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Technological Advancements in Halal Ecosystem: Harnessing Information Technology for Certification and Traceability

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Abstract

This paper explores the role of technological advancements in addressing challenges within the Halal ecosystem, with a specific focus on certification and traceability. Applying information technology solutions such as blockchain, Internet of Things (IoT), artificial intelligence (AI), and big data analytics, this study investigates how these technologies can streamline certification processes, enhance transparency, and improve traceability in the Halal supply chain. By examining current practices, challenges, and opportunities in the Halal industry, this research aims to contribute to the advancement of Halal certification and traceability through the utilization of information technology.

Keywords: Halal Ecosystem, Halal Certification, Halal Traceability

1. Introduction

Halal certification and traceability processes are integral components of the Halal ecosystem, ensuring compliance with Islamic dietary laws and ethical standards throughout the production, distribution, and consumption of Halal products. These processes involve various stakeholders, including certification bodies, producers, suppliers, and regulatory authorities, and aim to provide transparency, integrity, and assurance to consumers seeking Halal products.

The Halal certification is a comprehensive procedure aimed at ensuring that products and services comply with Islamic dietary laws and ethical standards. It begins with the producer or manufacturer submitting an application to a recognized Halal certification body, accompanied by detailed documentation outlining the ingredients used, production processes, and other relevant information related to Halal compliance. Following this, the certification body conducts a thorough assessment and inspection of the production facilities, equipment, ingredients, and processes. This assessment involves on-site visits, audits, and reviews of documentation to verify compliance with Halal standards. Specifically, the certification body examines the ingredients to confirm their Halal status and assesses the production processes to ensure adherence to Islamic principles, such as proper slaughtering methods for meat products. Upon successful verification of compliance, the certification body issues a Halal certificate to the producer or manufacturer, affirming that the products meet Halal requirements and can be marketed as Halal-certified. Importantly, Halal certification is not a one-time process; it requires ongoing monitoring and compliance. Certification bodies may conduct regular inspections and audits to ensure continued adherence to Halal standards, and certificates typically need to be renewed periodically

to maintain validity. This rigorous certification process is essential for maintaining consumer trust and confidence in Halal products and contributes to the integrity and authenticity of the Halal ecosystem.

The Halal traceability plays a crucial role in ensuring the integrity, authenticity, and safety of Halal products throughout the supply chain. It begins with product identification, where Halal products are assigned unique identifiers through labeling, barcoding, or other tracking mechanisms, allowing them to be traced from production to consumption. Producers and suppliers maintain detailed records of Halal products, including information about ingredients, suppliers, production dates, and batch numbers, facilitating traceability and quick identification in case of recalls or quality issues. This record-keeping is essential for maintaining transparency and accountability in the supply chain, enabling stakeholders to track the movement of Halal products from production facilities to distribution centers, retailers, and ultimately, consumers. By providing visibility into the supply chain, traceability mechanisms ensure that Halal products maintain their integrity and authenticity, thereby building consumer trust and confidence. Moreover, traceability facilitates quality control and assurance by allowing producers to monitor the entire lifecycle of Halal products, identify deviations from Halal standards or quality issues, and take prompt corrective actions. In the event of a product recall or contamination, traceability enables swift and targeted recalls, minimizing the impact on consumers and the reputation of Halal brands. Overall, the Halal traceability process is essential for maintaining the highest standards of Halal integrity and ensuring consumer safety in the Halal ecosystem.

The Halal industry has witnessed significant growth globally, driven by the increasing demand for Halal products and services among Muslim consumers. However, ensuring the authenticity and compliance of products with Halal standards remains a challenge due to the complexities of supply chains, certification processes, and the global nature of trade. Traditional methods of certification and traceability are often labor-intensive, time-consuming, and prone to errors, leading to inefficiencies and risks in the Halal ecosystem.

In recent years, advancements in information technology (IT) have offered promising solutions to address these challenges. Technologies such as blockchain, Internet of Things (IoT), artificial intelligence (AI), and big data analytics have the potential to revolutionize the Halal ecosystem by providing robust tools for certification, traceability, and market growth. These technologies can enhance transparency, trust, and efficiency throughout the Halal supply chain, enabling stakeholders to better meet the needs and expectations of Halal consumers.

