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BLOCKCHAIN TECHNOLOGY AS A SOLUTION OF INTEGRATION ISSUE IN HALAL FOOD SUPPLY CHAIN

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ABSTRACT

Halal food is an obligation for Muslims to consume. Therefore, Halal food can be consumed when it meets the requirement of Halal certification. However, there are several issues in Halal industry, such as Halal counterfeiting, Halal fraud, Cross-contamination food, etc. One of the most sensitive issues in the Halal industry is the integrity of the food supply chain. The paper provides a conceptual framework for the verification of the halal food chain for processed food products. It is hoped that the framework will assist food industry players in developing a mechanism that will enhance the transparency and legitimacy of the halal food chain. Along with 4th Industrial Revolution era, the emerging technologies provide an ideal solution to the issues currently faced by companies across the world, and one such area is the Supply Chain Management. The issues in the Halal Food Supply Chain can effectively be addressed by the emerging Blockchain Technology.

Keywords: Blockchain Technology, Halal Food, Supply Chain Management, Smart Contract

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PROBLEM DESCRIPTION

The name "Halal" comes from the Arabic word "halal," which meaning "lawful" or "accepted." It necessitates permissibility under the Shariah (Islamic Law), which is the polar opposite of "Haram," or prohibition, from an Islamic legal standpoint. The Halal idea is highly significant in the life of a believer since it provides a complete set of guiding principles.

According to Islamic beliefs, consumer items, particularly foodstuffs, are directly linked to an individual's piety and purity of soul. Halal food addresses issues such as appropriate slaughtering, processing, presentation, planning, grooming, sanitation, and transparency. Furthermore, according to Shariah law, halal food must comply with the several requirements: does not contain any non-halal goods or components of haram living creatures, or products or animals that are not butchered in the name of Allah and according to Shariah approaches; does not consist any substances that are considered unclean ; safe and non-harmful; not prepared, processed or produced using equipment that are contaminated or used together with non-halal; ingredients does not contain any human parts; and during the process of manufacturing, preparation, packaging, storage or distribution, product must be physically separated between halal and haram products.

The halal logo or certification is shown on product packaging to notify consumers about food goods' adherence to halal rules and Sharia law principles. However, there are still counterfeit logos or certifications on product packaging, which is a concern. In the United Kingdom, Halal counterfeiting was discovered, and a meat seller who purported to offer Halal meat was arrested for food fraud. After a laboratory test revealed that cheaper beef cut was detected in the lamb meat offered by the supplier, the food fraud was discovered. The vendor also placed a Halal emblem in the store, which had never been certified previously (Johari, 2010).

The integrity of the food supply chain is one of the most sensitive concerns in the Halal sector. Cross-contamination is a major problem that jeopardizes the Halal supply chain's integrity. As we all know, halal ingredients are extremely important to Muslim customers, and because there are no well controlled marketplaces for halal raw materials, non-sharia-compliant substances are more likely to leave traces on the meal. Because of the intricacy and interconnectedness of the global food supply system, contamination is difficult to avoid, making food safety compliance difficult as well.

To resolve these issues, the Halal food supply chain requires adequate traceability and transparency, which can track product information and assure confidence as well as halal food authenticity. Blockchain technology has the potential to offer the traceability needed for better levels of assurance in the food chain of custody. The use of blockchain allows customers to verify the items' integrity, ensuring that they continue to trust them. It provides automated alignment of market requirements to a supply chain situation in terms of chain integrity (Tripoli & Schmidhuber, 2018).

RESEARCH QUESTIONS

In this study, the main question that needs to be answered is to what extent blockchain technology with smart contract could solve certain problems in order to maintain halal food quality?

Meanwhile, this study also provides with following sub questions:

1. Does blockchain technology able to reducing cost in the halal food supply chain?
2. To what extent the smart contract with QR code could maintain the food segregation process?
3. Will the consumer be able to get all the information gathered throughout halal food supply chain by reading the QR code?
4. What are the challenges faced while implementing the blockchain technology in halal food supply chain?

