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INTEGRATING ARTIFICIAL INTELLIGENCE AND BLOCKCHAIN TO IMPROVE THE ACCURACY OF HALAL CERTIFICATION

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ABSTRACT

Objective: The study aims to explore the integration of artificial intelligence (AI) and blockchain technology into the halal certification process, focusing on improving accuracy, transparency, and efficiency. It evaluates how these technologies can enhance the halal certification system in Indonesia, mainly through the SiHalal platform developed by the Halal Product Assurance Agency (BPJPH).

Research Design & Methods: This study uses a qualitative approach, reviewing the literature and analyzing the implementation of AI and blockchain technologies in halal certification in Indonesia through case studies and interviews with key stakeholders to assess the effectiveness and potential impact of integrating these technologies.

Findings: The study found that AI and blockchain improve efficiency, transparency, and security in the halal certification process. AI automates error detection and improves accuracy, while blockchain prevents fraud through immutable records. The SiHalal platform successfully integrates the two to simplify the process and increase public trust and user satisfaction.

Implications & Recommendations: The study recommends the expansion of the SiHalal platform and further development of AI and blockchain integration to improve scalability and security, policy support for technology infrastructure and training of halal auditors, and adoption of SiHalal by halal businesses to improve efficiency and transparency, with suggestions for technology developers to continue innovating in addressing scalability and interoperability challenges.

Contribution & Value Added: This study contributes to the literature on modernizing halal certification systems by showing how integrating AI and blockchain can revolutionize the process. It also provides insights into how technology increases trust, reduces fraud, and enables regulation, positioning Indonesia as a global halal market leader.

Keywords: artificial intelligence (AI), blockchain, halal certification

JEL codes: Z12, O33
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INTRODUCTION

The integration of AI and blockchain technology has received significant research attention in recent years due to its potential to revolutionize various industries (Ekramifard et al., 2020; Kurni et al., 2022). This combination offers opportunities for secure data sharing, decentralized decision-making, and increased trust in digital systems (Tian et al., 2022). The combination of AI and blockchain improves security in data management and decision-making and increases user trust in digital systems, making them more transparent and reliable.

Blockchain can create a decentralized system that ensures the authenticity and transparency of data in the supply chain of halal products, from the source of raw materials to the end consumer. Blockchain technology's ability to provide secure and tamper-proof records (Kurni et al., 2022; Tian et al., 2022). For example, blockchain can ensure the integrity of supply chain data. Blockchain can strengthen audit trails and protect against the risk of counterfeiting, as each entity in the supply chain can verify the origin and status of products in real-time. For example, in the halal food supply chain, blockchain enables product tracking and verification from production to distribution using technologies such as QR codes and IoT, making it easier for consumers to access information related to product halalness (Shuib et al., 2021). With blockchain, critical information such as raw material sources, processing methods, and product distribution can be transparently monitored, thereby strengthening consumer trust and minimizing opportunities for counterfeiting (Junejo et al., 2021). This makes blockchain a potential solution to improve the reliability of halal supply chains and ensure compliance with sharia requirements.

On the other side, AI can strengthen this process by offering predictive analysis and automation in certification validation. However, challenges remain, such as varying standards and the need for cross-sector collaboration (Bux et al., 2022; Dewi & Hakiki, 2023; Tan et al., 2022). AI's capacity for intelligent decision-making can be particularly relevant for the Halal certification process. Unlike blockchain, AI can analyze data to judge Halal compliance accurately. AI provides intelligent analysis, efficient data processing, and automated decision-making, while blockchain ensures data security through a decentralized mechanism, which makes data immutable and more trustworthy. The combination of these two technologies offers great opportunities for secure data sharing in various sectors, including finance, healthcare, and supply chain, where sensitive data can be better protected from the threat of manipulation or cyberattacks (Tian et al., 2022). In decentralized decision-making, AI integrated with blockchain enables the creation of autonomous systems free from centralized control, increasing trust in digital systems through smart contracts that are automatically executed without third-party intervention (Chavali et al., 2020).