Despite the potential benefits, there is a lack of comprehensive research exploring the application of information technology in the Halal ecosystem. Understanding the current landscape, challenges, and opportunities in leveraging IT for Halal certification and traceability is crucial for the development and implementation of effective technological solutions.

In this paper, it aims to describe technological advancements related to halal certification and traceability.

2. Methodology

This research used the literature analysis method to delve into the topic of halal certification and traceability in the digital age. The researchers conducted a systematic search in academic literature, scientific articles, books, and related sources that focused on the said topic. This approach helped the researchers formulate a comprehensive understanding of the research topic.

3. Impact of Information Technology in Halal Certification and Traceability

Information technology (IT) has significantly impacted Halal certification and traceability within the Halal ecosystem, revolutionizing traditional practices and addressing longstanding challenges. It has significantly transformed traditional certification processes, leading to increased efficiency, transparency, and trustworthiness. One of the primary impact of IT on Halal certification is the digitization and automation of certification procedures. With the adoption of digital platforms and software solutions, certification bodies can now manage certification applications, documentation, and assessments more efficiently, reducing processing times and administrative burdens. This digitization streamlines the entire certification process, making it faster, more accessible, and less prone to errors. It facilitated the standardization and harmonization of Halal certification procedures across different regions and countries. Through digital platforms and online databases, certification bodies can now access and share standardized certification guidelines, best practices, and regulatory requirements, fostering greater consistency and uniformity in Halal certification processes worldwide. This standardization not only reduces confusion and ambiguity but also promotes global acceptance and recognition of Halal certifications, facilitating international trade and market access for Halal products.

In halal traceability, information technology applications offers transformative solutions that enhance transparency, efficiency, and accountability throughout the supply chain. Nowadays, there are technologies that enable real-time tracking of Halal products from production to consumption, providing stakeholders with unprecedented visibility into the movement and handling of products. By leveraging IT solutions, certification bodies, manufacturers, and retailers can effectively monitor the entire lifecycle of Halal products, ensuring compliance with Halal standards and facilitating rapid response in the event of product recalls or quality issues. Further, it has facilitated the implementation of robust traceability systems that enable seamless data collection, sharing, and analysis across the supply chain. Through digital platforms and data analytics tools, stakeholders can capture and analyze vast amounts of data related to Halal products, including information about origins, production methods, handling procedures, and distribution channels. This data-driven approach to traceability not only enhances transparency and accountability but also enables stakeholders to identify trends, detect anomalies, and optimize supply chain processes, ultimately improving efficiency and reducing risks associated with Halal traceability.

4. Application of Information Technology Relevant to Halal Certification and Traceability

Blockchain technology holds the potential to ensure the quality and adherence to Halal standards of food products. A study about blockchain based halal food production tracking extensively examines the application of blockchain technology in the food industry, focusing on its role in addressing Halal-related concerns, implementation strategies, and operational mechanisms. Data recording throughout the supply chain process is facilitated by a private blockchain, while complaint resolution is managed through a permissioned blockchain. Smart contracts are integrated into the transaction system, forming part of the blockchain infrastructure. The utilization of blockchain for managing complaints and tracking Halal products presents significant advantages, as evidenced by findings indicating tracking speeds up to 10 times faster than conventional methods, thereby minimizing losses through targeted issue resolution.

As supply chains expands globally, there is an increasing concern about the full integrity and traceability of halal food. A study on applying blockchain for halal food traceability highlights the traceability issues that Malaysia's food supply chain is currently facing in order to meet Halal regulations. The researchers of this study contextualize these challenges within the frameworks of agency theory and institutional

theory. This paper present a brand-new blockchain-based traceability framework that is based on actual blockchain implementation in three different halal supply chains. With input from three Blockchain software companies, the technology with smart contract is suggested with the goal of developing a conceptual framework that combines Halal procedures and technologies to enhance the traceability of the Halal food supply chain from farm to fork. In another study conducted entitled "Blockchain-Based Traceability System to Support the Indonesian Halal Supply Chain Ecosystem" it proposed a model that can be enhanced to be a national standard tool to develop the economy towards a sustainable supply chain. The model involves actors such as Slaughterhouse, Abattoir, Halal Body, Distributor, Retailer and Consumer. It also proposed a layered system design to separate physical-related action and digital-related action. To keep digital and physical actions apart, we suggest a tiered system architecture. For the digital process, it leverage blockchain as a publicly accessible, unaltered database and IoT devices for data entry.

