International Journal on Advanced Science Engineering Information Technology

Vol.15 (2025) No. 2
ISSN: 2088-5334

A Dual Approach to Halal Meat Traceability through QR Codes and Blockchain

Roslan Abdul Wahab [a,c], Ummul Hanan Mohamad [a,b,*], Mohammad Nazir Ahmad [a,b]

[a] *Institute of Visual Informatics, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia*
[b] *iAI-UKM Research Group, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia*
[c] *Koperasi Al-Falah Wealth Berhad, No. 20A, Persiaran Tembok, Taman Tawas Gemilang, Ipoh, Perak, Malaysia*
*Corresponding author: *ummulhanan@ukm.edu.my*

***Abstract*—Existing traceability systems in the halal meat supply chain are acknowledged as having significant shortcomings, leading to decreased consumer confidence and halal standard violations. In response to these challenges, this paper proposed an integrated approach using QR codes and blockchain to improve traceability, especially in the halal meat supply chain ecosystem. This research contributes to developing a schematic diagram that illustrates the interaction of QR codes with the inclusion of a ledger system on a blockchain level from farm to consumer. This provides a step-by-step representation of how these technologies interact across the supply chain. The QR code allows easy access to product information, and blockchain establishes widespread trust in the data through an immutable ledger. Despite its practicality and promising concept, a narrative review of the 22 selected studies showed that the proposed ecosystem has a positive potential for enhancing transparency, restoring consumers' trust, and improving the compliance rate. Moreover, the results highlighted the system's ability to minimize traceability fraud and simplify halal certification procedures. However, the study also highlighted several challenges, including the implementation costs, the absence of standardized data systems, and the requirements of sufficient infrastructure and qualified human resources. This study contributes to the body of knowledge by identifying the key challenges to establishing successful halal meat traceability, highlighting the focus of potential future work on scalability, interoperability, and supply chain optimization.**

***Keywords*— Consumer trust; data integrity; digital authentication; food fraud prevention; supply chain transparency.**

Manuscript received 30 Sep. 2024; revised 19 Jan. 2025; accepted 2 Mar. 2025. Date of publication 30 Apr. 2025.
IJASEIT is licensed under a Creative Commons Attribution-Share Alike 4.0 International License.

I. INTRODUCTION

The halal meat industry is governed by strict dietary guidelines rooted in Islamic law, which guides the process, handling, and distribution of halal meat products. Hence, robust traceability from farm to fork is demanded to uphold halal integrity. Yet until now, the industry has faced challenges in maintaining transparency [1]. Consumers doubt the authenticity and compliance due to the continuous occurrence of halal meat issues [2]. Scandals involving fraudulent practices like mislabeling and adulteration undermine consumers' trust [3], as worrying consumers may inadvertently consume non-compliant meat [4]. This erosion impacts confidence and poses ethical, religious, and health risks for adherents.

According to [5], the halal meat supply chain has continuously been involved in transparency issues, which exacerbate concerns, decrease demand, and damage reputations. Increased scrutiny looms as accountability falters in the supply chain. An urgent need exists to leverage emerging technologies, especially QR codes and blockchain, to restore assurance.

QR codes store substantial data accessible by a simple scan, allowing users to view product origins, processing, and certification [6], [7]. Blockchain maintains an immutable ledger recording every transaction and process [8], decentralizing storage while ensuring records remain unmodified [9]. The solutions offer promising ways to enhance traceability and rebuild confidence for all involved through transparency from start to finish.

Integrity and authentication in halal certification are crucial benchmarks for upholding standards [9]. Merging QR codes with blockchain technology demonstrates the potential for comprehensively resolving traceability deficiencies. According to [10], QR codes can function as a user-friendly interface through which consumers access blockchain-verified information, better ensuring transparency and

trustworthiness. Blockchain guarantees that any information encoded in QR codes remains precise, contemporary, and tamper-proof [11].

