Artificial Intelligence (AI) Integration of Shariah Compliance in Halal Meat Production through Advanced Manufacturing by Laser

Mohd Sadad Mahmud., Ibraheem Alani AbdulKareem., Ong Yew Chuan., Mohamad Sobri Hamid & Omar Abdul Hamid

Universiti Sultan Zainal Abidin, Malaysia

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ABSTRACT

The global demand for halal meat is steadily increasing, highlighting the need for innovative production methods that enhance efficiency, hygiene, and continuous Shariah compliance. Traditional halal slaughter and certification practices, deeply rooted in Islamic ethics, face growing challenges in terms of scalability, traceability, and maintaining consumer confidence, particularly in industrial-scale production. This paper investigates how Artificial Intelligence (AI) and advanced manufacturing technologies especially laser-based systems can modernise halal meat production while upholding Islamic principles. AI tools, including computer vision, the Internet of Things (IoT), blockchain, and robotics, offer potential for real-time monitoring, automated documentation, and transparent certification across the supply chain. Likewise, laser technology presents opportunities for cleaner, more precise, and standardised slaughter processes. Drawing on relevant studies and practical insights, the research examines how these innovations can enhance production efficiency, foster consumer trust, and improve competitiveness in global markets. However, key challenges persist, including theological concerns about automating sacred processes, regulatory inconsistencies, and the high costs and technical limitations faced by small and medium enterprises (SMEs). To address these issues, the paper proposes a conceptual framework that integrates AI with Shariah governance principles, encouraging collaboration between technologists, regulators, and Islamic scholars. It concludes that the successful adoption of AI and laser-based systems will depend on harmonising technological advancement with religious values, ensuring both spiritual integrity and sustainable industrial growth.

Keywords: Halal meat production; Artificial Intelligence (AI); Shariah compliance; Laser-based manufacturing; Automation; Blockchain and IoT; Islamic jurisprudence

INTRODUCTION

The global halal meat industry is experiencing rapid growth, fuelled by the expanding Muslim population and the rising demand for ethical, safe, and traceable food products. Ensuring Shariah compliance in halal meat production requires strict adherence to Islamic principles, particularly in the methods of animal slaughter, prevention of contamination, and maintaining transparency throughout the supply chain (Dashti et al., 2024). Halal meat has become a vital component of the international food economy, supported by ethical consumer choices and the growing integration of halal supply chains worldwide. The global halal market is expected to surpass USD 3 trillion by 2028 (Othman et al., 2025). Interestingly, the appeal of halal-certified food extends beyond Muslim consumers, as many non-Muslims associate halal products with higher standards of cleanliness, safety, and ethics (Bachtiar et al., 2024). To preserve its integrity, halal meat production must comply with the essential requirements of Shariah, including lawful slaughter (Dhabihah), hygienic handling, and clear separation from non-halal materials (Rahman et al., 2024).

However, traditional certification methods, which rely heavily on manual inspections and human assessment, are increasingly limited by inefficiency, inconsistency, and the risk of fraud within complex global supply chains. At the same time, the meat industry is embracing digital transformation through automation, robotics, and data analytics, technologies that offer both opportunities and challenges for halal compliance (Umar & Parakkasi, 2025). AI now stands at the forefront of this transformation. AI technologies, including computer vision,

machine learning, natural language processing, and IoT, can enable real-time monitoring of slaughter practices, ensure product segregation, automate certification processes, and enhance transparency throughout the supply chain (Salleh et al., 2023). Nevertheless, applying AI in religiously sensitive contexts requires careful ethical and theological consideration, as maintaining human oversight remains essential to preserving the sanctity and authenticity of halal practices.

Halal slaughter, or Zabh, refers to the humane and religiously guided process of killing an animal in accordance with Islamic law. It requires the swift cutting of the animal's four main neck vessels using a sharp knife while reciting the Tasmiya—the invocation of God's name as an expression of faith, humility, and acknowledgement that the act is permitted by divine authority (Arshad et al., 2022). The animal must be healthy, alive, and conscious at the time of slaughter, and the process should be carried out swiftly to minimise pain and distress. Ethical considerations are central to this practice, including lawful ownership, the provision of food and water, and calm handling to prevent fear. The knife should never be shown to the animal, and slaughter should not occur in the sight of other animals (Naeem et al., 2024).

According to Al-Qaradawi (1984), invoking God's name during slaughter symbolises the acknowledgement of divine sovereignty and the ethical responsibility entrusted to humans. It affirms that the act is not one of cruelty, but a necessary process conducted with gratitude and moral consciousness to sustain life (Ellahi et al., 2025). Conversely, certain conditions render the meat impermissible, such as when the animal dies before exsanguination, when God's name is omitted, or when another deity's name is invoked. These actions are considered spiritually harmful, as they compromise sincerity, piety, and the ethical essence of worship (Ülkü, 2024; Mahmud et al., 2019).