Artificial intelligence and Internet of Things (IoT) technologies are revolutionizing halal traceability and certification by enabling real-time monitoring and data-driven insights throughout the supply chain. A study entitled "Integrating the Internet of Things in the Halal Food Supply Chain: A Systematic Literature Review and Research Agenda" showed that IoT offers the Halal Food Supply Chain (HFSC) with five key advantages: product traceability, improved supply chain efficiencies, easier livestock management, food authenticity verification, and halal certification monitoring. Several obstacles were noted, such as the cost and regulatory constraints, lack of consumer adoption, technological immaturity, and the technical limits of IoT devices. The results of the study offer scholars, policy makers, and the HFSC community better insight into the current state of IoT research in the halal food literature, as well as its development, challenges, and potential research paths. In a study entitled "Halal Meat Supply Chain Traceability Based on HACCP, Blockchain and Internet of Things" significantly advances the field by proposing a real-time food tracing system for the halal meat supply chain that integrates blockchain, Internet of Things, and Islamic dietary rules intoHazard Analysis Critical Control Point (HACCP).

The application of technology is not only limited to Blockchain, Artificial Intelligence and Internet of Things, a study proposed the utilization of Near Field Communication (NFC) technology for premise Halal Certification by attaching an NFC chip to the Halal certificate displayed at the premises, customers or authorities can easily authenticate the certificate. Given the widespread use of smartphones today, which are equipped with NFC capabilities, this technology presents an accessible solution. An application software can be designed for customers, available for download from the authority's website. By simply tapping their smartphone to the Halal certificate embedded with an NFC chip, customers can verify its authenticity. Another advantage of this system is that it facilitates spot checks by authorities to ensure that Halal certificates are up-to-date and authentic, as they can swiftly tap the certificate with a mobile phone or handheld reader, connecting to the authority's database for verification. In a study entitled "Tracking and Tracing the Halal Food Supply Chain Management using Blockchain, RFID, and QR Code" implemented some special tags (RFID/QR Code). These special tags track the food products from farm to consumer and vice versa tracing the halal food from consumer to producer to reduce the contamination of food items with halal food items.

5. Technological Advancements in Halal Certification and Traceability

This section describes the technological advancements related to halal certification and traceability.

Artificial Intelligence

1. **AI-powered Halal Compliance Assessment:** Develop AI algorithms to analyze production processes and ingredients to ensure compliance with Halal standards. AI can identify and flag potential non-compliance issues, improving the accuracy and efficiency of certification assessments.
2. **Natural Language Processing (NLP) for Halal Document Analysis:** Utilize NLP algorithms to analyze textual documents related to Halal certification, such as ingredient lists, manufacturing procedures, and Halal standards. AI can extract relevant information, identify discrepancies, and ensure consistency in certification documentation.
3. **AI-driven Halal Product Authentication:** Implement AI-powered authentication systems to verify the authenticity of Halal products. AI algorithms can analyze product features, packaging, and labeling to determine the Halal status and detect counterfeit or fraudulent products.
4. **Predictive Analytics for Halal Compliance Monitoring:** Employ predictive analytics using AI to forecast potential Halal compliance issues in production processes. By analyzing historical data and trends, AI algorithms can identify patterns and predict future non-compliance risks, allowing for proactive corrective actions.
5. **AI-based Halal Traceability Solutions:** Develop AI-powered traceability systems to track and trace Halal products throughout the supply chain. AI algorithms can analyze data from various sources, including IoT sensors and blockchain records, to provide real-time visibility into product movement, handling, and authenticity.
6. **Machine Learning for Halal Certification Decision-making:** Implement machine learning models to support decision-making in Halal certification processes. By analyzing historical certification data and outcomes, machine learning algorithms can assist certification bodies in making informed decisions and predicting certification results.
7. **AI-driven Virtual Auditing for Halal Compliance:** Develop AI-powered virtual auditing solutions for assessing Halal compliance in production facilities. Using AI algorithms and computer vision technology, virtual auditors can conduct remote inspections, analyze facility conditions, and identify potential compliance issues without the need for physical presence.
8. **Deep Learning for Halal Labeling and Packaging Compliance:** Utilize deep learning techniques to ensure compliance with Halal labeling and packaging requirements. Deep learning algorithms can analyze images and visual data to verify accurate labeling of Halal products, including Halal logos, certification marks, and product information.
9. **AI-enabled Halal Certification Training and Education:** Offer AI-enabled training programs for Halal certification professionals and auditors. AI algorithms can simulate certification scenarios, provide real-time feedback, and offer personalized training modules to enhance certification skills and knowledge.
10. **AI-powered Halal Market Insights and Trends Analysis:** Develop AI algorithms to analyze market trends, consumer preferences, and Halal industry dynamics. AI-driven analytics can provide valuable insights into market demand, product innovation opportunities, and emerging Halal certification trends, facilitating strategic decision-making for businesses and certification bodies.