RESEARCH METHODOLOGY

This paper research conduct data collection basically based on secondary data from several journal that have already conduct an interview in three different countries with three different companies. Besides that, the use of critical literature review related to food traceability and tracking system and archival research will be the foundation of this research. This study proposes the conceptual framework of halal food supply chain, the conceptual framework of halal food traceability and tracking system using blockchain technology specifically smart contract.

In order to meet the needs of Muslim consumers to consume halal food, therefore parties involved in the halal food supply chain need to prioritize the criteria listed in Halal certification and also to obtain permission to use the halal logo on the packaging of a product. In this case, I am sulking towards the halal certification issued by Malaysia and Indonesia. Halal certification from the two countries is issued by JAKIM (Malaysia Islamic Progress Position) and MUI (Indonesian Ulema Council).

RESEARCH OBJECTIVE

The purpose of this research is to find out about all the problems that exist in the Halal food supply chain system which then from these problems encourages an idea to solve them by using blockchain technology. The usage of Blockchain technology has a great influence on the Halal industry, especially the halal food supply chain, since it can meet the needs of Muslim consumers by fulfilling the criteria for halal certification. In addition, with blockchain technology, the halal food supply chain system is more efficient in cost, time and energy. This paper describes how to Halal food supply chain's framework with blockchain technology displays a comprehensive traceability process with the help of

smart contract tools with QR code.

THEORITICAL FRAMEWORK

Blockchain Technology

Blockchain, a structured and decentralized ledger, was initially developed to provide a practical solution to reaching an agreement in an untrusted decentralized distributed environment, as defined by Nakamoto (2008). In blockchain, information is structured in a chain of blocks, where each block keeps a set of transactions executed at a given time and also blockchain incorporates cryptography, mathematics, complex algorithms and economic models, using peer-to-peer networks and unanimous distributed algorithms to solve traditional distributed database synchronization problems and therefore it is an integrated multi-stage tool (Casino et al, 2019). The blockchain is resistant to any data modification (immutability), which means that once information is registered it cannot be altered or modified. Moreover, blockchain technology is evolving to be the most significant technology revolution since the invention of the Internet and its adoption is a reality in many fields, as claimed by Rabah (2018); Gromovs and Lammi (2017); Garay et al. (2015); Saha et al. (2018); Casino et al. (2018).

Smart Contract

Smart contracts are computer programmes or codes that automatically execute when predefined conditions are met. Smart contracts are designed to automate much of the contractual process. The performance, monitoring and enforcement of contractual agreements are done autonomously, without any central authority or human involvement to the cost of monitoring the different actors (Jensen and Meckling, 1976).

Halal Food Traceability Supply Chain System

The Halal food supply chain is defined as a series of the farm-to-fork process involving Halal food supply and the Halal integrity of all the processes is accordingly maintained. Bahrudin, Illyas, and Desa (2011) defined the Halal food supply chain as management towards the procurement, transportation, storage and handling of livestock, parts, materials, as well as semi-fin- ished food inventory. The implementation of blockchain technology in the Halal industry is desired to achieve more reliability in the supply chain data and improve the trust level in the supply chain processes. Blockchain can also potentially improve the efficiency of the processes that include all the players from the source point to the final consumer point. The confidence level of the consumers is potentially improved as blockchain technology embraces transparency and security. Blockchain technology also offers an automated system that can lead to time reduction in solving certain problems. Problems that are solved in a short period of time will help Halal certified products minimise the damage of their brand image or reputation. Most importantly, blockchain technology allows globalisation towards the Halal industry. The technology integrates all the

different Islamic teachings and Halal certification requirements around the world.

Halal traceability systems can be set up with one purpose in mind in which to increase Halal transparency in the production chain. More halal transparency is likely to increase consumers trust in Halalness of the food due to the increased amount of information about among others, production processes, food-safety controls etc., increasing Halal transparency is also likely to enhance the actual level of Halalness of the food as the result of the improved information flows throughout the chain.

