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Implementation of Blockchain Technology to Increase Trust and Transparency in Halal Supply Chain: Case Study in Indonesia

Hendri Hermawan ADINUGRAHA[*1], Muhammad Rikzam KAMAL[2] and Teddy DYATMIKA[3]

[1]*State Islamic University of KH Abdurrahman Wahid Pekalongan, Department of Sharia Economics, Indonesia*
[2]*State Islamic University of KH Abdurrahman Wahid Pekalongan, Department of Information Technology, Indonesia*
[3]*State Islamic University of KH Abdurrahman Wahid Pekalongan, Department of Islamic Communication and Broadcasting, Indonesia*

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ABSTRACT
The halal industry in Indonesia faces challenges in ensuring transparency and trust in the supply chain, such as data manip ulation and limited traceability. This study aims to explore the implementation of blockchain technology to overcome these problems, focusing on increasing efficiency, transparency, and consumer trust. The research method involves interviews with halal industry players, secondary data analysis from related reports, and simulation of blockchain implementation through digital recording of raw material, certification, and distribution data. The results show that blockchain enables decentralized data recording that cannot be manipulated, thereby increasing supply chain transparency up to 40% faster than traditional methods. This technology also strengthens data integrity by implementing smart contracts, which ensure Sharia compliance at every stage of the process. Consumers can verify the halalness of products in real time through QR codes, increasing trust in local halal products. In addition, blockchain adoption helps manufacturers comply with national halal standards more efficiently and opens up opportunities for increasing exports by up to 30% through compliance with international standards. This study proves blockchain can be a strategic solution in overcoming transparency challenges in the Indonesian halal industry, supporting digital transformation efforts, and strengthening the country's position as the world's halal economic center. Collaboration between government, certification bodies, and industry is needed to maximize the implementation of this technology.

1. INTRODUCTION

The global halal industry has experienced significant growth in the last decade. As one of the countries with the largest Muslim population, Indonesia plays a strategic role in developing the halal ecosystem in the food, pharmaceutical, cosmetic, and tourism sectors. Based on the Global Islamic Economy Report 2023, the global halal economy is estimated to reach USD 7.2 trillion in 2024, with Indonesia's contribution increasing [1] . However, the halal industry still faces significant challenges in ensuring transparency and trust in its supply chain.

The halal supply chain in Indonesia includes various actors, from producers and distributors to end consumers [2]. However, the lack of a system to ensure the halalness of products end-to-end is often a significant issue. For example, reports of misusing halal labels and lack of transparency in raw material processing usually harm consumers and weaken market confidence [3]. Therefore, innovative solutions are needed that meet Sharia standards and increase operational efficiency and trust in the supply chain.

Many previous studies have discussed the importance of transparency in the halal supply chain. However, traditional approaches such as manual audits and certification are often time-consuming, prone to manipulation, and inefficient at scale [4]. Meanwhile, blockchain technology is gaining attention as a potential tool to increase transparency in various sectors, including finance, health, and logistics. Unfortunately, the adoption of blockchain in the context of the halal supply chain

[*]Corresponding author
*e-mail : hendri.uingusdur.ac.id
ORCID ID: 0009-0003-5488-8252

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in Indonesia is still limited, both in terms of practical implementation and scientific studies.

Furthermore, while several studies, such as Saberi et al. ([5], have explored the benefits of blockchain for the general supply chain, little research integrates halal-specific needs, such as sharia compliance and certification. Therefore, there is an urgent need to bridge this gap through a comprehensive approach that examines how blockchain can be effectively implemented in the Indonesian halal ecosystem.

Based on the above phenomena and research gaps, several main problems that can be formulated are: 1) How can blockchain technology be implemented to ensure transparency and trust in the halal supply chain in Indonesia?; 2) What are the obstacles faced in implementing blockchain technology in the halal industry, both in terms of technical and regulatory aspects? 3) How can blockchain integrate with national halal standards (Indonesian National Standard/SNI) effectively?

This study uses the Technology Acceptance Model (TAM) theoretical approach developed by Davis [6]. TAM is relevant to understanding the factors that influence the adoption of new technologies, including blockchain, in organizations and society [7]. In addition, Institutional Theory is used to explain how regulatory pressures, social norms, and culture influence the adoption of blockchain technology in the halal supply chain [8].

Several previous studies provide an essential foundation for this research. Cai et al. [9], identified the benefits of blockchain in the supply chain, such as increased transparency and reduced operational costs. Iskandar et al. [10], discusses the importance of halal supply chain management and the challenges faced in halal product certification. Purwanto et al. [11], explored the factors influencing blockchain adoption in the agribusiness sector, suggesting that regulation and public awareness are the determining factors. However, these studies have not explicitly examined the context of the halal supply chain in Indonesia, leaving a gap that can be filled.

The focus of this study is to explore the application of blockchain technology in Indonesia's halal supply chain, aiming to increase transparency, efficiency, and consumer trust. Although Yahya et al. [12], study has shown the benefits of blockchain in the supply chain, such as increased transparency and cost efficiency, the study has not specifically explored blockchain applications in the halal industry. Similarly, Ali et al. [13], highlights the importance of halal supply chain management and certification challenges without integrating blockchain technology as a potential solution to overcome these obstacles. Meanwhile, Puspita et al. [14], discuss the factors of blockchain adoption in the agribusiness sector, such as regulation and public awareness, but do not relate them to the unique requirements and complexities of halal certification.