The halal meat industry also faces ongoing economic and structural challenges, including inefficiencies in supply chains, communication barriers, and inconsistencies in recognising halal standards across regions. These issues can disrupt production processes and influence consumer trust and purchasing behaviour (Ellahi et al., 2025). Grounded in Islamic economic principles, the halal philosophy serves as a framework for ethical conduct, guiding business decisions and promoting justice, sustainability, and community welfare (Abderahman et al., 2021). Although regulatory systems have strengthened product integrity, the absence of unified global standards continues to hinder industry growth. Collaborative efforts among regulators, producers, and governments are therefore essential to harmonise standards, enhance competitiveness, and ensure the long-term resilience of the halal market.

Ensuring consistent Shariah compliance in large-scale halal meat production presents an ongoing challenge for the industry. Islamic slaughter, or Dhabihah, must meet specific religious and ethical requirements: the animal must be healthy and alive at the time of slaughter, the act must be performed by a Muslim, the name of Allah (Bismillah) must be invoked, the trachea, oesophagus, and major neck vessels must be swiftly severed, and the blood must be fully drained from the body. Traditionally, these practices have depended heavily on manual labour and direct human supervision. However, as production scales increase, maintaining uniform compliance and efficiency through manual methods alone has become increasingly difficult.

In response to these operational pressures, the halal industry is exploring the use of advanced manufacturing technologies, particularly AI and laser-assisted systems, to enhance process control, hygiene, and documentation while preserving Shariah integrity. AI-based monitoring can improve accuracy and traceability, whereas laser technology offers precision and standardisation in slaughter operations. This paper examines the potential integration of these technologies within halal meat production, drawing on existing research to highlight their advantages, limitations and implications for Shariah compliance. The discussion also addresses the theological and technical challenges surrounding automation in religiously governed practices. These themes are explored in greater depth in the subsequent.

LITERATURE REVIEW

Shariah Compliance in Halal Slaughter

Muslim scholars hold differing views on the use of stunning in halal slaughter. When applied correctly, stunning renders the animal unconscious almost instantaneously, reducing pain and stress during slaughter. However, the

practice remains a sensitive and debated topic, as religious slaughter intersects with concerns about animal welfare, human rights, consumer protection, freedom of religion, and market dynamics (Al-Azmi et al., 2025). The term halal is an Arabic word closely associated with Islam and the Muslim community, referring to what is lawful, permissible, and approved under Islamic law. It conveys valid, authorised, and trustworthy (Chandia & Soon, 2018). The concept of halal is mentioned repeatedly in the Qur'an and in the Hadiths, the recorded sayings and actions of Prophet Muhammad (peace be upon him) (Mahmud et al., 2024).

Although halal is often associated with meat, food, and ingredients that Muslims are permitted to consume, its meaning extends far beyond that. Halal also encompasses the source, preparation, and conditions under which food is produced (Hashim et al., 2018). For example, meat obtained through Islamic slaughter (Zabiha or Dhabihah) must meet specific requirements before it can be considered halal. The animal must be alive and healthy at the time of slaughter (Alhayat Almustaqirah), and the name of Allah must be invoked before the cut is made (Qur'an 6:121). Failure to follow these rules renders the meat non-halal, or unsuitable for Muslim consumption, as stated in Surah Al-An'am (6:119): "And why should you not eat of that meat on which Allah's name has been pronounced (at the time of slaughtering the animal), while He has explained to you in detail what is forbidden to you…"

The current practice of halal slaughter is based on Shariah principles derived from the Qur'an and Hadith. According to Islamic law, Zabiha or Dhabihah must fulfil specific conditions to be considered valid. These include:

1- The animal must be alive at the time of slaughter.

2- The name of Allah (Tasmiyyah) must be recited during the act.

3- As stated in the Qur'an, "Do not eat from animals on which the name of Allah has not been mentioned."

4- The person performing the slaughter must be mature and of sound mind.

5- A Muslim should ideally carry out the slaughter; however, it is also permissible to consume meat slaughtered by the People of the Book.

Additionally, the following guidelines are recommended to ensure that halal slaughter is conducted in accordance with Islamic principles and animal welfare standards:

1- The animal should be positioned to face the Qibla (direction of prayer).

2- The knife should be sharpened away from the animal's view.

3- Slaughter should occur out of sight of other animals, and the animal should be shielded from seeing blood.

4- The cut should be made in a single, swift movement to minimise pain and distress.