This review aims to depict an overview of the existing traceability mechanisms and practices within the halal meat supply chain, consequently pinpointing gaps in existing research. It then explores applying QR codes and blockchain technology as possible solutions for enhancing traceability within the halal meat supply chain. Additionally, the review revealed the benefits and challenges related to these technologies. Ultimately, it seeks to offer an inclusive understanding of how QR codes and blockchain can be incorporated to improve the authenticity and integrity of halal meat products, hence nurturing greater consumer confidence and adherence to halal standards.

II. Materials and Methods

Fig.1 details a narrative review method, distinctly focused on the scope of traceability in the halal meat supply chain using QR codes and blockchain technology. The methodology involved five key steps, each with specified activities and criteria.

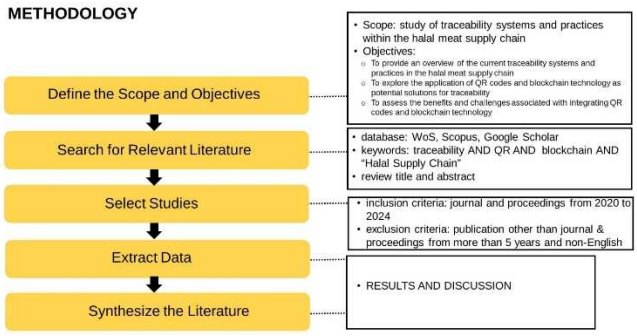

Fig. 1 Review q methodology

A. Define the Scope and Objectives

This initial step involves outlining the research scope and establishing the main objectives. In this context, the research scope includes examining traceability systems and practices within the halal meat supply chain. The objectives are (i) to provide an overview of the prevailing traceability systems and practices in the halal meat supply chain, (ii) to explore applying QR codes and blockchain technology as possible solutions for traceability, and (iii) to assess the advantages and challenges related to these technologies.

B. Search for Relevant Literature

A comprehensive review using several renowned scholarly databases, including Web of Science (WoS), Scopus, and Google Scholar, was performed. Keywords such as "traceability AND QR AND blockchain AND Halal Supply Chain" were used for the search process. Then, the search process was further carried out to perform thorough analyses of titles and abstracts to identify relevant literature.

C. Select Studies

The selection criteria specified only journal articles and proceedings published between 2020 and 2024, written in English. Publications preceding 2020 and outside of journals and proceedings were excluded to focus the research on the recent literature.

D. Extract Data

Systematic extraction of data from chosen studies involved gathering detailed information consistent with the study objectives, ensuring complete information collection for subsequent evaluation.

E. Synthesize the Literature

The final stage synthesizes extracted data, deriving meaningful insights and conclusions. This synthesis was presented in the subsequent section.

III. Results and Discussion

A. Search Findings

Initial searches yielded 210 articles. After removing duplicates and screening titles and abstracts, 42 articles appeared potentially relevant to this study. The selected articles underwent full-text review, resulting in 22 inclusion for analysis (see Table 1).

TABLE I
SEARCH FINDINGS

Database	Total Articles Retrieved	Articles After Screening (2020-2024)	Relevant Articles	Selected for Review
Google Scholar	107	54	32	12
WoS	15	12	7	7
Scopus	7	5	3	3
Total	210	65	42	22

B. Findings of Included Studies

Information and Communication Technology (ICT)can advance traceability and transparency throughout the halal meat supply chain in this digital era. Innovative technologies such as blockchain and QR codes can address traceability and authenticity issues [12]. Traceability is essential to ensure compliance with Islamic dietary rules and to increase trust and transparency in the supply chain. It provides high standards of halal integrity, with a chain of custody at every stage, from the sourcing of the animal and the halal-compliant slaughtering of the animal to processing, packaging, and distribution, to negate the risk of contamination and fraud [13]. Traceability aims to increase consumer confidence by providing accurate product information through QR codes and blockchain, including certification and location provenance, which acts as a seal of approval on the product being consumed. In addition, it offers protection against regulatory violations by allowing tamper-evident records that can enable auditing and minimize abuse of halal labels, preserving the integrity and ethical aspects of halal.