Therefore, this study fills the gap in the literature by focusing on: a)Indonesian context: As one of the world's largest halal markets, Indonesia faces significant challenges in ensuring halal and supply chain transparency, including raw material traceability and certification; b) Blockchain Integration with Halal Supply Chain: This research explores how blockchain technology can address specific issues in halal supply chain data management, including halal certification authentication, upstream-to-downstream product tracking, and fraud risk reduction; c) Increasing Trust and Transparency: With the adoption of blockchain, this study aims to prove that this technology can provide technology-based solutions to increase consumer trust in halal products in Indonesia.

This study not only broadens the academic understanding of blockchain implementation in the halal supply chain but also offers practical recommendations for industry players and policymakers to drive digital transformation in the halal sector in Indonesia [15].

This research is relevant considering the increasing global demand for transparent, trusted halal products. In Indonesia, blockchain implementation can help strengthen the country's position as the center of the world's halal industry. In addition, this research can provide practical recommendations to the government and industry players to overcome existing challenges while increasing the competitiveness of Indonesian halal products in the international market. This study explores blockchain technology's potential to increase transparency and trust in Indonesia's halal industry supply chain. Combining theoretical and practical approaches is expected to contribute significantly to developing Indonesia's sustainable, technology-based halal ecosystem.

2. MATERIALS AND METHODS

2.1. Research Approach

This research was conducted using an applied exploration approach to identify how blockchain technology can improve transparency and trust in Indonesia's halal industry supply chain. This research mainly focuses on recording the halal certification process and digital product tracking from upstream to downstream.

The research protocol was approved by the Ethics Committee of State Islamic University K.H.

Abdurrahman Wahid Pekalongan, Indonesia. Participants provided informed consent through a voluntary form that included details about the study, potential risks, benefits, confidentiality, and participants' rights. This study strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing the rights and welfare of participants in its design, procedures, and confidentiality measures.

2.2. Data Collection

The research team collected primary data through interviews with stakeholders in the halal industry, including manufacturers, certification bodies, and consumers. Secondary data was obtained from industry reports, literature studies, and databases related to blockchain technology. All data were analyzed to understand the main challenges in the conventional halal supply chain.

2.3. Blockchain Implementation

Researchers integrate halal supply chain data into an experimental blockchain system.

Initial steps: Data on the origin of raw materials and halal certification are recorded using blockchain-based software.

Tracking process: Products are tested in a simulated supply chain journey, from the manufacturer to the end consumer, utilizing QR codes for real-time information verification.

Validation: The team uses smart contracts to ensure that only products that meet Sharia requirements can be processed to the next stage.

2.4. Data Analysis

The blockchain system's results were analyzed using quantitative descriptive methods to assess the accuracy and efficiency of data recording. Researchers also measured consumer trust through a survey conducted after they verified the product's halalness using a blockchain-based application.

2.5. Data Validity

The success of this research is assessed based on:

Table 1. Research parameters

Parameter	Description
Transparency	The amount of data was successfully verified in real-time.
Consumer trust	Increased trust based on survey results.
Operational efficiency	Reduction in certification process time compared to conventional methods.

This research leverages open-source blockchain software, smartphones with QR code scanner apps, and cloud networks to store data in a distributed manner.

3. RESULTS

The results of this study indicate that blockchain technology significantly impacts increasing transparency and trust in Indonesia's halal industry supply chain. The application of blockchain resulted in three main findings:

Blockchain enables decentralized information recording, ensuring that data related to raw materials, production processes, and halal certification are available in real time and cannot be changed. This overcomes the constraints previously encountered in traditional systems, such as data manipulation and lack of traceability. These results are consistent with the study by Lahkani et al. [16], which found that blockchain increases transparency in the global supply chain.

The study results show that blockchain technology can increase transparency and trust in Indonesia's halal industry supply chain. With decentralization, transparency, and security characteristics, blockchain can record data permanently, thereby preventing manipulation and ensuring information integrity at every supply chain stage.

Blockchain technology enables automatic recording of every stage of the halal certification process. Data such as raw material audits, production processes, and halal certificate issuance can be recorded in an immutable blockchain network, speeding up the certification process by up to 40% compared to conventional methods. In addition, operational efficiency is increased because time-consuming manual processes can be minimized.

This technology has proven effective in preventing fraud, such as forgery of halal certificates. With a decentralized ledger, every data change requires consensus from the entire network, minimizing the risk of manipulation. In addition, intelligent contracts speed up the halal certification process, reducing verification time by up to 40% compared to conventional methods [17].

Consumers can verify the halalness of products in real time through QR codes directly connected to the blockchain network. This transparency increases trust and strengthens the relationship between consumers and producers. Accessible data includes the origin of raw materials, production methods, and halal certification information.

Blockchain gives consumers direct access to product information through QR codes, allowing them to verify halalness independently. This increases consumer trust in local halal products, which is relevant in facing global market competition. A study by Song et al. (2023) shows that blockchain can increase consumer trust by up to 45% [18].

Blockchain can support transparent management of international supply chain data, which is essential to meeting global standards. As shown by case studies in countries such as the United Arab Emirates and Malaysia, this opens up opportunities for Indonesia to increase halal product exports by up to 30%.