Halal Food Supply with Blockchain Technology Framework

There are several criteria to remember in order to ensure a smooth deployment of Blockchain technology in the Halal industry. The farm's animals will be given id numbers, which will be saved in a specific ledger. The animals will be monitored by a scheme that covers their living arrangements and food consumption. The welfare of the animals will be closely examined at the slaughterhouses, and a report by a respected veterinarian will be provided to verify the animals' health conditions. Following that, different timestamps would be applied to the blockchain in order to recognize the cut of meat from the animal as well as how the animals were handled at the slaughterhouse. The information can be used as a guide to ensure that the animal/meat is Halal. A DNA sensor may also be used to ensure that Halal meat is of high quality as it is cooked. The meat is packaged in smart packaging, which allows for a tracking phase of the product's logistics from the manufacturer to the store or restaurant. To track the Ha- lal integrity of the items, smart packaging and sensors can be combined with blockchain technology. Apart from that, environmental data associated with locations must be stored in the blockchain system. (Tan et al., 2020)

Stakeholders and customers can access information about Halal integrity since all of the data is contained in the available ledger. They have the option of using a smartphone app or a website to access the information. Governments would benefit from blockchain technology because it provides options for import restrictions. The use of blockchain leads to an increase in regulatory enforcement requirements.

It is also possible to track details relevant to legal and tax once blockchain collects input from various parties across the supply chain. Blockchain implementation will benefit both B2C (Business to Consumer) and B2B (Business to Business) relationships because it is a device that provides a greater degree of confidentiality and credibility security. Consumers will have more respect because they will be able to track the ingredients' roots as well as the treatment of the animals during the slaughtering process. Finally, Halal market players will be able to use blockchain technologies as a tool to improve accountability and transparency in the process. Better quality Halal goods are available on the market as a result of increased clarity and accountability. (Tan et al., 2020).

2.4 Halal Food Supply Chain with Smart Contract

The framework's aim and novelty are to use Blockchain technologies to collect relevant information along the food supply chain from farm to retailer. To ensure the authentication and authenticity of information flow among supply chain partners, Blockchain technologies can provide delivery ledgers as well as smart contracts (Lu and Xu 2017). As food goods migrate through the supply chain, this system will allow real-time data to be modified.

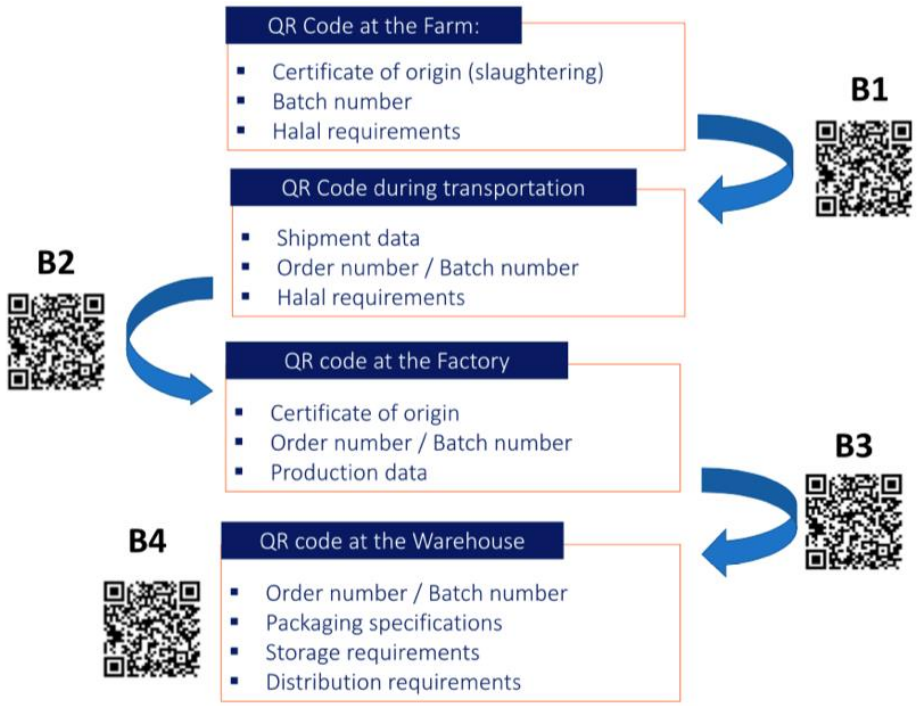


Figure 4: Blockchain Smart Contracts with QR code for Halal Food Supply Chain (adapted from Tan et al, 2020)