QR codes offer a simple interface through which a user can access detailed information about a product. By connecting them to blockchain records, they allow consumers and stakeholders to quickly and efficiently view the halal status of the meat product and track its history [10]. On the other hand, blockchain technology guarantees the irreversibility and security of traceability records [14]. The decentralized nature treats a tamper-proof ledger to write down each deal and

process inside the supply chain, which makes the supply chain more transparent and more responsible [15].

Integrating QR codes and blockchain can be a game-changer in providing consumers with more control, ensuring seamless compliance, and improving the integrity of the halal meat supply chain as a whole. This would foster greater confidence and trust in halal offerings within the meat supply chain.

1) QR technology for traceability: QR Codes offer a simple but effective way to encode information in a visually readable format [16]. Stakeholders can attach QR codes on the packaging of halal meat, where they can embed relevant and essential data that consumers can then read using their phones to retrieve real-time updates to know if the products are halal or not. This can boost transparency and build trust [17]. This section discusses QR codes' advantages in encoding and accessing halal-related information on meat packaging and tracing the whole chain.

2) Encoding Halal-related information: QR codes can store different types of information in a small two-dimensional format. For example, in the case of halal meat, QR codes can be used to store essential data points related to the lifecycle of the product from farm to fork [18]. This information may include:

a. Product Origin: Information related to the origin of the meat, including the farm or territory from where the animal was produced, bred, and raised, and methods of rearing.
b. Slaughter: Name of halal-certified slaughterhouse, details for halal slaughter process, date and time of slaughter, and name of slaughter personnel.
c. Certification Status: Certification from recognized halal certifying bodies that the meat complies with Islamic guidelines and criteria.
d. Processing and Packaging: Information about how the meat was processed and packaged, including any additives or preservatives used, and the packaging date and expiration date.
e. Supply Chain Transparency: Information on the different entities in the supply chain, including but not limited to distributors, wholesalers, and retailers, and their functions and responsibilities.

Stakeholders can facilitate end-to-end traceability and transparency by encoding such information into QR codes printed on meat packaging labels or tags, thus creating a digital footprint that follows the product along its journey.

3) Accessing information through QR codes: Consumers can view what the QR code hold by using their smartphone or any QR code scanning app [19]. By performing a simple action of scanning the QR code printed on the meat packaging, consumers can immediately access detailed information on the product's halal status and provenance. This knowledge enables consumers to freely consume and purchase food items according to their religion and diet.

Additionally, QR code scanning could also serve an educational purpose to consumers for a better understanding of halal practices, certification standards, and the importance of halal integrity [20]. QR code-enabled platforms help brands and retailers deliver targeted messaging, promotional offers, and educational content, building trust and loyalty among halal-conscious consumers.

4) Blockchain technology for immutable record-keeping: As a decentralized ledger technology, blockchain offers a secure and tamperproof way to record, verify, and safely store transactions among a distributed network of nodes [21]. In the context of the halal meat supply chain, blockchain can be implemented to establish an unalterable record of all chain of custody activities, including sourcing, slaughtering, processing, and distribution [22]. All transactions are securely encrypted and chained with prior transactions to guarantee transparency, accountability, and the ability to trace assets at any supply chain step. This aspect explores how blockchain can establish an unalterable and secure record of halal meat transactions, promoting trust and accountability throughout the supply chain.

5) Decentralized Ledger for Transaction Recording: Blockchain is a decentralized technology that securely and transparently records transactions. Blockchain is a decentralized network, which means it runs through a network of nodes rather than a central database, with each node maintaining a copy of the entire ledger. This transaction or activity is stored in a chain along with multiple transactions, each block cryptographically linked to the previous block in a chain. As a global supply chain, the halal meat industry can adopt blockchain as a decentralized ledger to record all relevant information at every level of the production and distribution process [23].

6) Security and immutability features: Security and immutability are some of the essential features of blockchain technology. Once a transaction is recorded in the blockchain, it can be complicated to change or tamper with the information without a consensus of the network participants. This property guarantees the integrity and authenticity of the recorded data, protecting it from fraud, manipulation, and unauthorized access.