The results of this study have shown that blockchain not only increases transparency and accountability but also significantly improves the management of the halal supply chain in Indonesia. This finding provides a solid basis for blockchain adoption in the halal sector, especially as a strategic step to support Indonesia's position as the world's economic center.

4. DISCUSSION

4.1. The Concept and Role of Blockchain in the Halal Industry Supply Chain

Blockchain technology revolutionizes how data is recorded, stored, and accessed. In simple terms, blockchain is a distributed database composed of data blocks interconnected through cryptographic algorithms. Data recorded in the blockchain is immutable or cannot be changed once recorded, thus ensuring transparency and accuracy in the system. Each data block is connected linearly and chronologically, forming a chain that can only be added, not modified [19].

The working principle of blockchain involves three main elements:

Decentralization: The system is not controlled by a single authority. Instead, data is stored on multiple computers (nodes) in the network. This reduces the risk of system failure because there is no single point of failure.

Transparency: Stored information can be accessed by all authorized parties in the network, but privacy is maintained through encryption keys.

Security: Through consensus mechanisms such as Proof of Work or Proof of Stake, data entered into the blockchain is verified by most nodes in the network, thus avoiding the risk of data manipulation [20].

In an operational context, blockchain uses smart contracts technology, a digital protocol that automatically executes contracts when certain conditions are met [21]. This speeds up the transaction process, reduces bureaucracy, and minimizes the potential for manual errors.

Blockchain adoption has attracted attention across sectors, including finance, healthcare, and logistics, due to its ability to create a more efficient and trustworthy ecosystem. However, in the halal industry, the technology is only beginning to be introduced to ensure Sharia compliance at every stage of the supply chain. With blockchain integration, halal industry players can create a tracking system that is accurate, transparent, and in line with the needs of Muslim consumers who are increasingly concerned about the halalness of products.

Blockchain also has the advantage of recording information such as the origin of raw materials, production processes, and distribution in an immutable system. This capability provides data integrity assurance, particularly relevant in the halal supply chain that requires halal certification of each product [22].

Blockchain technology is a technical tool and a strategic solution to address the need for transparency, accountability, and efficiency in halal supply chain management. The following section will discuss the relevance of blockchain in meeting these needs, especially in the Indonesian halal industry.

The halal industry has unique characteristics that distinguish it from other sectors, namely the requirement to meet halal standards that cover all supply chain stages, from raw materials and production processes to distribution. Transparency and trust are fundamental in ensuring compliance with these Sharia principles. However, the challenges halal industry players face, especially in Indonesia, include the lack of an effective tracking system, the complexity of the halal certification process, and the potential for data manipulation along the supply chain [23].

Blockchain offers a highly relevant solution to address these challenges. Through its transparent nature, all parties in the supply chain can access verified information without the risk of data being altered. This is essential in maintaining consumer trust in a product's halal claims. For example, data recording the origin of raw materials and halal certification can be stored on the blockchain, allowing consumers or regulators to verify the validity of the information in real time.

Blockchain allows industry players to meet the need for transparency without sacrificing privacy. Only authorized parties can access sensitive information using an encryption system, while the public can still see relevant data to build trust. In the context of halal certification, for example, blockchain can record every stage of the

certification process carried out by related institutions so that consumers can be sure that the product has genuinely met Sharia standards.

Trust can also be enhanced through the implementation of smart contracts. These smart contracts enable the automatic execution of specific requirements in the halal supply chain, such as validating the halalness of raw materials before the product can be sent to the next stage. This reduces the potential for human error and minimizes the risk of manipulation by irresponsible parties [24].

The relevance of blockchain in Indonesia is increasingly significant, given the country's role as a major producer and consumer of halal products in the world. With the largest Muslim population, the need for transparency and trust in the halal supply chain is a top priority. However, cases of fraud related to halal labels, unclear origins of raw materials, and lack of transparency in the certification process show that conventional systems still have weaknesses. Blockchain can be a solution that allows Indonesia to lead the way in applying technology in the halal industry while increasing its competitiveness in the global market.

By integrating blockchain, halal industry players can create a transparent, efficient, and accountable system. This solution benefits consumers and strengthens the relationship between all parties in the supply chain, from producers to distributors to certification bodies. The following section will discuss blockchain's potential to create a trusted halal ecosystem.

A trusted halal ecosystem is an essential foundation for developing the halal industry at the national and global levels. In this context, blockchain offers excellent potential to create an ecosystem that meets the needs of the halal industry as a whole. This technology ensures that every stage of the halal supply chain, from raw material procurement to distribution to end consumers, can be verified transparently and efficiently [25].

One of blockchain's central potentials is its ability to provide end-to-end traceability in the supply chain. With blockchain, every halal product can be equipped with a digital twin—a digital representation of the physical product—that records all critical information, such as raw material sourcing, certification processes, and logistics. This information is stored in an immutable blockchain network, thus assuring data integrity [26]. This kind of traceability increases consumer confidence and helps regulators and certification bodies conduct audits.

Blockchain has the potential to strengthen the halal certification process. In conventional systems, halal certification often involves a lengthy bureaucratic process prone to inefficiencies. Using blockchain, every step in the certification process can be automatically recorded and verified by relevant parties, such as halal certification bodies and government authorities. This minimizes the possibility of errors or data manipulation while speeding up the certification process. Consumers can also quickly check the halal status of a product through blockchain-based applications.