At the moment, blockchain networks function independently of one another. The presence of multiple blockchain networks with different criteria such as con- sensus types, settlement schemes, and smart contract features is the greatest barrier to interoperability (Lu and Xu 2017). Several standardisation initiatives, including the use of APIs, are underway to combat interoperability problems. Using current protocols in new blockchain implementations is one choice. IBM and Microsoft, for example, are using the GS1 data specifications to ensure interoperability of their supply chain blockchain applications. Another alternative is to create guidelines from the ground up. The Enterprise Ethereum Alliance, for example, created a business-friendly implementation of the Ethereum blockchain. For complete traceability, this framework will have full monitoring capability from the point of sale to the origin of the animal or source. When looking at the poultry supply chain (Figure 1), for example, parties in the food supply chain may use a smartphone device to check the QR code on the product tag to track the product's origins and movements across each phase of the supply chain. The chain would begin with a parent QR code from the farmers, who would keep records of all information on the poultry or animal (such as feed

and medicines), animal health, location, breed, age, sex, production cost, and any other technological information required for domestic or export markets in one blockchain [B1]. The transaction will be registered into another blockchain [B2] each time the poultry or animal was shipped to another party in the supply chain, as seen in Figure 4. Time (slaughter date, time in transit, expiration dates), as well as related Halal related enforcement or qualification, will be registered in another blockchain [B3] (such as health and country of origin certifications). (Tan et al, 2020)

The animal is cut into different pieces until it arrives at the slaughterhouse. The features of the parent QR code will be copied and saved in all of the 'children' QR codes for similar cuts like wings and drumsticks. Different sections of the poultry will eventually make their way to the food processing department, where they will be processed and packaged. The meat production data is once again saved in the blockchain [B4]. The stock details is applied to the blockchain and appended to the QR code after it has been packaged. When the merchandise is shipped to the retail store, the buyer can scan the QR code to read all of the knowledge collected in the supply chain. (Tan et al, 2020)

Benefits of using Blockchain Technology for Halal Food Supply Chain

Blockchain technology can provide backward control from the end consumer to the factory or farm, by- pass traditional authorities and ensure faster and secure transactions. For instance, blockchain-enabled applications enhance the sharing of information among disparate partners across food supply chain networks without compromising privacy and security. Significant benefits from the adoption of blockchain-enabled applications in food supply chain traceability may relate to data interoperability, cost reduction, transparency, auditability, integrity and authenticity. It is worth noting that blockchain-enabled food supply chain approaches coupled with IoT will improve communication and selective export of data, offering several additional benefits to the logistics sector regarding data management and data analytics, according to Banafa (2017); Huh et al. (2017).

Food companies can utilize the blockchain to inculcate transparency in their supply chain process. Blockchain has the potential to add an extra layer of security to the food industry.

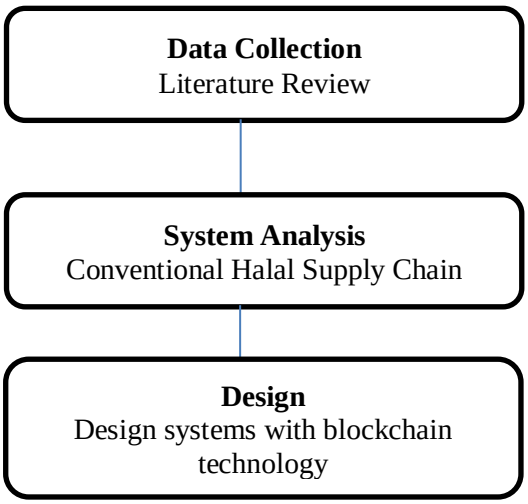
- **Transparency**
  Blockchain will help add accountability to the supply chain by making the data collected at each level available to all in the network. Anything about a food commodity can be registered on the blockchain, from manufacturing to sale, to eliminate food theft and recalls.
- **Efficiency**
  The way food is tracked, shipped, and sold will all benefit from blockchain technology.