Sazili et al. (2023) outlined the fundamental requirements for halal slaughter as follows:

1- The animal must be alive at the time of slaughter, and all pre-slaughter handling must avoid causing death to the animal.

2- Stunning, if used, should be reversible, allowing the animal to regain full consciousness if not slaughtered.

3- The slaughterer must recite the name of Allah at the time of slaughter.

4- A sharp knife should be used, and the cut should be made in one continuous movement.

5- The incision must be made at the front of the neck.

6- The head should not be severed during slaughter to allow proper bleeding.

7- Further processing or handling should occur only after the animal has died and shows no eye reflex.

8- Maximum blood should be drained from the carcass so that death occurs due to cerebral anoxia caused by blood loss.

Shariah principles emphasise both the spiritual and physical dimensions of halal slaughter. The main requirements are derived from the Qur'an (Surah Al-Ma'idah 5:3) and the Hadiths. Manual slaughter is traditionally preferred because it involves human intention (niyyah) and the invocation of God's name (Hasanah, 2025). Halal meat must be produced in accordance with Islamic jurisprudence, which outlines several key conditions. The animal must be healthy at the time of slaughter; a Muslim must perform the act; the prayer (Bismillah, Allahu Akbar) must be recited; and the cut must sever the carotid arteries, trachea, and oesophagus using a sharp instrument (Permata et al., 2025). After slaughter, the meat must be handled hygienically to avoid contamination with non-halal substances (Mylostyvyi et al., 2025). According to Sudi (2025), certification bodies such as JAKIM in Malaysia, MUIS in Singapore, and HFA in the United Kingdom play a central role in ensuring compliance. However, variations in standards and interpretations across countries continue to pose challenges for exporters and multinational producers.

Role of AI in Halal Meat Production

AI has significantly influenced industries around the world (Ridho, 2025). Using advanced algorithms and powerful data processing capabilities, AI has transformed how organisations operate across different sectors (Satria et al., 2025; Azwar & Usman, 2025). One of the sectors that has greatly benefited from this development is the halal industry (Iswanto, 2024). The halal industry spans various fields, including food, pharmaceuticals, financial services, beverages, cosmetics, and halal tourism (Mahmudy & Kurnianingtyas, 2025). Its growth is not limited to Muslim-majority countries; many Western nations have also recognised the economic potential of the global halal market. As the global Muslim population continues to grow, the halal industry has become a vital component of the world economy, with its market value increasing steadily each year (Nawaz et al., 2025).

The use of AI in the halal industry provides several significant advantages. In production, AI helps automate quality control, detect non-halal ingredients, and ensure that halal standards are followed throughout the process (Ridho, 2025). Machine learning and computer vision allow faster and more accurate analysis of raw materials and final products (Bakar & Rosbi, 2019). Computer vision, a branch of AI, is increasingly applied in meat processing to monitor slaughter methods, identify defects, and detect non-compliance in real time. Salleh et al. (2023) developed a vision-based AI system that verifies the angle and position of cuts during slaughter to confirm halal compliance. The system achieved 94% accuracy in distinguishing between compliant and non-compliant cuts, demonstrating the potential of AI to support real-time decision-making in slaughterhouses. Religious scholars emphasise that technology should only assist human oversight despite these benefits. The spiritual intention (niyyah) and recitation of prayers during slaughter remain essential elements that automation cannot replace (Arshad et al., 2023).

Therefore, AI systems should be regarded as supportive tools rather than independent decision-makers in halal operations. AI has shown strong potential across several aspects of food production.

- Computer vision can monitor slaughter techniques to verify proper incisions, animal positioning, and bleeding (Md Salleh et al., 2023).

- Machine learning models help detect irregularities, predict equipment failures, and maintain traceability throughout the process.

- Blockchain and IoT technologies enhance end-to-end halal tracking within supply chains (Sunmola et al., 2023).

AI, blockchain, and IoT create transparent and traceable halal supply chains when integrated. Blockchain records each production stage in a tamper-proof digital ledger, from farm to table, while IoT sensors monitor temperature, humidity, and potential cross-contamination (Sunmola et al., 2023). In Malaysia, halal certification bodies are testing blockchain-based systems, allowing consumers to instantly verify product compliance by scanning QR codes. Such innovations are particularly valuable in global supply chains where halal authenticity can be rugged to confirm (Ahmed & Latiff, 2023). These technologies are increasingly being adopted in halal logistics and traceability systems, but their use in religiously sensitive stages such as slaughter remains contentious.