Any attempt to alter or tamper with the recorded transaction at any stage of the halal meat supply chain can easily be identified, hence it provides consumers, regulators, and industry stakeholders with guarantees for the authenticity and compliance of halal meat products. Being transparent and tamper-proof, blockchain ensures that crucial information like halal certification status and production details is verifiable & trustworthy throughout the supply chain.

7) Integration of QR codes and blockchain for end-to-end traceability: Fig.2 illustrates an integrated QR-blockchain ecosystem designed to ensure the traceability and transparency of the halal meat supply chain. The flow of the supply chain is represented from the farm to the consumer, with key stages including breeding and raising animals, slaughtering, processing, distribution, and retail.

The supply chain flow is represented by solid arrows, indicating the progression of meat products through the supply chain from the farm to the consumer. Meanwhile, data transmission to blockchain is indicated by the dashed lines showing how QR code data is sent to the blockchain network at each stage. Blockchain nodes are represented by blue hexagons, indicating the secure storage points within the

blockchain network where data is recorded and verified. The key components include the following:

a. Farm: Breeding and Raising Animals: The process begins at the farm, where animals are bred and raised. QR codes are assigned to each animal, capturing essential data about their origin, breed, and rearing conditions. This information is sent to the blockchain network, ensuring the data is securely stored and immutable.
   Slaughtering: The next stage involves slaughtering, where QR codes continue to be used to document halal certification and adherence to halal slaughtering practices. This data is also uploaded to the blockchain, providing a transparent and verifiable compliance record.
b. Processing: QR codes are again utilized to track the meat products through various stages. The blockchain nodes ensure that all data recorded via the QR codes is securely transmitted to the blockchain network, maintaining a continuous, tamper-proof record of the product's journey.
c. Distribution: The processed meat products are packaged and sold. QR codes on the packaging enable tracking during shipping and storage. Every transaction or transfer of the product is logged on the blockchain so that the entire distribution process can be traceable and verifiable.
d. Retail: Products with QR codes are available for sale at the retail stage. Retailers can scan and verify the halal status and history of the entire supply chain from the farm to the consumer, reassuring customers of the product's integrity.
e. Consumer: Finally, consumers can just scan the QR codes on the product packaging using their smartphones if they are interested in knowing where their meat comes from. Consumers can access all the information on a blockchain from the farm to the table, hence they can trust that their meat is halal by the transaction records stored on the chain.

One of the unique approaches to strengthening halal tracing is the combination of QR codes and blockchain technologies. Conventional systems are either based on centralized databases or do not have any homogenized documents, which has appeared to be ineffective in reducing wastage, fraud, and human errors in the supplier framework [1]. However, QR codes provide a simplified interface to what the stakeholders and consumers are looking for regarding up-to-date, fact-based, demystified information about product origin, processing, and certified identity.

However, the proposed system carries much more interpersonal accommodation than alternative systems, thus enhancing fraud prevention, compliance monitoring, and interaction with the end consumer, a main world-level competition gain. The schematic diagram in Fig. 2 shows the end-to-end traceability using this connected system, which is practically implemented and scalable. These are the two key contributions of the current study to the halal meat industry traceability domain.

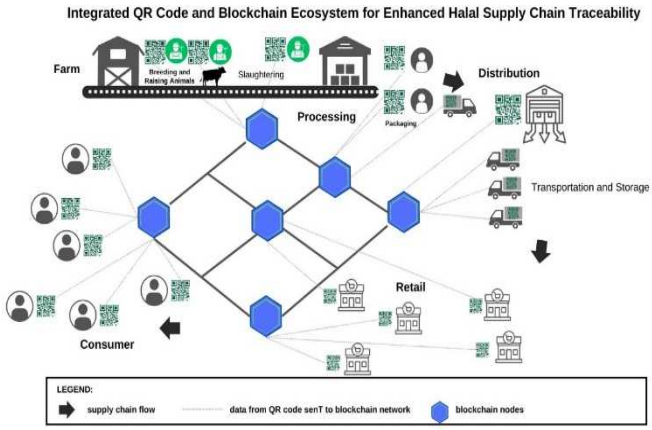

Fig. 2 Schematic diagram of integrated QR code and blockchain ecosystem for enhanced halal supply chain traceability