Blockchain could eliminate inaccuracies created by conventional paper-based documents by preserving any digital record of the transaction. In the event of a food recall or audit, the procedure will be completed quickly and efficiently thanks to blockchain's end-to-end traceability.

- **Secure and quick transactions**
  It is possible to transmit information in a matter of minutes using blockchain. Once the data has been tested, it is distributed across several networks to ensure its security.
- **Food Safety**
  By saving lives and lowering prices, blockchain may make significant improvements in food safety. There are less risks of contamination and permanent archives of knowledge are held on the blockchain.

ANALYTICAL DATA

This paper will cover solving problems that occur when the Halal food supply chain process occurs using blockchain technology. The data source used will be obtained from a halal food company that uses blockchain technology as its supply chain management system. This paper used qualitative approach with a descriptive method where the work steps are follows:



Data Collection

The question of how blockchain technology can be used for Halal product assurance arises after learning the appropriate components of blockchain technology. Blockchain is a technology that stores all information relating to food goods and makes it accessible and available to all parties involved in the supply chain (Rejeb 2018; Tian 2017). All participants in the Halal supply chain structure (customers, sellers, distribution companies, producers, dealers, and retailers) store their purchases on a mutual ledger, which is regulated by a smart contract. Halal certification bodies (HCB) have access to the shared ledger and the smart contract for commodity certification for Halal certification. A search using Google Scholar, Scopus, and Ebscohost search using the keywords 'Blockchain and Traceability' returns 14 articles as indicated in Table 1.

The usage of blockchain in the Halal food commodity supply chain was also mentioned by Chandra and Sharma (2019). Regulatory authorities, raw material suppliers, manufacturers, dealers, wholesalers, sellers, and end consumers are all part of the supply chain. Regulatory bodies approve new transactions from raw material suppliers, manufacturers, and distributors only after their quality assurance has been verified, according to the blockchain framework. IoT and smart contracts monitor the transactions, which are registered in the blockchain. A search using Google Scholar, Scopus, and Ebscohost search using the

Author	Industry	Findings
Weber et al. (2016)	Multiple sectors	Specific techniques are proposed to integrate blockchain into the choreography of processes in such a way that no central authority is needed, but trust maintained in a collaborative process execution
Patel, Bothra, and Patel (2017)	Multiple sectors	Blockchain technology will revolutionise several financial and non-financial sectors. However, it will also face security, legal, regulatory and technological challenges
Mansfield (2017)	Multiple sectors	Blockchain's impact will reach far beyond financial sectors providing 'assurance as a service' in the commercial world
Kshetri (2017a)	Multiple sectors	Blockchain will enable the promotion of transparency in international trade finance in the third world

keywords 'Blockchain and Halal' returns

Table 1. Blockchain and traceability literature (adapted from Tan et al, 2020)