In the context of Halal certification, this technology has the potential to be an innovative solution to improve accuracy, transparency, and trust in the system. This is important as the demand for halal products continues to increase globally, with Muslims accounting for more than 1.9 billion people worldwide. Halal certification is crucial in the food and consumer products industry, especially for the growing Muslim market globally. As a symbol of assurance that products do not contain haram elements and are processed according to Islamic law, halal certification is crucial to meet the demands of Muslim consumers who are increasingly aware of the importance of halal aspects in their daily consumption. Halal certification not only guarantees halalness but also increases consumer confidence and expands the market for producers, especially for SMEs that want to penetrate international markets (Bux et al., 2022).

Indonesia, a country with the largest Muslim population, considers halal certification an important element in increasing product competitiveness in local and global markets and an important tool in increasing sales for food manufacturers. According to Law No. 33 of 2014 concerning Halal Product Guarantee, products that enter, circulate, and trade in Indonesia must be halal certified (Naisabur & Putra, 2024). Halal certification has been proven to increase added value for MSME (Micro, Small, and Medium Enterprises) products by helping to increase Muslim consumer confidence in the safety and halalness of these products while increasing competitiveness in international markets (Gayatri Anggarkasih & Sukmana Resma, 2022). Thus, they have greater access to the rapidly growing global market for halal products (Purnomo, 2023). Thus, halal certification helps protect Muslim consumers and provides a great opportunity for Indonesia to become one of the major exporters of halal products in the international market.

The Quran and Hadith are the primary reference sources in Islam, which guide Muslims in various aspects of life, including halal and haram issues (Permana et al., 2021). Although specific verses about the halal industry are not mentioned, the Quran generally emphasizes the importance of following Islamic principles in all aspects of life, which also applies to industrial practices. For example, in the food industry, principles drawn from the Quran and Hadith strongly emphasize the importance of ensuring food ingredients' halalness and quality (tayyib). As explained in the Al-Quran letter Al-Baqarah verse 168:

يٰٓاَيُّهَا النَّاسُ كُلُوْا مِمَّا فِى الْاَرْضِ حَلٰلًا طَيِّبًاۖ وَّلَا تَتَّبِعُوْا خُطُوٰتِ الشَّيْطٰنِۗ اِنَّهٗ لَكُمْ عَدُوٌّ مُّبِيْنٌ

Meaning:

"O humans, eat of the lawful (food) of the earth and do not follow the steps of the devil. Indeed, he is a real enemy to you."

In the Quran, Surah Al-Baqarah verse 168, Allah calls humans to eat halal and good (thayyib) food and not follow the steps of Satan who misleads. This verse is an important basis for regulating the halalness of products in Islam. Modern technologies such as blockchain and artificial intelligence (AI) significantly ensure product halalness by increasing the halal supply chain's transparency, trust, and efficiency.

The concept of halal *thayyib*, which means 'halal and good,' not only refers to the halal status of food but also ensures that it is free from hazards or elements that harm health. This approach covers various aspects, from ingredients and production processes to distribution, by Sharia principles that prioritize food safety and hygiene to protect the ummah from the dangers of consuming products that are unfit or contain haram substances. The setting of standards and application of the halal concept has evolved, reflecting the need to adapt the application of sharia principles to the complexities of modern industry. These principles are explained in various Sharia sources, including the Quran and Hadith, which are the main basis for Muslims in ensuring compliance with halal rules (Kirihara, 2021).

Halal certification has become an obligation for business owners, especially for food and beverage products, a significant challenge for the halal industry in the digital economy era (Hasan & Pasyah, 2022). Interestingly, despite the importance of halal certification, enforcing this regulation still has some challenges. The research found that there are practices of halal label manipulation in some food stalls, including the use of fake halal labels and cooking processes that mix non-halal ingredients (Fasiha et al., 2019). In addition, the complicated halal certification process is also an obstacle for Micro, Small, and Medium Enterprises (MSMEs) to fulfill halal certification obligations (Fasiha et al., 2019; Naisabur & Putra, 2024).

The complex certification process and high costs make it difficult for many Micro, Small, and Medium Enterprises (MSMEs) to obtain halal certification. Several studies have shown that the main obstacles for MSMEs are a lack of understanding of halal regulations, high certification costs, and convoluted administrative processes (Masyhuri & Risdiyanti, 2022; Ramadhan & Gunanto, 2021). On the other hand, although regulated by various laws, existing regulations are often ineffective in enforcement. For example, law enforcement and supervision of the use of fake or expired halal logos is still a problem that has not been fully resolved, causing consumer confidence to be compromised (Sholeh & Mursidi, 2023).