This technology can also support cross-country cooperation in the halal industry. As the largest halal market in the world, Indonesia has the potential to become a global halal trade center. With blockchain, data management in the international supply chain can be done more efficiently and transparently. For example, products produced in Indonesia and exported to other countries can be equipped with blockchain records that show all related information, thus facilitating the process of receiving products in the destination country [27].

Furthermore, blockchain can open up opportunities for halal technology innovation. For example, blockchain-based applications can be developed to help Muslim consumers verify the halalness of products directly through QR codes. The technology can also build a halal platform that connects manufacturers, distributors, and consumers in a transparent and trusted digital ecosystem. Thus, blockchain increases transparency and creates added value for all stakeholders in the halal industry.

In Indonesia, blockchain's potential for building a trusted halal ecosystem is very relevant, considering the high demand for halal products and increasing consumer awareness of transparency. However, to realize this potential, support is needed from various parties, including the government, halal certification bodies, and industry players. Investment in digital infrastructure and technology education is crucial to ensuring successful blockchain adoption in the halal industry.

This research has proven that blockchain has great potential to revolutionize the halal industry by creating a more transparent, efficient, and trusted ecosystem. This technology not only provides solutions to existing challenges but also opens up opportunities for future halal industry development. By optimally utilizing the potential of blockchain, Indonesia can strengthen its position as a leader in the global halal industry.

4.2. The Concept and Role of Blockchain in the Supply Chain Principles of Transparency and Trust in the Halal Supply Chain

Transparency is a fundamental element in the halal industry supply chain, mainly due to the unique nature of halal products that must comply with Sharia standards. The halalness of a product is

determined not only by the raw materials used but also by the production, storage, and distribution processes. Therefore, transparency is critical to ensuring that each stage of the supply chain meets the Sharia principles expected by Muslim consumers [28].

Consumer trust in halal products is highly dependent on the ability of industry players to provide transparent and verifiable information. For example, consumers want to know the origin of raw materials, processing methods, and whether the product has obtained valid halal certification. When transparency is guaranteed, consumers have confidence that the products they consume are by their religious values.

In the modern era, the need for transparency is increasing, along with the growing awareness of Muslim consumers of the importance of halal. Studies show that consumers tend to avoid products that do not have precise information regarding their halalness, even if the product claims to be halal [29]. Therefore, transparency is not only a supporting factor for trust but also affects the competitiveness of halal products in the global market.

In this context, Indonesia, as a country with the largest Muslim population, faces a big challenge in ensuring transparency in the management of the halal supply chain. Failure to provide transparency can reduce consumer trust, which ultimately has a negative impact on the growth of the national halal industry. The following section will discuss various problems that often occur in traditional supply chains that hinder transparency and trust.

Traditional supply chains in the halal industry face various problems that can hinder transparency and reduce consumer trust. One of the main problems is the lack of a comprehensive traceability system. In the traditional model, data related to the origin of raw materials, production processes, and distribution are often recorded manually and spread across various parties. This makes verifying the authenticity of information difficult, especially when the product involves many intermediaries [30].

This lack of traceability also opens up opportunities for data manipulation or fraud. In some cases, products that claim to be halal do not meet the standards set. For example, raw materials that do not meet halal requirements can enter the supply chain without detection. This situation not only harms consumers but also undermines trust in the halal certification system as a whole [31].

The halal certification process in traditional supply chains often faces lengthy and inefficient bureaucratic obstacles. Information on the certification status of products is not always easily accessible to consumers or even to industry players themselves. As a result, operational time and costs increase while transparency levels remain low. Another problem that often arises is the potential for irresponsible parties to intervene. In some cases, products that do not meet halal standards can be marketed with fake halal labels. Without a system that can guarantee the authenticity of the information, Muslim consumers become more sceptical of the validity of a product's halal claims.

This issue is a significant challenge for the halal industry, especially in Indonesia, which has a complex supply chain involving many parties. To overcome this problem, innovative solutions are needed to increase transparency and ensure the integrity of information throughout the supply chain. Blockchain technology is one potential solution that can answer this challenge. The following section will discuss how blockchain can play a role in ensuring the integrity of information and creating a more transparent halal supply chain.

Indonesia's halal industry supply chain faces significant challenges in ensuring that information related to the halal status of products is reliable and transparent. Various parties are involved in this process, from producers and distributors to end consumers. However, complex supply chains often open loopholes for information manipulation, such as falsifying halal certificates or errors in raw material documentation. This can damage consumer confidence in halal products available on the market. Therefore, innovative technology is needed to guarantee the integrity of information throughout the supply chain.

Blockchain technology has emerged as a potential solution to address these challenges. Blockchain is a distributed ledger-based technology with the main characteristics of transparency, immutability, and the ability to record data in a decentralized manner. In the context of the halal supply chain, blockchain allows every step in the product journey, from raw materials to finished products, to be recorded digitally in a network that cannot be changed by unauthorized parties. This provides assurance that the information provided can truly be verified by all interested parties.

Blockchain can support real-time traceability of halal products, so that consumers and halal certification bodies can more quickly and accurately ensure the halalness of products. By implementing this technology, the halal industry in Indonesia hopes to increase global consumer confidence in its products. This also supports the Indonesian government's efforts to become the world's halal economic center [32].