Laser-Assisted Slaughter in Meat Processing

Laser technology in food processing is valued for:

- Precision cutting
- Minimal contamination
- Fast processing speed
- Hygienic handling

Laser-guided tools are widely used in industrial butchering and deboning (Park et al., 2021). However, the use of lasers for actual slaughtering in halal contexts raises theological questions. While laser cutting can meet anatomical requirements for *Dhabihah*, scholars debate its acceptability due to:

- Lack of tactile contact by a Muslim slaughterman
- Difficulty in associating human *niyyah* and invocation with automated tools
- Perception of replacing sacred human action with machines (Yunos et al., 2022).

Natural language processing (NLP) and machine learning technologies can automatically analyse ingredient lists, supplier certificates, and potential risk factors, making the halal certification process more efficient. These systems can identify terms such as “gelatin” or “emulsifier” and determine whether the ingredients come from halal-approved sources (Halal Times, 2023). By automating these checks, AI helps reduce human workload and lowers the risk of error or document fraud. In addition, AI is increasingly used for remote monitoring and auditing of halal practices through digital twins and virtual inspections. This enables certification bodies to conduct compliance assessments virtually, which is beneficial during pandemics or in locations where physical inspections are difficult (Md Salleh et al., 2023).

Challenges and Considerations

Theological Acceptability

The theological acceptability of AI in halal meat production is an important consideration to ensure that Islamic principles are not compromised. A key requirement in halal slaughter is that a sane, practising Muslim must perform the act while reciting the name of Allah (tasmiyah). This raises concerns about whether AI technologies, such as robotic arms or automated knives, can fulfil this religious obligation. Many Islamic scholars maintain that complete automation conflicts with the essential human elements of intention (niyyah) and verbal invocation, both of which are central to the validity of halal slaughter. Consequently, while AI can support monitoring, quality control, and supply chain traceability, its direct role in slaughter remains a theological debate.

The use of AI in decision-making for halal compliance introduces an additional level of complexity. AI technologies can identify animals, detect defects, and monitor hygiene in real time, helping to maintain halal standards. However, some scholars warn that excessive reliance on algorithms may weaken the human oversight required by Islamic law. In Islam, moral responsibility cannot be assigned to machines; therefore, all AI-assisted

processes must remain under human control and supervision. The theological acceptance of such technologies depends on ensuring that AI functions as a supportive tool, not a replacement for the human actions prescribed by religion (Mahmud et al., 2020).

The theological debate also extends to the issues of trust and transparency. For AI to be accepted in halal meat production, Muslim consumers and scholars must be confident that the technology operates in accordance with Shariah principles. This requires AI systems to be transparent, explainable, and open to audit so that their processes can be reviewed and verified by Shariah authorities. When AI is used as a tool to support compliance rather than as an independent decision-maker, it is more likely to gain religious acceptance. Ultimately, the integration of AI into halal production depends on its alignment with Islamic values, continued human oversight, and regular consultation with religious scholars.

One of the main challenges is the religious legitimacy of laser-based slaughter. Islamic law requires that the act of slaughter be performed by a conscious Muslim who recites the name of Allah before each slaughter. When a laser device operates automatically without human control or invocation, its permissibility becomes questionable. Although laser and AI technologies offer significant potential for efficiency and accuracy, their integration into halal meat production raises essential religious and ethical concerns:

- Fatwa councils in Malaysia and Indonesia have yet to provide definitive rulings on laser slaughter.
- Scholars suggest that automation may be permitted if a Muslim initiates the laser process and invokes it correctly, keeping human intention intact (Yunos et al., 2022).
- Theological Integrity: Replacing humans in religiously significant processes (e.g., slaughter) remains controversial.
- Cost of Implementation: SMEs may lack resources to adopt AI or integrate blockchain systems.
- Regulatory Fragmentation: Different countries have varying halal standards, complicating AI model training and compliance algorithms.
- Data Security and Ethics: Storing religious data and food certifications on digital platforms requires secure, ethical handling.

Regulatory and Certification Gaps

The use of AI in halal meat production presents significant opportunities to enhance efficiency, traceability, and compliance monitoring. However, one of the main challenges lies in the absence of comprehensive regulatory frameworks that define how AI technologies should be applied within halal certification systems. Existing halal standards largely focus on religious and procedural requirements, such as slaughtering practices, ingredient verification, and hygiene, while giving limited attention to emerging digital technologies. This gap has left producers and certification authorities uncertain about how to evaluate or approve AI-based systems, such as automated slaughter monitoring and blockchain-enabled supply chain tracking, in accordance with Shariah principles (Abdulkareem et al., 2020).

Another concern is the lack of harmonised certification procedures for AI-driven technologies across different jurisdictions. Halal authorities vary in their interpretations of Shariah compliance, and introducing AI without clear, unified guidelines may widen these differences. For example, an AI-powered vision system used to verify slaughter compliance may be recognised in one country but rejected in another due to differing views on automation. Such inconsistencies can erode consumer confidence and create barriers to international halal trade, which depends on reliable and standardised certification practices.