Government challenges and collaboration with businesses are relevant. However, there is a need for collaboration between the government, certification bodies, and industry players to strengthen socialization, simplify the certification process, and use digital technology that supports traceability and transparency. For this digitalization solution to be successful, collaboration between the government, industry players, and certification bodies is essential. The government must provide supporting regulations and infrastructure, such as an integrated national halal blockchain platform. Industry players should invest in training and adopting technological tools, while certification bodies can draft standardized protocols for integrating blockchain and AI in halal auditing. With this approach, digital technology not only simplifies the certification process but also improves traceability and consumer confidence while strengthening the competitiveness of Indonesian halal products in the global market.

LITERATURE REVIEW

This literature review will discuss various studies conducted regarding integrating blockchain technology and artificial intelligence (AI) in the halal certification process. Reviewing previous research will outline how these two technologies have improved transparency, accuracy,

and efficiency in various sectors, including the halal supply chain. The literature will also evaluate the strengths and weaknesses of each approach, as well as their potential impact on halal data management, consumer confidence, and company competitiveness. Prior research will form the basis for understanding how AI and blockchain can be optimized to improve the accuracy of halal certification.

Halal Certification

Halal certification refers to a verification process that ensures a product or service complies with Islamic law, making it suitable for consumption or use by Muslims. It covers sectors such as food, cosmetics, pharmaceuticals, and financial products and is seen as a guarantee that the product was produced, processed, and distributed without violating Sharia principles. In some countries, such as Malaysia, the halal certification has evolved into a strict and globally recognized industry standard, where the government regulates and ensures compliance through specialized agencies (Fischer, 2016). According to Rafiki (2019), halal certification covers religious aspects and is also related to compliance with product safety and hygiene standards, especially in the food industry. This is important to build trust and ensure the product is acceptable to Muslim consumers.

In various countries, including Indonesia, halal certification is regulated through strict regulations. In Indonesia, Law No. 33/2014 on Halal Product Guarantee requires all products on the market, including food, beverages, medicines, and cosmetics, to have halal certification. This is an effort to provide legal protection and ensure that products in circulation comply with sharia principles. Mellita et al., (2020) added that halal certification also serves as a tool to increase the added value of a product. In Indonesia, this certification is mandatory for all products in circulation by the law on Halal Product Guarantee. This certification fulfills the maqasid al-shariah principle, which includes the protection of religion, soul, mind, offspring, and property (Hasan, 2019).

With the growing demand for halal products worldwide, halal certification has become an important tool in international trade. These certifications help products meet global standards and facilitate exports to countries with a majority Muslim population. In addition, the halal market also includes non-Muslim consumers who consider halal products an additional symbol of quality and safety. Therefore, the implementation of halal certification is not only important for Muslim consumers but also contributes to broader market appeal.

Blockchain in Halal Certification

Blockchain is a digital tool that can complement the halal validation, certification, and audit process from upstream to downstream (Sim & Abdullah, 2022). This technology allows the storage and verification of halal certificates, thereby increasing trust in the product or service because the stored data cannot be changed or accessed by the public (Karyani et al., 2024). Blockchain can improve halal supply chain performance and company competitiveness (Hendayani & Fernando, 2023). This system can also speed up the tracking of halal products up to 10 times faster than conventional methods (Imanto & Yazid, 2021).

Blockchain in halal certification can be defined as a technology that provides a distributed and transparent system for tracking the halal status of food products along the supply chain. Blockchain enables the storage and verification of halal certificates, thereby increasing trust in the product or service as the data cannot be altered or accessed by the public once stored. This technology also helps track the halal status of food from raw materials, processing, packaging, and transportation to the end consumer (Novianti et al., 2020). Some studies show contradictions in the readiness of blockchain implementation. While the Halal Examining Agency is not ready to implement blockchain technology, the Halal Product Guarantee Agency (HPGA) strongly supports adopting this technology in the certification process (Karyani et al., 2024). However, overall, blockchain is seen as a promising solution to improve the transparency and integrity of the halal supply chain.

