. Table 6 outlines these strategies, their learning focus, and intended pedagogical outcomes, offering a practical framework for educators in halal food law and sanitation.

Table 6 Proposed Teaching Strategies for Integrating Halal Cultured Meat into the Curriculum

Teaching Strategy	Learning Focus	Pedagogical Purpose
Simulated halal certification exercises	Regulatory procedures, compliance standards	To develop a practical understanding of halal certification processes and decision-making.
Fatwa analysis using jurisprudential texts	Syariah reasoning, legal interpretation	To enhance students' ability to interpret fatwa and apply Islamic legal principles.
Structured ethical debates	Ethical dilemmas, contemporary halal issues	To foster critical thinking and encourage balanced discussion on emerging food technologies.
Case-based discussion of cultured meat scenarios	Real-world application, policy implications	To promote contextual learning and link theory to current industry developments.
Comparative analysis of regional fatwa rulings	Cross-jurisdictional understanding, global halal discourse	To expose students to diverse scholarly views and strengthen comparative reasoning.

Source: Researcher's synthesis of pedagogical recommendations based on thematic findings.

In conclusion, improving the production of halal lab-grown meat in Selangor requires a multifaceted approach

that addresses regulatory, policy, and market challenges. By developing financial support mechanisms, specialized facilities, and international partnerships, Malaysia can position itself as a leader in the halal laboratory-cultured meat industry while meeting consumer dietary needs and demands in the future. As one expert respondent emphasized, 'If we want cultured meat to be halal, we must build the ecosystem, not just the product.' This reinforces the need for holistic development involving infrastructure, policy, and education."

CONCLUSIONS

This study has explored the feasibility, challenges, and prospects of integrating halal laboratory-cultured meat into Malaysia's food system and higher education curriculum. Through qualitative inquiry involving expert interviews and document analysis, the research has highlighted the complex relationship between religious compliance, regulatory preparedness, and pedagogical relevance, particularly within the context of the subject Standard Halal, Food Law and Sanitation.

The findings indicate that although cultured meat presents unique challenges to halal certification, especially regarding the use of fetal bovine serum, stem cell sourcing, and the absence of conventional slaughter procedures, these concerns can be addressed through strategic guideline development, jurisprudential clarity, and technological adaptation. The recent fatwa issued by the Office of the Federal Mufti of Malaysia, which affirms the permissibility of cultured meat under specific conditions, provides a foundational reference for future policy and curriculum integration.

From an environmental perspective, cultured meat offers significant advantages over traditional livestock farming. It requires less land, water, and energy, and contributes to lower greenhouse gas emissions. These benefits align with Malaysia's sustainability goals and its commitment to halal innovation, as reflected in national initiatives such as the digitization of halal certification by 2026 and the establishment of cultivated meat facilities by Cell AgriTech.

The study also emphasizes the importance of collaboration among regulatory authorities, industry stakeholders, and academic institutions to ensure that halal-cultured meat production meets both religious and scientific standards. Embedding this topic into higher education, particularly as a case study under halal innovation and emerging food technologies, will enhance curriculum relevance, foster critical engagement, and prepare future professionals to navigate evolving halal landscapes.

In conclusion, Malaysia holds strong potential to lead in the development of halal laboratory-cultured meat. By addressing existing challenges and leveraging available opportunities, the country can advance a model of food production that is environmentally sustainable, religiously compliant, and educationally transformative.

The integration of halal cultured meat into higher education syllabi has the potential to reinforce Malaysia's leadership in halal innovation. It also equips future professionals with the analytical skills required to navigate ethical, legal, and scientific complexities in the evolving landscape of food technology.

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