Issues of accountability and transparency also arise when integrating AI into halal assurance. Many AI systems rely on complex algorithms that are challenging for Shariah scholars and regulators to understand and interpret. Without clear auditing mechanisms, verifying that these systems uphold halal standards becomes challenging. Furthermore, the absence of specific ethical and legal guidelines for AI use in halal production raises additional concerns regarding data protection, cybersecurity, and the misuse of automated tools. Addressing these

regulatory and certification gaps is essential to ensure that AI integration strengthens, rather than undermines, the integrity and credibility of halal meat production.

Global halal certification standards differ significantly. Without unified regulations for AI and laser use in halal meat production:

- Cross-border trade may be restricted.
- Duplicate certification may be required, increasing costs.
- Consumer trust may be undermined in regions where laser use is not yet recognised.

Global halal certification bodies must coordinate and issue joint guidelines on the application of automation in religious practices (Tieman, 2015).

Technical Limitations

The use of AI in halal meat production faces several technical challenges that limit its reliability and acceptance. A significant concern is whether AI systems can accurately perform or monitor key halal requirements. For instance, vision-based AI tools may find it difficult to determine in real time if an animal was slaughtered according to Shariah principles, such as verifying a proper cut or confirming that the tasmiyah was recited by a Muslim operator. Poor lighting, animal movement, or equipment faults can reduce accuracy. These limitations raise valid concerns about whether AI can consistently uphold the strict religious and ethical standards demanded in halal certification.

Another challenge is the high cost and complexity of adopting AI technologies in meat production. Many halal meat producers, especially small and medium enterprises (SMEs), operate with limited budgets and may lack the financial or technical capacity to implement such systems. Using AI often requires specialised equipment, regular software updates, skilled personnel, and ongoing maintenance to ensure reliability. These demands make AI adoption difficult for smaller producers. As a result, the advantages of AI in improving consistency, traceability, and efficiency may only benefit larger companies, widening the gap between small and large halal suppliers.

Finally, the lack of interoperability and standardisation poses significant technical challenges. Halal meat production involves several stages: slaughter, processing, transportation, storage, and retail. AI systems used at different points in this chain may not work well together, creating gaps in monitoring and traceability. Moreover, few AI tools are explicitly designed for halal requirements, so existing technologies often require modification, which can lead to inefficiencies and errors. Until issues such as accuracy, cost, and system integration are resolved, the full benefits of AI in halal meat production will remain limited.

Although laser tools offer precise cutting, their implementation in halal slaughter must:

- Ensure real-time sensor feedback to detect animal vitality
- Be controlled by a Muslim operator for each slaughter
- Avoid thermal coagulation that could prevent complete blood drainage

Developing AI-laser systems that adapt to these needs requires specialised engineering and theological consultation.

Consumer Perception and Market Readiness

Consumer perception is a key factor in the successful use of AI in halal meat production. Many Muslim consumers place a strong emphasis on authenticity and religious compliance, and they may be cautious about AI if it appears to reduce human involvement in essential religious processes. Questions such as whether a robot can perform slaughter or whether algorithms can fully protect Shariah principles can create uncertainty and

doubt. Building trust will require collaboration among certifying bodies, religious scholars, and industry stakeholders to clearly explain and demonstrate that AI is meant to support, not replace, halal practices (Abdulkareem et al., 2024).

Market readiness for AI adoption varies across regions and is influenced by technological advancements, regulations, and consumer awareness. There is generally more openness to using AI in developed halal markets such as Malaysia, the Gulf states, and parts of Europe, particularly in managing supply chains and improving traceability. In contrast, less developed markets or more traditional communities may be more hesitant, often due to a limited understanding of AI or concerns that automation weakens the spiritual and ethical aspects of halal. These differences highlight the importance of adopting strategies that are tailored to each region's unique cultural, economic, and educational context.

Transparency and communication also play a crucial role in gaining consumer trust. When AI systems are introduced with transparent certification processes, public awareness efforts, and the involvement of respected religious authorities, consumers are more likely to accept them. Demonstrating how AI can enhance food safety, strengthen traceability, and mitigate fraud in the halal industry can further foster confidence and readiness. However, limited transparency or weak communication may create doubt and resistance.

Ultimately, consumer trust and market readiness will determine whether AI in halal meat production becomes a common practice or remains a limited experiment. Muslim consumers often associate halal with:

- Human involvement
- Ethical animal treatment
- Religious intention

Automated slaughter using lasers may face scepticism or rejection unless supported by transparent halal labelling, religious approval, and proper consumer education. Studies in Malaysia and Indonesia show that over 70% of halal consumers prefer meat slaughtered by hand, unless the technology is clearly certified and well explained (Bonne & Verbeke, 2008).