Korpela et al.	Multiple sectors	Blockchain will enable hyper-levels of supply chain integration with end-to-end integration of product and process data Blockchain can play a key role in tracking the sources of insecurity in supply chains and in handling crisis situations like product recalls that occur after safety and security vulnerabilities are found.
Collomb and Sok (2016)	Global Supply chain	Disintermediation in international trade finance and settlement will increase efficiency in cross-border operations
Guo and Liang (2016)	Global supply chains	Disintermediation and digitisation of supply chain finance enabled by blockchain will enhance the efficiency in cross border trade settlement
Kshetri (2017b)	Global Supply chain	Transparency and process integration in consumer electronics supply chain management will be enhanced by blockchain. Areas where blockchains can affect supply chains include a tamper-proof history of product manufacturing, handling and maintenance, digital identity for ownership and packaging, tendering across the supply chain through smart contracts and engagement with consumers
Casey and Wong (2017)	Global supply chains	End-to-end traceability and the encrypted inclusion of human beings to the supply chain audit is a significant value of blockchain
Glover and Hermans (2017)	Global supply chains	Blockchain technology has the potential to improve the traceability of a clinical trial supply chain and track patient responses
Hull et al. (2017)	Global Supply chain	Single trusted source of data from blockchain will contribute to streamlined data sharing and dispute resolution. Smart contracts will prevail in supporting supply chain collaboration but several challenges need to be addressed: diversity and variation in country policies, product types, transport and tax rates; programming language, solution architectures, interoperability and verification process
Li et al. (2017)	Global Supply chain	A framework that supports supply chain visibility by using a hybrid (semi-open) P2P architecture is introduced, providing the cost-effective real-time tracking information of shipments to all stakeholders
Tian (2016)	Agri-food industry	A conceptual framework for an agri-food supply chain traceability system is proposed, integrating RFID and blockchain technology
Lu and Xu (2017),	Agri-food industry	Using the originChain case demonstrates the value of blockchain in tracing the origin of products across complex supply chains. This blockchain system requires a transparent, tamper-proof metadata infrastructure that is also adaptable to changing environments and regulations
Tian (2017)	Agri-food industry	To address the scale-up issue of blockchain application, a decentralised traceability conceptual system based on IOTs and blockchain technology was proposed. A scenario demonstrated how it works in a food supply chain with Hazard Analysis and Critical Control Points (HACCP)
Chen et al. (2017)	Computer Industry	A blockchain-based supply chain quality management (SCQM) framework is proposed which consists of IoT sensor, blockchain data, contract and business layers
Shireesh and Petrovsky (2016)	Pharmaceutical industry	Blockchain will enable advances in authentication and validation of supply chain information auditing process
Mackey and Nayyar (2017)	Pharmaceutical industry	A few blockchain use cases and initiatives were identified and briefly discussed for security and anticounterfeiting purposes .
Shanley (2017)	Pharmaceutical industry	Blockchain's serialisations of products and tracking of origin will be significant value of pharmaceutical supply chains

Table 1. Blockchain and traceability literature (adapted from Tan et al, 2020)

Author	Industry	Topic
Nugraha et al. (2018)	Multiple sectors	A qualitative study of private blockchain implementation of Halal Supply Chain
Tieman and Williams (2019)	Multiple sectors	Qualitative analysis of Halal blockchain parameters for HCBs in certifying Halal products
Rejeb (2018)	Meat sector	A conceptual framework for blockchain implementation in Halal meat supply chain
Senjoyo et al. (2018)	Food sector	A qualitative study on how to maintain the stability of warehouse temperature using blockchain
Husny et al. (2018)	Food sector	A quantitative study on characteristics of technology that facilitates quality assurance for Halal product
Chandra and Sharma 2019	Food sector	Technical evaluation of blockchain digital solution

Table 2. Halal Food Supply Chain with Blockchain Topic (adapted from Tan et al, 2020)

Results and Discussion

	Foodchain (Food-chain.it)	*WhatsHalal (WhatsHalal.com)*	*Haladinar (Haladinar.com)*
Background	Started in 2012 providing blockchain solution for food traceability.	Started in 2017 providing blockchain solution for the Halal community.	Started in 2015 providing blockchain solution for the Halal marketplace.
Business registration	Italy	Singapore	Singapore
Objectives	Offer farm to fork traceability for food supply chain	Offer food traceability and Halal certification	Provide a marketplace for Halal products and services
Value proposition	Collect data at critical points in the supply chain for full traceability from the farm to the retailer.	Manage the life cycle of a Halal certificate, from the application phase to the daily management of the Halal assurance systems.	Match buyers with sellers for products and services within the Halal community.
Key users	Farmers, slaughter house, transporters, warehouse providers, retailers and consumers	Merchants and consumers, religious organisations, Accreditation of Halal standards	Merchants, Vendors, Traders, Wholesalers, Retailers, religious organisations
Technologies employed	Blockchain with smart contract, QR codes, RFID and IOT.	Blockchain with smart contract and bar code.	Blockchain with smart contract.
Challenges faced	Securing initial costs to implement the solution.	Harmonising different Halal standards in each country.	Tracking source of ingredients or contamination is limited.

Table 3. Overview of Blockchain information process from three companies (adapted from Tan et al, 2020)

The table above describes three companies that use blockchain technology for the supply chain process. Two of the companies are using Ethereum software, which is an open source, public, block- chain-based distributed software with smart contract capability while another company is using Quadrans Blockchain software. Each of the company has its own unique proposition and customer segment.

