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Ensuring halal compliance in agrifood systems: A review of concepts, principles, and advanced technologies

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A B S T R A C T

The global halal market is witnessing rapid expansion driven by increased demand from Muslim consumers. This necessitates strict adherence to Islamic dietary rules throughout the agri-food supply chain. However, inconsistencies in halal certification standards, complexity of supply chains, and lack of global standardization raised concerns about the integrity and authenticity of halal products. Therefore, this research aims to explore the core concepts and ethical foundations of halal in food industry, emphasizing the balance between sustainability and humane practices. The critical role of advanced technologies is also reported, such as DNA testing, blockchain, sensors, and artificial intelligence, in ensuring traceability, transparency, and contamination prevention within halal food chains. The results show that the implementation of quality management systems is discussed as a fundamental method for maintaining halal compliance, with clear policies, procedures, and performance evaluations essential for effective assurance. This research suggests the necessity of technological integration and quality management to strengthen consumer trust and global competitiveness in halal food industry.

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1 Introduction

Global halal market is expanding due to increased demand for products by Muslim consumers (Lada *et al.* 2017). The market is estimated to be $3 trillion and is set to become a significant stream of consumption. In 2023, the organic food market was $1 trillion and the industry played a large part in the expansion (Grand View Research 2020). Therefore, there is increasing concern about adequately implementing halal food chain. This has become a significant problem because the industry has experienced a worrying time trying to reassure Muslim consumers.

Halal agrifood system is a chain of people, components, and activities conducted in compliance with the Islamic dietary rules (Ahmed 2017). The system includes the farmers, processors, manufacturers, distributors, and retailers who oversee halal factors in food products (Zakaria 2017). However, the system is complicated in maintaining halal nature of the end product since there are no standard measurements or stringent legal requirements (Lada *et al.* 2017).

The increasing internationalization of food sector introduces additional issues into halal market because products are imported from various countries with degrees of compliance with halal guidelines. This global supply chain risks the product, such as cross-contamination or the usage of non-halal ingredients, which will affect consumers' confidence.

There is a need for a strong certification process since the range of halal products penetrates other industries such as the pharmaceutical, cosmetic, and fashion industries. These issues are compounded due to the inconsistency in the level of halal standards between and across different countries as well as the absence of certification of products. There is also a need to establish higher levels of standardization and harmonization of halal certification processes (Tieman 2017). Ethical consumerism has led to increased scrutiny of halal practices, with consumers seeking greater transparency in the sourcing and production of halal goods (Bonne & Verbeke 2008). Therefore, this research aimed to examine the role of advanced technology in ensuring halal compliance in food industry, explore the importance of quality management in food chains, and identify challenges and opportunities in implementing halal food chains.

2 Halal Agrifood System: Concepts and Principles

Halal is an Arabic term translated as lawful, allowable, or permitted (Riaz 2017). Concerning the agrifood system, halal describes food allowed for Muslims to consume as provided by the Islamic laws on eating. These food products must originate from Halal sources, and be free from Haraam substance or contact during production, processing, and handling (Zakaria 2017).

In the Islamic belief system and practice, halal has been seen as a significant concept. Therefore, the existence of halal goes beyond the security of food supply system and is connected to religious and ethnic/cultural values (Lada *et al.* 2017). Halal has a close connection with the notions of cleanliness and purity, as well as key values of Islam (Riaz 2017). Halal practices include the avoidance of oppression in production and the avoidance of harm to animals during slaughtering. These ethical issues are consistent with the current global trends of consumption. Additionally, halal compliance plays a significant role in providing confidence and faith to Muslim consumers to engage with specific products that bear halal logos (Weekes 2013). Halal certification is an andala of ethical, environmental, and social consumption in Islam. The application of halal certification is not only religious compliance but also regulation of quality and safety of food products. This second function of halal as a sign of quality intensifies the important position of the concept for Muslim consumers (Bonne & Verbeke 2008).

Halal practices are also used to enhance diversity in the world food market. Apart from the Muslim consumer, the trend showing the increased awareness of ethics and sustainability improved the appeal of halal certification. For example, the treatment of animals and purity, are in harmony with the modern ethical and environmental standards relevant to many consumers who are more concerned with the humane treatment of animals and the environment. In following halal standards, consumer segmentation is covered to create a reputation for adhering to responsibilities.

The global halal market is rapidly growing since there is a large standard population that adheres to the Islamic faith. Furthermore, there is increasing concern in the global market for halal products. In this context,

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the expansion is seen as an opportunity to establish additional foreign presence and partnerships for businesses. This is important since the role of halal certification is increasingly global and perhaps standardized to access new foreign markets (Ibrahim *et al.* 2018).