Findings

This study reveals that the integration of AI and laser-based technologies in halal meat production presents both promising opportunities and significant challenges. On the positive side, AI applications such as computer vision, blockchain, the IoT, and robotics can substantially enhance efficiency, hygiene, and traceability across the halal supply chain. Evidence from recent research and case studies indicates that AI can support compliance monitoring, automate certification processes, and strengthen consumer confidence by promoting transparency from farm to table. Similarly, laser-assisted slaughter offers greater precision, improved hygiene, and consistency, making it suitable for large-scale halal operations.

However, several challenges limit the full adoption of these technologies. The most critical concern relates to theological acceptability, as Islamic law places great importance on human intention (niyyah) and the verbal invocation (tasmiyah) during slaughter. Many scholars express caution toward automation that appears to diminish or replace human involvement in these sacred acts. Furthermore, regulatory and certification gaps persist, as global halal authorities have yet to develop harmonised standards governing AI-based monitoring and laser applications. This lack of coordination creates uncertainty for both producers and consumers. The study also identifies several key insights that contribute to understanding how technological innovation can align with Shariah principles to ensure both operational efficiency and religious integrity.

Technological Opportunities

The study finds that AI offers a promising path for modernising halal meat production. Technologies such as computer vision, robotics, the IoT, and blockchain show strong potential to improve efficiency and consistency in large-scale operations. They can enable real-time monitoring of slaughter processes, strengthen hygiene

control, and ensure accurate record-keeping. Together, these innovations help address many challenges traditional halal practices face in modern industrial settings.

Laser Precision in Slaughter

Laser-based systems offer additional advantages, particularly in achieving hygienic and precise slaughter. Advanced laser technology can help maintain consistency in large-scale production and reduce errors often associated with manual methods. Lasers also meet modern food safety standards by minimising the risk of contamination. This presents halal producers with new opportunities to compete in global markets, where efficiency and hygiene are paramount.

Shariah Compliance Considerations

Despite these technological advantages, the study highlights significant theological concerns. Islamic law places great importance on the human role in halal slaughter, particularly the niyyah (intention) and tasmiyah (invocation of God's name). Many scholars question whether AI or laser systems can fulfil these obligations when human participation is reduced. Therefore, theological acceptability remains the main obstacle to widespread adoption.

Regulatory and Certification Gaps

Another key finding is the absence of unified standards for using AI and laser technologies in halal certification. Halal authorities in various countries interpret Shariah principles in different ways, leading to inconsistent regulations. Without harmonised guidelines, producers remain uncertain whether AI-based or laser-assisted systems will be accepted internationally. This lack of consistency weakens consumer confidence and limits global trade opportunities.

Technical Limitations

From a practical perspective, AI systems continue to face significant technical challenges. Issues such as poor lighting, animal movement, or software errors can reduce the accuracy of computer vision in monitoring halal compliance. Additionally, interoperability issues frequently arise when AI tools are utilised across various stages of the supply chain. These technical limitations make it difficult to rely on AI for consistent and reliable halal assurance.

Cost and Accessibility Barriers

The study also finds that high implementation costs are a significant barrier, particularly for SMEs. AI-based tools and laser technologies require substantial investments in equipment, training, and maintenance. While large producers may afford these expenses, smaller businesses often cannot, leaving them behind in technological advancement. This imbalance creates inequality within the halal industry and may widen the gap between traditional producers and industrial exporters.

Consumer Perception

Consumer trust is a key factor in determining market readiness. Surveys and case studies reveal that many Muslim consumers remain cautious about automation in religiously sensitive processes. Concern is that relying on machines may weaken Halal's spiritual and ethical values. However, the study also finds that clear certification, blockchain-based traceability, and approval from trusted religious authorities can help increase consumer confidence and acceptance.

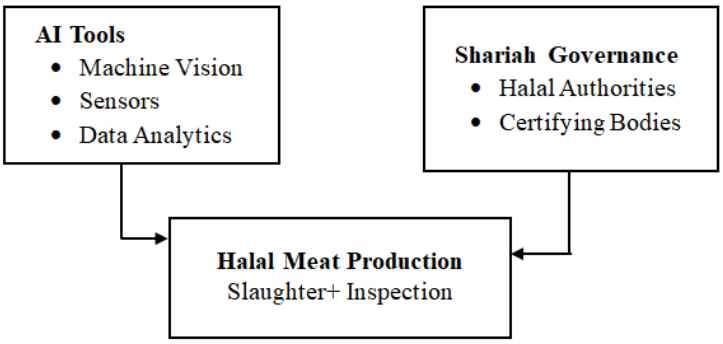
Pathways for Integration

The study emphasises the importance of a balanced approach to integrating AI and laser technologies in halal meat production. Successful implementation requires aligning technological innovation with Islamic jurisprudence, supported by cooperation among technologists, regulators, and religious scholars. Consumer

education and harmonised regulations are also vital to ensure that AI and laser applications achieve industrial efficiency while maintaining the integrity of halal principles.