The use of technology in the halal certification process is growing to improve efficiency and reliability. For example, blockchain technology can record and verify the halalness of products

transparently. A blockchain-based certification system that allows all data related to the halalness of products to be stored securely and can be accessed by consumers at any time. This technology provides additional trust because the information stored in the blockchain cannot be changed, reducing the risk of counterfeiting halal certificates (Agung et al., 2022).

Blockchain in halal certification offers an innovative solution to improve halal products' transparency, integrity, and traceability. This technology can overcome various challenges in the halal supply chain, including cross-contamination, certificate forgery, and logistical issues (Munawar & Mugiono, 2024). The blockchain implementation enables secure and immutable data recording during the supply chain process, while complaint handling uses permissioned blockchain (Imanto & Yazid, 2021). Several studies have proposed blockchain frameworks and architectures for halal food integrity. For example, in Indonesia, business players and Indonesian halal authorities are the two main layers that influence the integrity of halal food based on blockchain platforms (Vanany et al., 2020). Blockchain can also facilitate continuous halal validation and certification, especially during the COVID-19 pandemic when Muslim consumers turn to online shopping (Sim, 2023; Sim & Abdullah, 2022).

The adoption of blockchain in halal certification has the potential to increase consumer confidence and the efficiency of the certification process. Studies show that consumers' intention to use this technology is directly influenced by their attitudes and indirectly by their beliefs (Karyani et al., 2024). Although some halal inspection bodies may not be ready to implement blockchain technology, halal certification authorities generally support adopting this technology (Dewi & Hakiki, 2023; Karyani et al., 2024). The use of blockchain for halal product tracking is proven to be up to 10 times faster than conventional methods and can minimize losses due to more targeted handling of issues (Imanto & Yazid, 2021). Thus, blockchain is emerging as a transformative tool that can empower halal authorities to adapt to the evolving demands of Muslim consumers, especially in the online realm that is rapidly expanding during and post-pandemic (Sim, 2023).

Role of AI in the Halal Certification Process

Artificial Intelligence (AI) plays an important role in the certification process in various sectors. The main focus of implementing AI certification is ensuring that AI systems operate ethically and reliably. This certification is important in maintaining the quality and reliability of AI systems, whether in production, technology, or public use. AI certification can be done through third-party or self-help approaches, where ethical standards and transparency are key to the success of the process (Cihon et al., 2021). In the production sector, certification of AI-enabled systems ensures the quality of production processes and highlights the importance of AI transparency and accountability to ensure high-quality standards. Measurement and improvement of the apparent capabilities of these systems are a key focus in the certification process to ensure public trust.

The development of certification is also related to ethical and sustainability needs, where AI certification should be able to ensure that AI systems adhere to ethical and sustainable principles. For example, in the European sector, discussions on AI certification have also emphasized the importance of including sustainability in AI auditing and certification to ensure positive long-term impacts (Genovesi & Mönig, 2022). Certification also plays a role in building consumer confidence in using AI in various scenarios, including both high and low-risk ones, through certification labels designed to increase transparency (Scharowski et al., 2023).

AI can be used to ensure the production process complies with halal standards, improving the safety and quality of halal products. AI can scan, inspect, and incorporate errors that may occur in a product (Tobing et al., 2024). This has the potential to improve halal compliance, streamline the supply chain, and increase the productivity of the halal industry. In the context of halal tourism, AI can enhance the Muslim traveler experience at every stage of the journey, from planning to the evaluation visit (Battour et al., 2022). This shows the potential of AI to expand its application not only to the production process but also to the service aspect in the halal industry.

The application of AI in ensuring halal production processes can have a significant impact on improving transparency, efficiency, and product quality. Technologies such as the Internet of Things (IoT) and AI enable real-time monitoring of raw material sourcing to delivery, ensuring products remain compliant with halal standards throughout the supply chain. With this capability, AI plays an important role in checking for potential errors or deviations from halal standards, increasing consumer confidence in product safety. An example of implementing advanced technology to improve the efficiency of the halal supply chain is already evident through the development of an IoT-based warehouse management system that helps guarantee the integrity of halal products, improve operational efficiency, and ensure compliance with halal standards (Rizki et al., 2023).