In recent years, the combination of QR codes and blockchain technology has proven to be a powerful two-prong solution for realizing end-to-end traceability, especially in industries like the halal meat industry. Similar to physical keys, QR codes act as digital keys that connect our physical world to the blockchain world, allowing consumers and stakeholders fast access to blockchain records. A unique identifier or cryptographic token associated with QR codes attached to halal meat packaging links to a particular entry on the blockchain ledger. Scanning the QR code with our smartphone or QR code scanner sends a query to the blockchain network to fetch its corresponding data. Blockchain creates immutable and secure traceability records, as it offers a distributed ledger that is tamper-proof and stores records of transactions and degrees of halal compliance.

8) Benefits of QR Code and blockchain integration: This system aims to link QR codes to halal meat to ensure all stakeholders along the supply chain can benefit from landmark halal traceability developments enabled by blockchain technology.

a. Improved Transparency and Trust: QR codes provide consumers access to verifiable information about meat products' halal status, source, and journey. Similarly, blockchain guarantees data transparency and integrity, building consumer trust and confidence.
b. Enhanced Traceability and Accountability: Blockchain, a decentralized ledger, ensures secure recording and time stamping of transactions at every stage of the supply chain. Through QR codes, stakeholders such as suppliers can access this transparent ledger to trace the flow of products and validate that they are genuine and conventionally halal certified.
c. Optimized Compliance Processes: The digital submission of halal certification documents on a blockchain network enables all stakeholders to audit and optimize compliance processes more quickly, minimizing the administrative workload associated with halal certificates. QR codes provide instant access to certification information, confirming that products comply with regulatory and industry standards.
d. Informed Consumers: QR codes also empower consumers to make informed decisions about halal purchases, enabling them to check the product's origin and halal status at the point of sale. This transparency

leads to consumer loyalty and brand trust, which increases the demand for halal-certified products.

9) Challenges *in Integrating QR Codes and blockchain as a dual approach traceability solution for halal meat supply chain:* Some factors must be considered to make the QR codes-Blockchain duo a complete traceability solution for halal meat supply chains. The halal meat supply chain stakeholders must buy in and work together for QR codes and blockchain to be successfully implemented [24]. Therefore, to address the situation, some educational and awareness initiatives might have to be implemented to overcome resistance to change and increase understanding and technological adoption.

Moreover, standard data formats and protocols should be established to guarantee interoperability and compatibility among different systems and platforms [25]. This will enable the standardization process where common standards must be agreed upon by the industry stakeholders such that any halal-related information can be encoded and shared without any difficulty across entity boundaries.

When using QR codes and blockchain technology, consumer privacy and data security are of the utmost importance [26]. Integrating security measures to safeguard sensitive data and comply with privacy laws (e.g., encryption, access controls, data anonymization) is crucial.

As for infrastructure requirements, the initial deployment of QR codes and blockchain-enabled solutions may necessitate infrastructure investment [27], such as the acquisition of digital scanning devices, installation of blockchain nodes, and secure data storage facilities Before embarking on implementation projects, stakeholders need to evaluate their technological preparedness and resource capabilities.

The QR code and blockchain implementations must adhere to the applicable regulatory requirements and industry standards [28]Stakeholders must operate within a framework of pending regulations and may not have clear guidelines on how to comply.

C. Future Directions and Recommendations for Considerations

Integrating QR codes and blockchain technology in the halal meat industry is still evolving. This section introduces areas for future exploration, innovation, and implementation and suggestions for stakeholders to traverse this transformative pathway. Addressing scalability and interoperability issues related to the integration of QR and blockchain technology should be the objective of further studies [24], [27]. It might involve assessing methods to enhance blockchain scalability, minimize transaction fees, and facilitate smooth data transfer across various platforms and infrastructures. Furthermore, exploring advanced authentication mechanisms to reinforce endorsements of security and integrity of QR codes used in blockchain-based applications may be an important direction for future research. This enables tamper-proof authentication and provenance tracking by establishing ways to connect physical products with their digital identities stored on the blockchain.