A conceptual model illustrating the interaction among AI tools, Shariah governance, and production processes

A conceptual model that illustrates the interaction between AI tools, Shariah governance, and halal meat production processes provides a clearer understanding of the integration mechanism. Such a model can demonstrate how AI technologies—such as machine vision, sensors, and data analytics—support Shariah-compliant operations during slaughtering, inspection, and certification stages. It can also map the role of governance structures, including halal authorities and certifying bodies, in monitoring compliance and ensuring that automation does not compromise Islamic principles. By linking technological functions with ethical and legal requirements, the model would show how AI enhances transparency, traceability, and process control within halal manufacturing. Ultimately, this framework would guide policymakers, scholars, and industry stakeholders in adopting AI-driven solutions that maintain religious integrity while improving production efficiency and global competitiveness in the halal meat industry.



The study also highlights several important technical and social challenges. While AI systems have the potential to enhance real-time monitoring and process control, they continue to face limitations related to accuracy, system compatibility, and high implementation costs—particularly for SMEs. Consumer perception remains another critical factor, as many remain cautious about automated slaughter technologies. Surveys suggest that public acceptance depends largely on transparent certification processes and formal endorsement by recognised religious authorities. Overall, the findings suggest that the successful adoption of AI and laser technologies in halal meat production necessitates a balanced approach that harmonises technological advancements with Shariah compliance, consistent regulation, and active consumer engagement.

The comparative analysis of Shariah interpretations across Malaysia, the United Arab Emirates (UAE), and Saudi Arabia further reveals that, although all three jurisdictions uphold the fundamental principles of halal slaughter, they differ in governance structures, certification protocols, and openness to technological innovation. Malaysia places a strong emphasis on the halalan tayyiban principle and detailed documentation. The UAE prioritises standardisation and trade facilitation, while Saudi Arabia maintains strict oversight of slaughter procedures and certification validation. Recognising these distinctions offers a conceptual framework for applying AI and laser technologies in ways that respect local Shariah requirements while advancing efficiency, transparency, and trust in global halal markets. Accordingly, this study positions AI-driven manufacturing as a complementary tool that supports human oversight, strengthens compliance documentation, and reinforces the credibility of halal certification systems across diverse Shariah contexts.

METHODOLOGY

This study is conceptual in nature and reviews both theoretical and empirical works on how AI can support Shariah compliance in halal meat production through advanced manufacturing methods, especially laser technology. It is based on a review of existing literature on AI applications, halal certification, and Shariah governance. The paper discusses how AI can improve efficiency, traceability, and transparency in halal meat processing while ensuring full compliance with Islamic principles. The study draws information from credible

academic journals, conference papers, online sources, and industry publications. By analysing these sources, the paper offers a clear understanding of how AI-based manufacturing can help strengthen Shariah compliance and build greater trust in the halal meat industry in today's technology-driven world.

Proposed Regulatory Guidance for AI and Laser - Based Halal Meat Production (Applicable to JAKIM, Malaysia and BPJPH, Indonesia)

To uphold Shariah compliance while embracing technological advancement, Malaysia's Department of Islamic Development (JAKIM) and Indonesia's Halal Product Guarantee Organizing Agency (Badan Penyelenggara Jaminan Produk Halal - BPJPH) are encouraged to develop harmonised regulatory guidelines for the use of AI and laser-based systems in halal meat production. These guidelines aim to ensure that innovation supports, rather than compromises, the religious and ethical integrity of halal practices.

1- Human Oversight and Religious Intention: AI-assisted slaughter systems should function under the direct supervision of qualified Muslim personnel who perform the tasmiyah and verify that the animal is alive and conscious before slaughter. Automation must assist but not replace the human element required by Shariah.

2- Technology Validation and Shariah Compliance Testing: All AI and laser technologies should undergo validation processes aligned with fatwa-based standards to ensure compliance with halal slaughter requirements, humane treatment, and hygienic quality. Joint certification and research collaboration between JAKIM, BPJPH, and accredited halal research institutes is recommended.