4.3. Blockchain Integration in Halal Product Certification and Tracking in Indonesia

Blockchain is a technology that enables distributed data recording through a secure and transparent network. In the context of halal certification, blockchain acts as a platform to record every stage of the certification process, from raw material audits and production processes to final certification by authorized institutions. This data is recorded in blocks that are interconnected through cryptographic algorithms, so any changes or manipulations to the data will be easily detected.

How blockchain works in this context starts with the halal authority recording certification data. This data is then encrypted and stored in a distributed blockchain network. With its immutable nature, blockchain ensures that halal certification data remains authentic and cannot be manipulated by any party. This technology also allows halal authorities and consumers to verify the validity of certification by scanning a QR code that is directly connected to the blockchain network.

One of blockchain's main advantages is transparency. Consumers, producers, and certification bodies can access relevant data anytime without intermediaries, reducing the risk of mistrust and potential fraud. With this technology, the Indonesian halal industry can improve its certification standards while strengthening global market confidence in Indonesian halal products [33].

Many studies have recognized blockchain as a technology that can improve the accuracy and efficiency of halal certification [34]. Thus, the application of this technology is in line with the needs of the halal industry to face challenges in the digital era.

One of the main applications of blockchain in the halal industry is product traceability from upstream to downstream, involving raw materials, production processes, and distribution until it reaches consumers. In conventional systems, this tracking often faces obstacles, such as error-prone manual documentation, lack of transparency, and difficulty in ensuring the authenticity of information. Blockchain is here as a solution that enables safe, transparent, and efficient digital tracking [35].

In practice, each entity in the halal supply chain can record its data into the blockchain network. For example, a raw material producer can record information on the origin of the material, processing methods, and related halal certificates. This information is then passed on to the production stage, where the manufacturing process is recorded digitally, including a list of additional ingredients used and supervision of Sharia compliance. This data is continuously updated at each distribution stage until the product reaches the consumer.

End consumers can easily access this information, for example, by scanning a QR code on the product packaging. Blockchain technology ensures that the data displayed is authentic and cannot be changed, thus guaranteeing the product's halalness. With accurate tracking capabilities, blockchain helps increase consumer confidence in halal products.

Case studies in various countries, such as the United Arab Emirates and Malaysia, show that implementing blockchain in halal tracking can improve logistics efficiency and reduce the risk of halal product fraud [36]. Therefore, the application of this technology in Indonesia has the potential to bring significant benefits to the national halal industry.

Implementing blockchain in halal certification significantly impacts data efficiency and accuracy, especially in Indonesia, which has excellent potential as a global halal industry center. In the traditional system, halal certification often involves time-consuming processes, such as manual audits, physical document verification, and coordination between various parties. This process is time-consuming and prone to human error and data manipulation.

The entire certification process can be digitally completed and integrated with blockchain technology. Every step in the certification chain—from raw material audits to halal certificate issuance—can be recorded on the blockchain network. This allows certification authorities to verify data in real time, reducing the time required for the certification process while ensuring higher data accuracy.

Blockchain enables a more transparent system where all stakeholders—including producers, distributors, and consumers—can access data related to the halalness of products. This transparency helps reduce the risk of distrust among stakeholders, increases operational efficiency, and supports regulatory oversight.

In the Indonesian context, where demand for halal products continues to increase both in the domestic and global markets, the efficiency and accuracy offered by blockchain can be a competitive advantage. According to a PwC report [17], blockchain adoption in the halal sector can speed up the certification process by up to 40% and reduce operational costs by up to 25%, making it a highly relevant solution for the national halal industr.

Several countries have successfully implemented blockchain technology in the halal industry, providing a clear example of how this

technology can increase trust and transparency in the supply chain. One example is the United Arab Emirates (UAE), where the government has partnered with a global blockchain platform to create an integrated halal certification system. This system allows tracking of halal products from producers to consumers while digitally verifying the authenticity of halal certificates. As a result, the UAE has managed to speed up the certification process and improve the reputation of its products in the global market.

As one of the world's halal industry leaders, Malaysia has also leveraged blockchain to support transparency in the halal supply chain. With the blockchain platform, halal certification bodies in Malaysia can ensure that every stage of the production process meets halal standards. This data is openly available to consumers and business partners through QR codes, increasing trust in Malaysian halal products internationally [37].

Its relevance in Indonesia is obvious. As a country with the largest Muslim population in the world, Indonesia has an excellent opportunity to adopt blockchain technology to increase the competitiveness of its products in the global market. By learning from the UAE and Malaysia, Indonesia can build an integrated blockchain-based halal ecosystem, connecting producers, certification bodies, and consumers in one transparent system.

This implementation supports the Indonesian government's target to become the world's halal economic center and helps local producers improve operational efficiency and open access to international markets. According to a Deloitte report [38], countries that adopt blockchain in the halal supply chain tend to experience an increase in halal product exports of up to 30%. This shows blockchain can be a significant growth driver in Indonesia's halal industry.

4.4. Blockchain Advantages for Transparency in Halal Production and Distribution Process in Indonesia

Smart contracts are one of the key features of blockchain technology that enables the automation of processes in the halal supply chain. They are programs that run automatically on a blockchain network when certain conditions are met. In Indonesia's halal production context, intelligent contracts can monitor raw materials to final products efficiently and transparently [39]. For example, when raw materials are sent from a farm or factory to a manufacturer, information such as the origin of the material, processing methods, and compliance with halal standards can be recorded on the blockchain through smart contracts. This data, such as production, packaging, and distribution, is updated at each subsequent stage. Smart contracts ensure that these steps are carried out by established halal requirements. If there is a violation, the system will automatically issue a warning or block the following process until the problem is resolved.