Most useful are dedicated studies focusing on consumer behavior and other notable activities, such as buying habits and attitudes toward the brand. Future studies can conduct consumer studies and surveys to gauge consumer attitudes, preferences, and trust levels toward halal meat products accordingly labeled (e.g., QR codes, and blockchain-backed certifications).

In addition, another path for future works to optimize the supply chain could be to explore how QR code-based data and blockchain are used to optimize the supply chain vis-a-vis inventory management, demand prediction, and logistics optimization. Data analytics and machine learning algorithms have the potential to generate value by providing insights from blockchain data, empowering stakeholders to ensure efficiency and reduce waste in the halal meat supply chain.

IV. Conclusion

Traceability is a key factor affecting halal meat production and distribution, referring to the ability to track the movement of meat products through the entire supply chain, from farm to fork [29]Traceability means that each step in the supply chain—from sourcing to processing, packaging, and distribution—has its relevant information captured and recorded. For halal consumers, traceability ensures that products meet religious dietary requirements such as proper slaughtering and halal certification standards.

Additionally, [30] noted that traceability is essential for regulatory compliance, quality control, and food safety management. When accurate records and documentation are maintained, stakeholders can promptly trace issues like contamination, adulteration, and cross-contamination, ensuring the protection of public health and reducing the chances of foodborne diseases.

The study by [1] highlighted that utilizing the possibilities offered by QR codes and blockchain would enable visibility, traceability, and trust in the halal meat supply chain, benefiting consumers and industry actors. There are a few implementation challenges that face are high infrastructure and deployment costs, non-standardization of data systems, and requirements for infrastructure and human resources to maintain QR codes and blockchain in the halal meat supply chain.

A critical component of blockchain becoming widely used for anti-counterfeit is the active tracing and identification of the goods in question by consumers through QR codes. Consumers' involvement is vital to the success of adoption. They will actively scan the QR codes to learn more about the authenticity or traceability of the product. They will give feedback if any misleading information or incorrect data is found.

Educating consumers and engaging them through more user-friendly and accessible media can help build trust in these technologies and the benefits they provide during their adoption. A cooperative effort from other industry stakeholders, regulators, and developers will be required to tackle these challenges, facilitate scalability, and cover a broad cross-section of the system.

Most initiatives are currently in the pilot stage. Hence, future research should focus on scaling up these projects to assess their effectiveness and feasibility on a larger scale. Industry-wide standards for QR code encoding, blockchain data formats, and data-sharing protocols are needed. Developing these standards will ensure interoperability and consistency across the supply chain.

Other than that, ensuring that QR code and blockchain implementations comply with relevant regulations and

standards is crucial. Further studies need to be conducted regarding regulatory frameworks and best practices for the integration of these technologies [27]. In addition, a cost-benefit analysis would help stakeholders understand the economic implications of adopting QR codes and blockchain technologies. Future studies should assess cost-effectiveness and return on investment potential.

As with every technology, there are challenges, but there are also primarily benefits, and some recommendations can be considered to overcome the difficulties of QR code and blockchain integration in the halal meat industry. Working with all stakeholders along the supply chain, from producers to processors to distributors to retailers, and consumers, to ensure coordination and alignment with the requirements for implementing QR code and blockchain solutions. Education and training programs for stakeholders can be offered to foster understanding and awareness of QR codes and blockchain technology. This will allow stakeholders to understand how to utilize these technologies appropriately.

Moreover, integrating industry standards for QR code encoding, blockchain data formats, and data-sharing protocols will facilitate interoperability, compatibility, and consistency throughout the halal meat supply chain. Ontology is one potential solution to the demand for industry standards. Furthermore, the prioritization of privacy and security measures to protect consumer data and ensure compliance with privacy regulations is paramount, especially to prevent data breaches or even cyber threats.

The next step in research and implementation should be on scalability, interoperability, behavioral aspects regarding consumers, and supply chain optimization, especially with bulk products. Stakeholders can harness the potential of QR codes and blockchain integration in the halal meat sector by investing in innovation, encouraging coordination, creating awareness with the regulators, educating consumers, and tracking new trends [10]. In the longer term, economies may integrate QR code and blockchain technology into the halal meat industry in a way that fosters a supply chain ecosystem capable of building the transparency, resilience, and trust that halal-conscious consumers want and expect from their products worldwide. Innovation and collaboration will pave the way to a future where halal meat products are not only by religious dietary laws but are also synonymous with quality, trust, and integrity.