3- Data Transparency and Traceability: AI systems must generate secure, auditable records of slaughter, inspection, and packaging processes. The use of blockchain or other traceability technologies can enhance transparency and support mutual recognition of halal certificates between Malaysia and Indonesia.

4- Certification and Continuous Monitoring: Only technologies approved by JAKIM or BPJPH should be implemented. Regular audits, real-time monitoring, and periodic Shariah reviews should be integrated into the ongoing certification process to ensure sustained compliance.

5- Ethical and Sustainability Principles: AI integration should uphold the halalan tayyiban principles by promoting animal welfare, reducing waste, and supporting environmentally responsible production practices.

By adopting this harmonised framework, Malaysia and Indonesia can strengthen their leadership in halal innovation while preserving religious authenticity, consumer confidence, and global recognition of their certification systems.

AI and Laser-Based Halal Meat Production: Compliance Checklist (For SMEs, Halal Inspectors, and Certification Bodies - JAKIM & BPJPH Aligned)

1. Human Oversight and Religious Intention

- Ensure all slaughter operations are supervised by certified Muslim personnel.
- Confirm *tasmiyah* (invocation) is pronounced for every slaughter instance.
- Verify that automation assists but does not replace human religious actions.

2. Shariah Compliance and Technical Validation

- Obtain technology approval from JAKIM/BPJPH before system installation.
- Conduct a Shariah-based review of AI algorithms and laser precision systems.

- Confirm that the slaughter method does not cause unnecessary animal suffering.

3. System Certification and Operational Approval

- Use only AI and laser equipment certified by recognized halal authorities.
- Maintain updated licenses and halal certifications for machinery and processes.
- Submit systems for annual audit and real-time monitoring review.

4. Data Integrity and Traceability

- Install digital tracking tools (AI-based or blockchain-enabled) for process logging.
- Store all slaughter and inspection data in secure, tamper-proof databases.
- Ensure data can be shared transparently with JAKIM/BPJPH or auditors upon request.

5. Ethical and Sustainability Requirements

- Follow *halalan tayyiban* principles by maintaining cleanliness and humane practices.
- Implement energy-efficient and waste-reducing technologies.
- Periodically assess the ethical implications of AI use, ensuring accountability and fairness.

6. Continuous Improvement and Training

- Conduct regular staff training on AI system use and Shariah compliance.
- Encourage innovation while maintaining religious and ethical integrity.

CONCLUSION

Integrating AI and advanced manufacturing technologies, including laser-based systems, offers a transformative opportunity for the halal meat industry. AI tools, including computer vision, the IoT, blockchain, and robotics, can enhance efficiency, hygiene, traceability, and scalability, thereby strengthening Shariah-compliant practices in an expanding global market. Likewise, laser technology provides greater precision and cleanliness in slaughtering, improving consistency in large-scale operations.

However, successful adoption depends on more than technical capability. Theological acceptance, regulatory alignment, and consumer trust remain significant challenges. Many religious scholars continue to question the automation of sacred rituals, while inconsistent certification standards and high implementation costs create additional barriers, especially for small and medium-sized enterprises.

Ultimately, the future of AI and laser use in halal meat production rests on developing a balanced framework that aligns technological progress with Islamic jurisprudence. This requires close collaboration among technologists, regulators, and Shariah authorities to ensure innovations meet industrial needs while preserving the spiritual and ethical integrity of halal. With transparent practices and sound governance, AI-driven halal production can serve as a model for harmonising tradition and modernity in the global food system.

RECOMMENDATIONS

1. Strengthen Shariah Oversight in Technology Adoption

- Involve Islamic scholars consistently in designing, testing, and certifying AI and laser-based systems to ensure Shariah compliance.
- Establish advisory boards that bring together experts in Shariah, food science, and engineering to provide balanced guidance on innovation.

2. Develop' Unified Regulatory and Certification Frameworks

- Harmonise international halal standards to include clear guidelines for AI monitoring and laser applications.
- Foster collaboration among global halal certification bodies to reduce inconsistencies and strengthen consumer confidence.

3. Promote Transparency and Consumer Awareness

- Apply blockchain and IoT technologies to offer traceable and tamper-proof data that consumers can easily access.
- Launch educational campaigns to clarify that AI enhances halal compliance rather than replacing religious responsibilities.

4. Support SMEs in Technology Adoption

- Provide subsidies, training, and affordable AI tools for small and medium-sized halal producers.
- Encourage partnerships between technology developers and SMEs to make implementation more accessible and cost-effective.

5. Advance Research and Pilot Projects

- Support interdisciplinary research that explores the ethical, theological, and technical aspects of AI and laser integration.
- Conduct pilot projects in halal slaughter facilities to assess practicality, compliance, and consumer acceptance before broader adoption.

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