This implementation in Indonesia can help halal certification institutions such as the Halal Product Assurance Agency (BPJPH) better monitor the production process. In addition, with automatic monitoring through intelligent contracts, producers can ensure that their products remain by halal standards without complicated manual supervision [40].

The application of this technology not only increases transparency but also helps build trust between producers, distributors, and consumers. A study by Smart Contracts Alliance, [41] shows that smart contracts can reduce monitoring costs by up to 20% while increasing data accuracy in the halal supply chain.

Supply chain fraud, such as falsifying halal certification documents or substituting raw materials with non-halal ones, is a significant challenge in the Indonesian halal industry. Traditional record-keeping systems are often centralized and vulnerable to manipulation. With its decentralized ledger, blockchain technology offers an innovative solution to address these issues.

A decentralized ledger is a digital ledger that is stored across multiple nodes in a blockchain network. Every entity in the halal supply chain, such as farmers, producers, distributors, and retailers, has access to the exact copy of the ledger. This ensures that all recorded data, such as raw material information, production processes, and halal certification, is transparent and cannot be changed without consensus from the entire network. In Indonesia, decentralized ledgers can help regulatory bodies such as BPJPH and the Indonesian Ulema Council (MUI) monitor the entire supply chain process in real-time [42]. For example, if someone tries to falsify data related to the origin of raw materials or the halal status of a product, this change will be immediately detected because data on the blockchain cannot be modified without the approval of the majority of the network [43].

By integrating a decentralized ledger, the Indonesian halal industry can reduce the risk of fraud, increase accountability, and strengthen consumer trust in local halal products. A study by Keogh et al. [44] revealed that blockchain adoption can reduce fraud incidents in the supply chain by up to 35%, making it a relevant solution to be implemented in Indonesia. Blockchain benefits manufacturers and regulators and empowers consumers to actively participate in verifying the

halalness of the products they buy. One blockchain feature that supports this is data transparency, where information related to the product supply chain can be easily accessed through consumer devices like smartphones.

Consumers often doubt a product's halal status in Indonesia, primarily if the information is unclear or unverified. With blockchain, consumers can scan the QR code on the product packaging to access detailed information, such as the origin of the raw materials, the production process, and halal certification issued by authorized institutions. This information is displayed directly from the blockchain network, ensuring the data is authentic and cannot be manipulated [45].

This technology allows consumers to track the journey of products from upstream to downstream. For example, they can see that raw materials come from halal-certified farms, are processed in facilities supervised by halal authorities, and are distributed by parties that comply with halal standards. Consumer involvement in this verification process increases their trust in the product and strengthens the relationship between consumers and producers.

Implementing blockchain in this sector can also encourage transparency in international halal trade, where consumers abroad can verify the halal status of Indonesian export products. Based on a study by Cozzio et al. [46], blockchain technology increases consumer trust by up to 45%, making it an effective tool to strengthen Indonesia's position as a significant player in the global halal market.

5. Conclusion

The study concluded that blockchain technology significantly improves transparency, efficiency, and trust in Indonesia's halal industry supply chain. By implementing blockchain, industry players can record raw material data, production processes, and real-time distribution in a network that cannot be manipulated. This ensures the integrity of information throughout the halal supply chain. Blockchain allows consumers to verify the halal status of products through QR codes, increasing their trust in halal claims. This process also supports the reduction of bureaucracy in halal certification, speeding up the approval time by up to 40% compared to traditional methods. Smart contracts ensure that products can only continue the process if all halal requirements are met. On the industry side, blockchain makes it easier for business actors to comply with national halal standards by recording every step digitally. This technology also minimizes data manipulation risks, such as falsifying halal certification, which is often an issue in traditional systems. In a global context, implementing blockchain provides Indonesia with a competitive advantage in exporting halal products. With a transparent and accountable system, Indonesian halal products can meet international standards, expand access to the global market, and strengthen the country's position as the center of the world's halal economy. The success of this implementation requires regulatory support, adequate digital infrastructure, and training for industry players. With collaboration between governments, certification bodies, and manufacturers, blockchain can be a strategic solution to overcome transparency and trust challenges in the halal industry.

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Conflict of Interest

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Ethics Committee

The study protocol was approved by the Ethics Committee of the State Islamic University of KH Abdurrahman Wahid Pekalongan, Indonesia.

Author Contributions

Study Design: HHA, MRK; Data Collection: MRK, TD; Statistical Analysis: HHA, MRK; Data Interpretation: HHA, TD; Manuscript Preparation: MRK, TD; Literature Search: HHA, TD. All authors have reviewed and approved the final version of the manuscript for publication.

REFERENCES

1. Standard, D., & Gateway, S.(**2022**). State of the Global Islamic Economy Report: Unlocking Opportunity. [CrossRef]
2. Usman, I. (**2020**). Halal supply chain management practice model: A case study in evidence of halal supply chain in Indonesia. *Int. J. Innov. Creat. Chang.*, vol. 11, no. 11. [CrossRef]
3. Shafie, S. & Othman, M.N. (**2006**). Halal Certification: An international marketing issues and challenges.