ACKNOWLEDGMENT

The Geran Ganjaran Penyelidikan UKM, GP-K021917, supports this research.

REFERENCES

[1] I. Masudin et al., "Traceability system in halal procurement: A bibliometric review," *Logistics*, vol. 6, no. 4, p. 67, 2022, doi:10.3390/logistics6040067.

[2] F. Ahmad, M. Z. Shah, and Z. J. MohamadHusny, "Exploring the Halal meat cartel case: A legal framework and insight from the regulator," in *Halal Logistics and Supply Chain Management*. Routledge, 2022, pp. 122-131, doi: 10.4324/9781003223719-13.

[3] A. H. M. Daud, U. Lee, and A. Ismail, "The practice of Halal certification: A case of Malaysia's Halal meat-based industry," *Int. J. Acad. Res. Bus. Soc. Sci.*, vol. 13, no. 8, pp. 1563-1577, 2023, doi:10.6007/ijarbss/v13-i8/17666.

[4] L. A. H. F. Dashti et al., "Enhancing halal food traceability: A model for rebuilding trust and integrity in Muslim countries," *J. Islamic Mark.*, vol. 15, no. 12, pp. 3382-3408, 2024, doi: 10.1108/jima-06-2023-0167.

[5] M. R. Mustapha et al., "Ethical issues in the halal food supply chain: A systematic bibliometric review," *J. Islamic Mark.*, vol. 15, no. 12, pp. 3804-3819, 2024, doi: 10.1108/JIMA-07-2023-0210.

[6] P. Li et al., "Applications of food packaging quick response codes in information transmission toward food supply chain integrity," *Trends Food Sci. Technol.*, p. 104384, 2024, doi: 10.1016/j.tifs.2024.104384.

[7] M. T. H. Le, "Fostering product quality and brand trust by QR code traceability and customer reviews: The moderating role of brand reputation in blockchain," *J. High Technol. Manage. Res.*, vol. 35, no. 1, p. 100492, 2024, doi: 10.1016/j.hitech.2024.100492.

[8] D. W. Y. King et al., "Blockchain-Based Traceability Method - A Review," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2024. doi: 10.1007/978-981-99-7339-2_23.

[9] N. Mehmood, M. Shah, and H. Faisal, "Blockchain Technology and Halal Certification: Issues and Developments," in Emerging Technology and Crisis Management in The Halal Industry: Issues and Recent Developments, Springer, 2024, pp. 3–14. doi: 10.1007/978-981-97-1375-2_1.

[10] N. Mishra, S. Mistry, S. Choudhary, S. Kudu, and R. Mishra, "Food traceability system using blockchain and QR code," in IC-BCT 2019: Proceedings of the International Conference on Blockchain Technology, Springer, 2020, pp. 33–43. doi: 10.1007/978-981-15-4542-9_4.

[11] K. H. Chua, M. E. Rana, V. A. Hameed, and M. H. Rana, "Crosschecking Verification Over the Ethereum Blockchain Using QR Scannable Products," in 2024 5th International Conference on Data Analytics for Business and Industry (ICDABI), IEEE, 2024, pp. 190–199. doi: 10.1109/icdabi63787.2024.10800043.

[12] K. Duan, H. Onyeaka, and G. Pang, "Leveraging blockchain to tackle food fraud: Innovations and obstacles," J Agric Food Res, p. 101429, 2024, doi: 10.1016/j.jafr.2024.101429.

[13] A. Amid, "Halal Detection Technologies," Solving Halal Industry Issues Through Research in Halal Sciences, pp. 41–54, 2024, doi:10.1007/978-981-97-3843-4_3.

[14] F. Casino, T. K. Dasaklis, and C. Patsakis, "A systematic literature review of blockchain-based applications: Current status, classification and open issues," Telematics and informatics, vol. 36, pp. 55–81, 2019, doi: 10.1016/j.tele.2018.11.006.