AI also enables better data integration in the halal supply chain through blockchain technology, which enables transparent and accurate tracking of products from start to finish. This gives consumers more assurance over the halalness of their products and ensures that every production stage can be audited easily. This technology improves efficiency and provides stronger protection for the integrity of halal products in the global market (Chandra et al., 2019).

METHODS

This research uses a library research approach, focusing on collecting data from literature sources such as scientific journals, books, and research reports. The aim is to gain a comprehensive understanding of how Blockchain ensures data integrity and transparency, as well as how AI enhances analysis and prediction in the halal certification process. One key technique used in this study is the Systematic Literature Review (SLR). This method involves several stages, including: 1) Searching: Identifying relevant literature from various databases. 2) Filtering: Selecting studies that meet predefined inclusion criteria. 3)Analysing: Organising and coding data from the selected studies. Through this systematic process, researchers can synthesize findings, identify knowledge gaps, and draw evidence-based conclusions. This approach is particularly useful for providing a thorough understanding of theories, empirical findings, and best practices related to the topic. By adopting SLR, the study ensures that the conclusions drawn are valid, reliable, and supported by previous empirical evidence. This method not only highlights existing knowledge but also identifies opportunities for further research and development in the integration of Blockchain and AI within the halal certification framework.

RESULT AND DISCUSSION

The halal certification process using AI and Blockchain technology is increasingly important to improve accuracy, transparency, and efficiency. By using AI, the system can scan, analyze, and detect any potential errors in the certification process, such as non-compliance with halal standards. On the other hand, Blockchain is a decentralized platform that records all data related to the halal certification process permanently and securely, so it cannot be manipulated. Blockchain implementation in halal certification also enables a transparent audit trail, from raw materials to the final product, which increases consumer confidence in the halalness of the products consumed.

The Halal Product Guarantee Agency (BPJPH) of the Ministry of Religious Affairs is working to strengthen the Halal Information System through the development of artificial intelligence (AI) and blockchain technology. This technology is expected to increase transparency, reliability, and efficiency in the halal certification process. Cooperation with the Department of Sharia Economics and Finance (DEKS) of Bank Indonesia and the Blockchain, Robotics, and Artificial Intelligence Network (BRAIN) Team of IPB University shows the seriousness of BPJPH in presenting innovative solutions. Several studies have shown that the application of blockchain in the halal industry in Indonesia, such as in the supply chain of meat and other halal products, offers a system capable of facilitating transparency, product tracking, and protection from falsification of halal information (Alamsyah et al., 2022; Dewi & Hakiki, 2023). This initiative is also expected to address the challenges and limitations of the traditional halal certification process, which is often time-consuming and costly (Agung et al., 2023).

The AI and blockchain-based platform that can be implemented to make halal certification is SiHalal. The development of blockchain and AI in the Sihalal application can be the basis for standardizing a more efficient and measurable halal certification process in Indonesia and encouraging Indonesia's position as a global halal market leader. SiHalal has great potential to be implemented in the halal certification process in Indonesia. The use of blockchain in this application can increase transparency and efficiency, especially in ensuring the validity of halal products throughout the supply chain. Several studies have shown that integrating blockchain technology enables better tracking, increasing consumer confidence in the authenticity of halal products (Dewi & Hakiki, 2023). In addition, the use of smart contracts can also support a faster and more transparent certification process, enabling public scrutiny of the halal certificates issued (Agung et al., 2023). The implementation of these technologies not only accelerates the certification process but also opens up opportunities for Indonesia to lead the global halal market through innovative and scalable technological solutions (Alamsyah et al., 2022).

The registration process for SiHalal, a technology-based halal certification application managed by the Halal Product Guarantee Agency (BPJPH), involves several important steps to make it easier to obtain halal certification. This initiative is supported by the existence of a free halal certification scheme for small and medium enterprises (MSMEs) through the SEHATI program, which allows businesses to register by self-declare with guidance from halal product process assistants. This initiative is supported by the existence of a free halal certification scheme for small and medium enterprises (MSMEs) through the SEHATI program, which allows businesses to register on a self-declared basis with guidance from halal product process assistants (Fitri & Mardiah, 2023).