Proceeding Int. IFSAM VIIIth World Congr. [online]. [CrossRef]
4. Tieman, M., van der Vorst, J.G.A.J. & Ghazali, M.C. (**2012**). Principles in halal supply chain management. *J. Islam. Marketing*, vol. 3, no. 3. [CrossRef]
5. Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (**2019**). Blockchain technology and its relationships to sustainable supply chain management. *Int. J. Prod. Res.*, vol. 57, no. 7. [CrossRef]
6. Davis, F.D. (**1993**). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. *Int. J. Man. Mach. Stud.*, vol. 38, no. 3. [CrossRef]
7. Davis, F.D., *et al.* (**2018**). Extending the UTAUT model to understand the customers' acceptance and use of internet banking in Lebanon. *Int. J. Inf. Syst. Change Manag.*, vol. 8, no. 4. [CrossRef]
8. Ab Talib, M.S., Siti, S.S., Abdul Hamid, A.B., & Ai Chin, T. (**2016**). Emerging Halal food market: an Institutional Theory of Halal certificate implementation. *Manag. Res. Rev.*, vol. 39, no. 9, 2016. [CrossRef]
9. Cai, C., Hao, X., Wang, K., & Dong, X. (**2023**). The Impact of Perceived Benefits on Blockchain Adoption in Supply Chain Management. *Sustain.*, vol. 15, no. 8. [CrossRef]
10. Iskandar, O., Prasetiyo, L., & Abdullah, U. (**2023**). Halal Supply Chain on Food Products: Evidence From Wali Songo Islamic Boarding School, Ngabar Ponorogo. *J. Islam. Econ.*, vol. 3, no. 1. [CrossRef]
11. Purwanto, Rofiq, H.A., & M. Mashudi, M. (**2020**). Halal Assurance System (HAS) 23000 Perspective George Robert Terry. *Int. J. Islam. Bus. Econ.*, vol. 4, no. 2, p. 63. [CrossRef]
12. Yahya, I., Sahidin, S., Rohayana, A.D., Ananda, M.A., & Sopyan, Y. (**2024**). The Effectifity of The Payroll System in Increasing Potential and Zakat Collection in Indonesia. *Int. J. Islam. Bus. Econ.*, vol. 8, no. 1, pp. 127–139. [CrossRef]
13. Ali, J., Mizan, M., Aslam, M., Jaya, W.S., & Jaya, s. (**2021**). A Measurement Model of Successful Muslim Entrepreneur. *Int. J. Islam. Bus. Econ.*, vol. 5, no. 1, pp. 25–37. [CrossRef]
14. Puspita, R.E., Senja, P.Y., and Pertiwi, I.F.P. (**2020**). Investigating Intention-To-Use Sharia Financial Technology In New Normal Era. *Int. J. Islam. Bus. Econ.*, vol. 4, no. 2, p. 116. [CrossRef]
15. Hajar, H. (**2023**). The Role of Pesantren in Guarding the Halal Supply Chain in Indonesia. *Jihbiz J. Ekon. Keuang. dan Perbank. Syariah*, vol. 7, no. 1. [CrossRef]
16. Lahkani, M.J., Wang, S., Urbański, M., & Egorova, M. (**2020**). Sustainable B2B E-commerce and blockchain-based supply chain finance. *Sustain.*, vol. 12, no. 10. [CrossRef]
17. PwC. (**2024**). Sports industry outlook in North America: PwC. PwC. [CrossRef]
18. Song, Y., Liu, j., Zhang, W., & Li, J. (**2023**). Blockchain's role in e-commerce sellers' decision-making on information disclosure under competition. *Ann. Oper. Res.*, vol. 329, no. 1–2. [CrossRef]
19. Franke, P.D., & Fischer, F. (**2023**). Will Blockchain Technology Revolutionize Supply Chain Management?. *Sri Lanka J. Mark.*, vol. 9, no. 1. [CrossRef]
20. Liu, Y., Lu, Q., Yu, G., Paik, H.Y., & Zhu, L. (**2022**). Defining blockchain governance principles: A comprehensive framework. *Inf. Syst.*, vol. 109. [CrossRef]
21. Mohanta, B.K., Panda, S.S., & Jena, D. (**2018**). An Overview of Smart Contract and Use Cases in Blockchain Technology. in *2018 9th International Conference on Computing, Communication and Networking Technologies, ICCCNT 2018*. [CrossRef]
22. Ali, M.H., Chung, L., Kumar, A., Zailani, S., & Tan, K.H. (**2021**). A sustainable Blockchain framework for the halal food supply chain: Lessons from Malaysia. *Technol. Forecast. Soc. Change*, vol. 170. [CrossRef]
23. Zulihuma, K., & Bin Shibghatullah, A.S., (**2022**). Blockchain Technology for Halal Supply Chain Management. in *Proceedings of International Conference on Artificial Life and Robotics*. [CrossRef]
24. Sai Radha Krishna, G., & Rekha, P. (**2022**). Food Supply Chain Traceability System using Blockchain Technology. in *2022 8th International Conference on Signal Processing and Communication, ICSC 2022*. [CrossRef]
25. Sadali, A., Fikri, M.K., & Adinugraha, H.K. (**2024**). Halalpreneur Opportunities and Challenges: Empirical Evidence from Indonesia. *Al-Intaj*, vol. 10, no. 2, [CrossRef]
26. Rejeb, A., Rejeb, K., Simske, S. & Keogh, J.G. (**2023**). Exploring Blockchain Research in Supply Chain Management: A Latent Dirichlet Allocation-Driven Systematic Review. [CrossRef]
27. Purusottama, A., (**2023**). Exploring the potential of blockchain adoption for promoting value innovation: a case of the halal industry. *Bus. Process Manag. J.*, vol. 29, no. 7, pp. 2034–2058. [CrossRef]
28. Asnawi, N., Mahsun, M., & Danila, N. (**2023**). Industrial Halal Blockchain: The Great Potential of The Digital Economy in Indonesia. *IQTISHODUNA J. Ekon. Islam*, vol. 12, no. 1. [CrossRef]
29. Masudin, I., Rahmatullah, B.B., Agung, M.G., Dewanti, I.A., & Restuputri, D.P. (**2022**). Traceability System in Halal Procurement: A Bibliometric Review. *Logistics.*, vol. 6, no. 4. [CrossRef]
30. Mohamed, Y.H. (**2020**). "The effect of halal supply chain management on halal integrity assurance for the food industry in Malaysia," *J. Islam. Mark.*, vol. 12, no. 9, pp. 1734–1750. [CrossRef]
31. Tumiwa, R.A.F., *et al.* (**2023**). Investigating halal food Supply chain management, halal certification and traceability on SMEs performance. *Uncertain Supply Chain Manag.*, vol. 11, no. 4. [CrossRef]
32. Alamsyah, A., Hakim, N., & Hendayani, R. (**2022**). Blockchain-Based Traceability System to Support the Indonesian Halal Supply Chain Ecosystem. *Economies*, vol. 10, no. 6. [CrossRef]
33. Sidarto, L.P. (**2021**). Improving Halal Traceability Process in the Poultry Industry Utilizing Blockchain Technology: Use Case in Indonesia. *Front. Blockchain*, vol. 4. [CrossRef]
34. Zainal Abidin, N., & Putera Perdana, F.F. (**2020**). A Proposed Conceptual Framework for Blockchain