[15] K. Salah, N. Nizamuddin, R. Jayaraman, and M. Omar, "Blockchain-based soybean traceability in agricultural supply chain," Ieee Access, vol. 7, pp. 73295–73305, 2019, doi: 10.1109/ACCESS.2019.2918000.

[16] G.-P. Botilias et al., "Designing and Developing a Meat Traceability System: A Case Study for the Greek Meat Industry," Sustainability, vol. 15, no. 16, p. 12162, 2023, doi: 10.3390/su151612162.

[17] B. Harsanto, J. I. Farras, E. A. Firmansyah, M. Pradana, and A. Apriliadi, "Digital Technology 4.0 on Halal Supply Chain: A Systematic Review," Logistics, vol. 8, no. 1, p. 21, 2024, doi:10.3390/logistics8010021.

[18] A. Susanty, N. B. Puspitasari, Z. F. Rosyada, M. A. Pratama, and E. Kurniawan, "Design of blockchain-based halal traceability system applications for halal chicken meat-based food supply chain," International Journal of Information Technology, vol. 16, no. 3, pp. 1449–1473, 2024, doi: 10.1007/s41870-023-01650-8.

[19] J. Zhao, A. Li, X. Jin, and L. Pan, "Technologies in individual animal identification and meat products traceability," Biotechnology & Biotechnological Equipment, vol. 34, no. 1, pp. 48–57, 2020, doi:10.1080/13102818.2019.1711185.

[20] M. Nazir, "Technology and Digital Transaction in Halal Retailing," in Emerging Technology and Crisis Management in The Halal Industry: Issues and Recent Developments, Springer, 2024, pp. 123–137. doi:10.1007/978-981-97-1375-2_8.

[21] S. Dong et al., "Blockchain technology and application: An overview," *PeerJ Comput. Sci.*, vol. 9, p. e1705, 2023, doi:10.7717/peerj-cs.1705.

[22] A. Susanty et al., "Design of blockchain-based halal traceability system applications for halal chicken meat-based food supply chain," *Int. J. Inf. Technol.*, vol. 16, no. 3, pp. 1449-1473, 2024, doi:10.1007/s41870-023-01650-8.

[23] S. Jabbar et al., "Blockchain-enabled supply chain: Analysis, challenges, and future directions," *Multimedia Syst.*, 2021, doi:10.1007/s00530-020-00687-0.

[24] M. H. Ali et al., "A sustainable Blockchain framework for the halal food supply chain: Lessons from Malaysia," *Technol. Forecast. Soc.*

Change, vol. 170, p. 120870, 2021, doi:10.1016/j.techfore.2021.120870.
[25] R. Belchior et al., "A survey on blockchain interoperability: Past, present, and future trends," *ACM Comput. Surv.*, vol. 54, no. 8, pp. 1-41, 2021, doi: 10.1145/3471140.
[26] S. Zhang et al., "A traceability public service cloud platform incorporating IDcode system and colorful QR code technology for important product," *Math. Probl. Eng.*, vol. 2021, p. 5535535, 2021, doi: 10.1155/2021/5535535.
[27] A. Tan, D. Gligor, and A. Ngah, "Applying blockchain for halal food traceability," *Int. J. Logist. Res. Appl.*, vol. 25, no. 6, pp. 947-964, 2022, doi: 10.1080/13675567.2020.1825653.
[28] E. Karyani et al., "Intention to adopt a blockchain-based halal certification: Indonesia consumers and regulatory perspective," *J. Islamic Mark.*, vol. 15, no. 7, pp. 1766-1782, 2024, doi:10.1108/jima-03-2023-0069.
[29] K. Demestichas et al., "Blockchain in agriculture traceability systems: A review," *Appl. Sci.*, vol. 10, no. 12, 2020, doi:10.3390/app10124113.
[30] H. C. Wahyuni, "Analysis of interplay between food safety systems and halal standards in Indonesia," *Int. Food Res. J.*, 2024, doi:10.47836/ifrj.31.2.03.