Blockchain

1. **Blockchain-Based Halal Certification Platform:** Develop a decentralized blockchain platform specifically designed for Halal certification processes. This platform could facilitate transparent and

immutable recording of Halal certification transactions, ensuring tamper-proof certification records accessible to all stakeholders.

2. **Smart Contracts for Certification Compliance:** Utilize smart contracts on the blockchain to automate certification compliance processes. Smart contracts could be programmed to execute certification procedures automatically based on predefined criteria, reducing human intervention and ensuring consistency in certification assessments.
3. **Traceable Supply Chain on Blockchain:** Implement a blockchain-based traceability system for the Halal supply chain, allowing stakeholders to trace the journey of Halal products from source to shelf. Each transaction or movement of products could be recorded on the blockchain, providing transparency and authenticity in the supply chain.
4. **Blockchain-Based Halal Product Verification:** Develop a blockchain-enabled solution for consumers to verify the authenticity of Halal products. By scanning a product's QR code or barcode, consumers can access its blockchain record to confirm its Halal certification status, ingredients, and production details.
5. **Blockchain-Powered Halal Integrity Assurance:** Integrate blockchain technology with IoT devices to monitor and track Halal product integrity in real-time. IoT sensors could collect data on product conditions (e.g., temperature, humidity) during transportation and storage, which is then securely recorded on the blockchain, ensuring compliance with Halal standards.
6. **Cross-Border Certification Recognition:** Establish a blockchain network for cross-border recognition of Halal certifications. This network could enable seamless verification and acceptance of Halal certifications across different countries and regions, streamlining international trade of Halal products.
7. **Blockchain-Based Halal Audit Trail:** Create a blockchain-based audit trail for Halal certification audits. Auditors can securely record their findings and observations on the blockchain during certification assessments, providing transparent and traceable audit trails for regulatory compliance and quality assurance purposes.
8. **Blockchain-Based Halal Certification Marketplace:** Develop a decentralized marketplace on the blockchain for Halal certification services. This platform could connect Halal businesses with certified auditors and certification bodies, facilitating transparent and efficient certification processes.
9. **Blockchain-Enabled Halal Standards Development:** Collaborate with stakeholders to develop and update Halal standards and guidelines on a blockchain platform. This decentralized approach could allow for transparent and inclusive decision-making processes, ensuring the relevance and integrity of Halal certification standards.
10. **Blockchain-Based Halal Certification Training and Education:** Create an online blockchain-enabled platform for training and educating Halal certification professionals. This platform could offer courses, resources, and certification programs on Halal standards, practices, and blockchain technology, empowering professionals with the knowledge and skills needed for effective Halal certification processes.

Internet of Things

1. **IoT-enabled Halal Monitoring Devices:** Develop IoT devices equipped with sensors to monitor and track Halal compliance factors such as temperature, humidity, and hygiene conditions in

production facilities. These devices can provide real-time data to ensure adherence to Halal standards during the production process.