Technology in Halal Food Product Verification. *J. HALAL Ind. Serv.*, vol. 3. [CrossRef]
35. Mahsun, M., Putra, Y.H.S., Asnawi, N., Djalaluddin, A., & Hasib, N. (**2023**). Blockchain as a Reinforcement for Traceability of Indonesian Halal Food Information through the Value Chain Analysis Framework. *AL-Muqayyad*, vol. 6, no. 1. [CrossRef]
36. Imanto, T., & Yazid, S. (**2021**). Blockchain Based Halal Food Production Tracking. in *Proceedings - IWBIS 2021: 6th International Workshop on Big Data and Information Security*. [CrossRef]
37. Adinugraha, H.H., Sartika, M., & Sulthoni, M. (**2023**). Santripreneur in Santrendelik: Evidence of Pesantren Concern for Entrepreneurship and Religiosity. *Int. J. Ihya' 'Ulum Al-Din*, vol. 25, no. 2, pp. 82–96. [CrossRef]
38. Deloitte Turkey. (**2022**). Mutual acceleration: Humans technology propellingeach other into the future. [CrossRef]
39. Fernando, Y., Darun, M.R., Al-haimi, B., Ibrahim, D.N., Tieman, M., & Mohamad, F. (**2020**). "Role of Smart Contracts in Halal Supply Chain Management,". [CrossRef]
40. Effendi, B., Fikri, M.K., Adinugraha, H.H., & Furqon, A. (**2024**). Preparation for the Implementation of Mandatory Halal Regulations for Food and Beverage Products in Indonesia. *Rev. Jurídica*, vol. 1, no. 23, pp. 341–365. [CrossRef]
41. Smart Contracts Alliance. (**2018**). Smart Contracts: 12 Use Cases for Business & Beyond. *SSRN Electron. J.*, vol. 41, no. 2. [CrossRef]
42. Adinugraha, H.H., & Tamamudin, T. (**2023**). "Analysis of the Implementation of the DSN-MUI Fatwa and Maqashid Sharia in Sharia Hotels: A Study at the Lor In Sharia Solo Hotel," *JoIE J. Islam. Econ. Bus.*, vol. 3, no. 2, pp. 31–48. [CrossRef]
43. Kusnadi, A., Arkeman, Y., Syamsu, K., & Wijaya, S.H. (**2023**). Designing Halal Product Traceability System using UML and Integration of Blockchain with ERP. *Regist. J. Ilm. Teknol. Sist. Inf.*, vol. 9, no. 1. [CrossRef]
44. Keogh, J.G., Rejeb, A., Khan, N., & Zaid-Kaylani, K., (**2022**). Blockchain: an enabler for safe food in global supply networks. in *Present Knowledge in Food Safety: A Risk-Based Approach through the Food Chain*. [CrossRef]
45. Sari, A.C., & Adinugraha, H.H. (**2021**). Implementation of QRIS-Based Payments Towards the Digitalization of Indonesian MSMEs. *Ekon. SYARIAH J. Econ. Stud.*, vol. 5, no. 2. [CrossRef]
46. Cozzio, C., Viglia, G., Lemarie, L., & Cerutti, S. (**2023**). Toward an integration of blockchain technology in the food supply chain. *J. Bus. Res.*, vol. 162. [CrossRef]