The three companies above are tracking their halal product from the beginning of the supply chain using Blockchain before they are processed into food. Foodchain, which is based in Italy, has an objective for the traceability of the food supply chain starting from farmer to retailer. Meanwhile, WhatsHalal, which is based in Singapore, prioritizes blockchain solutions for the halal community by issuing halal certification. Halaldinar, which operates in Singapore, focuses on providing a marketplace for halal food products and services between sellers and buyers who are in the halal community or Muslim consumers.

Each company interviewed also has its own obstacles in operating blockchain technology for the halal food supply chain. Foodchain company concern about securing initial cost to implement the blockchain solution. Whatshalal has the main problem in harmonizing the differences that each halal certification has in each country. And finally, Halal dinar facing challanges in detecting the origin of the source of product ingredients.

CONCLUSION

Blockchain solution for halal food supply chain can answer various problems that arise in tracing the origins of components of halal products. Common problem that arises from the involvement of non-halal components during the processing of raw materials into semi-finished or finished goods. Given the complex processing process, so far it is not always easy to re-detect the presence of non-halal components after the halal product is in the form of finished goods.

Likewise, problems originating from cross-contamination with non-halal components during the storage period of the raw or semi-finished materials. It is not easy to detect cross-contamination after the raw or semi-finished materials have been processed. Even when halal products are in the form of finished goods, there is still a risk of contamination by non-halal components. For example, during distribution and sales by retailers.

Blockchain technology allows tracking of the components of a halal product in detail. In the case of halal food, for example, blockchain technology will enable tracking ranging from the treatment of animals at a farm site, trips to slaughterhouses, slaughter at slaughterhouses, trips to locations of meat distributors and retailers, to processing and serving of meat dishes in restaurants. Any contamination along the supply chain will be easier to detect. All activities along the supply chain can be recorded in a coherent, accurate and credible data stream.

Traceability process of blockchain technology to to trace the origins of components of halal products does require a large amount of money. Especially in the early days of development like today. However, the cost per unit of using this technology is likely to get smaller as the scope of use grows.

To conclude, the use of blockchain technology will provide a lot of benefits for Muslim consumers who want a guaranteed halal product.

POLICY AND SUGGESTION

To improve the trustworthiness of the system and the confidence that the right pieces of information are gathered by the consortium, there is a role for a neutral third party to certify, audit, and/or regulate participants (Donaldson and Davis 1991). The religious authority for each country can take up this role during implementation. As there are many actors involved in this consortium, it is recommended to start the implementation with the end consumers and then move upstream. Haladinar.com and Whatshalal.com are able to capture Halal markets with more consumers signing up to verify the products they are buying are certified Halal before consuming them. As more food producers and consumers start to use the portals to verify the products, these portals can partner with the upstream such as food-chain.it to provide end to end Blockchain solutions for the Halal community.

Other than that**,** an autonomous and resilient digital supply chain is proposed to give real-time

information to multiple partners in the food supply chain. As a result, there is Consortium Block Chain solution powered by Control Tower — a single visualisation layer that integrates data from traditionally segmented departments into a decision-making platform based on insights. To deploy Halal Supply Chain, the platform would make use of Blockchain technology.

In the user interfaces section, there are three types of user categories, namely End users, professional users and Smart Contracts or Software Administrators.

Farmers are in charge of incubating and growing animals, while abattoirs are in charge of slaughtering animals to meet halal criteria. Then a Food Processor will convert the raw meats into food for human consumption. A Merchant will trade Halal products within the community. After that, the logistics provider will provide logistics needs such as transportation and warhousing in accordance with Halal requirements. After all the stages in the professional are completed, halal products will arrive in the hands of consumers who play a role in conducting transactions with other participants in the network.

Meanwhile, users who use smart contracts in this case are blockchain developers and Food item regulatory bodies consisting of religious authorities, laboratories and certification authorities who will monitor, analyze and test whether a product has met the halal criteria. which will then be validated with a smart contract.

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