2. **IoT-based Traceability Solutions:** Implement IoT-based traceability solutions to track the movement of Halal products throughout the supply chain. By integrating IoT sensors with product packaging or containers, stakeholders can monitor the location, handling, and storage conditions of Halal products from production to consumption.
3. **Smart Halal Certification Tags:** Introduce smart certification tags embedded with IoT sensors to authenticate Halal products. These tags can contain unique identifiers linked to blockchain records, allowing consumers to verify the authenticity and Halal status of products by scanning the tag with their smartphones.
4. **Automated Halal Compliance Monitoring:** Deploy IoT-enabled devices for automated monitoring of Halal compliance factors in production processes. These devices can detect deviations from Halal standards in real-time and trigger alerts or corrective actions to maintain compliance.
5. **IoT-driven Quality Assurance Systems:** Implement IoT-based quality assurance systems to ensure the quality and integrity of Halal products. IoT sensors can monitor critical parameters such as freshness, shelf-life, and contamination risks, enabling proactive measures to maintain product quality and safety.
6. **IoT-enabled Halal Logistics Management:** Utilize IoT devices for efficient management of Halal logistics and transportation. IoT sensors can track the location, condition, and handling of Halal products during transit, ensuring compliance with Halal standards and minimizing risks of contamination or adulteration.

6. Conclusion

In conclusion, this paper highlights the transformative potential of information technology (IT) in enhancing certification and traceability processes within the Halal industry. Through the adoption of innovative IT solutions such as blockchain, Internet of Things (IoT), and artificial intelligence (AI), the Halal ecosystem can benefit from improved transparency, efficiency, and integrity in certification procedures, as well as enhanced traceability throughout the supply chain. These technological advancements not only streamline Halal certification processes but also ensure the authenticity and compliance of Halal products, ultimately fostering consumer trust and confidence in the Halal market. Moving forward, continued research and investment in IT-driven solutions will be essential for advancing the Halal ecosystem, driving innovation, and supporting the sustainable growth of the Halal industry.

List of References

1. American Halal Foundation. “The (Detailed) Halal Certification Process”. Retrieved from https://halalfoundation.org/the-detailed-halal-certification-process/
2. Alamsyah, A. et. al. (June 2022). “Blockchain-Based Traceability System to Support the Indonesian Halal Supply Chain Ecosystem”.Retrieved from https://www.mdpi.com/2227-7099/10/6/134
3. Gligor, D. & Ngah, Azizi.(April 2019). “Applying Blockchain for Halal Food Traceability”. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/13675567.2020.1825653
4. Imanto, T. & Yazid, S. (October 2021). “Blockchain Based Halal Food Production Tracking”. Retrieved from https://ieeexplore.ieee.org/abstract/document/9631868

5. International Halal Certification. “Simple Steps Towards Halal Certification”. Retrieved from https://international-halal.com/steps-for-halal-certification/Kadir, E. A. et. al. (May 2015). “Application of NFC technology for premise Halal certification”. Retrieved from https://ieeexplore.ieee.org/abstract/document/7231497
6. N. Nasurudeen Ahamed et.al . (November 2023). “Tracking and tracing the halal food supply chain management using blockchain, RFID, and QR code”. Retrieved from https://link.springer.com/article/10.1007/s11042-023-17474-4
7. Nusran, M. (2023) . “Halal Certification in The Digital Age: Leveraging Online Platforms for Enhanced Transparency and Accessibility”. Retrieved from https://jurnal.seaninstitute.or.id/index.php/Juemi/article/view/379/238
8. Rejeb, A. et.al. (March 2021). “Integrating the Internet of Things in the halal food supply chain: A systematic literature review and research agenda”. Retrieved from https://www.sciencedirect.com/science/article/pii/S2542660521000056
9. Rejeb, A. (November 2018). “Halal Meat Supply Chain Traceability Based on HACCP, Blockchain and Internet of Things”. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3319432
10. Shafi, et.al. (January 2012). “Halal Traceability Framework for Halal Food Production”. Retrieved from https://www.idosi.org/wasj/wasj17(TTHTA)12/1.pdf