The following are the general stages in the SiHalal registration process (Fitri & Mardiah, 2023):

1. Access the SiHalal platform

Access to the SiHalal platform is important for producers and entrepreneurs who want to obtain halal certification for their products. This platform is managed by BPJPH (Halal Product Assurance Organizing Agency). It is available through the official website and the SiHalal application, which can be accessed online both through the SiHalal application and the official website at https://sihalal.go.id.

2. Creating an account

The initial registration process usually requires creating an account, which can be done using a valid email address or business information. On the main page, business owners can choose the registration option by creating an account using an active email and password. Once the account is created, business owners need to verify their email to activate the account.

3. Filling in business data

After having an account, business actors must fill in complete data about their company or business. The information required includes the company name, product type, location, and several supporting documents such as business permits or other legal documents.

4. Upload documents

Prospective registrants are required to upload documents required for halal certification. These documents include product information, raw materials, production processes, and other documents such as certificates of materials used. All of these documents will be verified by the authorities. This process aims to ensure that the product meets halal criteria.

5. Halal auditor verification process

After the documents are uploaded, BPJPH will appoint a halal auditor to check the completeness of the documents and conduct an audit of the production process. The halal auditor may make a direct visit to the production site to ensure that the entire process is in accordance with halal principles. In this audit, the auditor will check whether all materials and tools used in production are truly free from haram or najis materials and whether the production process complies with the standards set by BPJPH and the Indonesian Ulema Council (MUI). If deficiencies or inconsistencies are found, the business actor must correct and re-upload the required documents or information.

6. Issuance of halal certificates

After all audit processes are completed and the product is declared halal by the auditor, BPJPH will issue a halal certificate digitally through the SiHalal platform. This certificate will contain information about the product, company, and validity period of the certificate. This halal certificate is recorded in the blockchain system so it can be verified by any party to ensure its authenticity, increasing transparency and consumer trust.

7. Payment and certificate activation

After the certificate is issued, business actors are required to complete the payment of the halal certification fee set by BPJPH. For micro and small businesses, there is a free halal certification scheme through the SEHATI program, which allows registration to be carried out without charge under certain conditions. After payment is completed, the certificate will be active and valid for a certain period of time (usually 4 years) before it must be renewed.

8. Monitoring and certificate extension

The halal certificate issued has a certain validity period. Users can monitor the status of the certificate through the SiHalal dashboard and will receive a notification if it is approaching the expiration date. To extend the certificate, users must submit a re-audit and follow the extension procedure determined by BPJPH.

With the integration of blockchain technology and artificial intelligence (AI) in the SiHalal platform, the halal certification process has become faster, more transparent, and more efficient. Blockchain technology allows for decentralized data storage and tracking so that information about halal products, including certificates and audit processes, can be accessed and verified by all interested parties. This system helps reduce the risk of document forgery and increases public trust in the authenticity of halal certificates. For example, using smart contracts in blockchain allows for automated management of halal certification requirements, where actions are only taken when certain conditions are met. This ensures that the certificates issued are in accordance with applicable halal standards (Agung et al., 2023). In addition, research shows that the application of blockchain in the halal supply chain improves the chain's performance and the companies' competitiveness by providing higher transparency and strengthening consumer trust in halal-certified products (Hendayani & Fernando, 2023).

CONCLUSION

Integrating AI and blockchain technology in the halal certification process offers significant potential to improve accuracy, transparency, and efficiency. AI can scan, analyze, and detect potential errors in the certification process, while blockchain is a decentralized platform that records all data related to the halal certification process permanently and securely, preventing manipulation. The Halal Product Assurance Agency (BPJPH) of the Ministry of Religious Affairs in Indonesia is seeking to strengthen the Halal Information System through the development of AI and blockchain technology. The SiHalal platform, which combines these technologies, has the potential to streamline the halal certification process in Indonesia and position the country as a leader in the global halal market. The SiHalal registration process involves several key steps, including accessing the platform, creating an account, filling in business data, uploading documents, verifying by a halal auditor, issuing a digital halal certificate, payment and activation of the certificate, and monitoring and renewing the certificate. Integrating blockchain and AI in SiHalal enables faster, more transparent, and more efficient halal certification, reducing the risk of document forgery and increasing public trust in the authenticity of halal certificates.

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