The reference to 'halal' includes a wider ethical perspective providing acceptable practices that are sustainable and humane. Therefore, halal certification plays a significant role in adapting business practices in line with religious beliefs and market trends. The guidelines governing the production of halal foods are anchored on Islamic law regarding the preparation (Zakaria 2017). These principles include the following.

a. Permissible sources: Halal food products require that plant and animal products as well as fish are acceptable under the Shariah laws (Riaz 2017).
b. Prohibition of haram substances: Halal food products should exclude additives of prohibited items such as pork, blood, and intoxicants (Ahmed 2017).
c. Cleanliness and purity: Halal food products have a strict requirement for hygiene concerning the processing, preparation, or storage.
d. Labeling and certification: Some of the guidelines include that halal food products must carry a label or certification to create awareness (Lada *et al.* 2017).
e. Animal Slaughter: Meat products require that animals must be slaughtered religiously by Islamic folks. These include the recitation of the name of Allah and Slaughtering of the healthy and living animals (Riaz & Chaudry 2016).
f. Animal Welfare: Islam as a religion, has enjoined people to be kind to animals and avoid any form of cruelty. These creatures should not be made to suffer more than necessary and the killing must be carried out most efficiently and least painfully possible.
g. Supply Chain Integrity: There is a need for total openness and tracking from one level of the supply chain to another to preserve halal integrity of a product from the producer to the consumer (Tieman & van der Vorst 2015).

These basic principles of production serve as a guideline for the option of pure and relatively genuine halal food (Riaz 2017). The aspect of halal corresponds with the Islamic prohibitive idea of showing compassion and mercy to other creatures with the contemporary postindustrial problem of animals. Moreover, the increasing complexity of global supply chains has necessitated rigorous monitoring and traceability measures to maintain halal integrity. Advances in technology, such as blockchain and IoT (Internet of Things) enhance the transparency and traceability of halal food products in compliance with Islamic laws. These technological innovations are crucial in addressing the challenges posed by the globalization of halal market, providing consumers with greater confidence.

3 Advanced Technology in Halal Food Industry

Technology plays an important role in halal food industry, particularly in ensuring compliance with standards related to food additives and preventing contamination. Additives refer to intentional substances added to food to enhance flavor, appearance, shelf life, or processing characteristics. These must be halal-certified to be permissible in halal products. Meanwhile, contaminants are unwanted substances that may accidentally enter food during production, processing, or packaging, such as traces of pork or alcohol, and must be strictly avoided.

The use of advanced technology helps in verifying halal status of food additives and preventing contamination throughout the production chain. This includes identifying the presence of non-halal substances, tracing sources, and optimizing production processes to maintain halal integrity. Some of the key technologies applied include the following.

a. DNA testing: Pork and other animal by-product residues are prohibited substances and DNA technology can be used for testing (Riaz 2017).
b. Sensors and monitoring systems: Sensors and monitoring equipment can be used to detect the level of contaminants in foods, guaranteeing the cleanliness of foods (Ahmed 2017).
c. Blockchain technology: Blockchain technology ensures transparency and traceability of food supply chain to provide a secured and immutable record of production (Lada *et al.* 2017).

Several technologies are being developed and adapted for halal food production, such as:

a. Halal-certified packaging: The use of Halal packaging material can be used to avoid cases of contamination and meet the required standards as required (Zakaria 2017).
b. Automated inspection systems: Another use of CS is in the inspection of faulty products, and dregs in processed foods (Riaz 2017).
c. Machine learning and AI: Machine learning and AI can be applied to the raw data to search for patterns and avoid contamination in enhancing quality of halal food products (Lada *et al.* 2017).
d. Developing as a transformative tool in halal food industry: Consumers and the state can track the origin of certain food products and check the reliability of the corresponding halal certifications with maximum precision. Blockchain can contribute to fraud and mislabeling is a critical problem for halal market. By coupling the use of blockchain with IoT sensors, the monitoring of halal compliance can be extended to real-time forms.

Integrating Quality Management (QM) systems such as ISO 22000 (food safety management) or Halal Assurance Systems (HAS) with these advanced technologies ensures a structured and measurable method of halal production. The frameworks help document, monitor, and improve halal-critical control points throughout the supply chain. This balance supports regulatory compliance and builds consumer trust to reinforce brand reputation in the competitive halal food market.

4 Quality Management in Halal Food Industry Chains

Quality management is important in halal food industry chains and assists in establishing dependable standards (Ahmed 2017). This concept comprises quality planning, control, and assurance (Zakaria 2017). The key components of quality management systems in halal food industry chains include the following.

a. Quality policy: A good policy statement, which articulates the policy on quality and halal standards (Riaz 2017).
b. Quality objectives: SMART stands for Specific, Measurable, Achievable, Relevant, and Time-bound goals and objectives addressing quality of the organization (Ahmed 2017).
c. Quality management processes: Written procedures explaining the conduction of quality planning, control, and assurance (Recovered from Zakaria 2017).
d. Quality measurement and evaluation: The process is the mechanics of measurement and evaluation of quality performance where consumer satisfaction and quality of products are used (Lada *et al.* 2017).

Certification is crucial in guaranteeing that food items adhere to quality and halal criteria. According to organizations responsible for certification, products and manufacturing processes must be consistent with Islamic dietary regulations. Talib stated that halal certification served as an essential control point within food supply chain. In this context, Islamic dietary laws are followed throughout all phases of production. Documentation is evaluated, and compliance with halal principles is ensured through audits and inspections of facilities. Additionally, certification bodies are responsible for creating and revising halal standards in response to new challenges and trends. The responsibilities also include providing education and training to companies regarding halal requirements, which supports consumer confidence and aids in accessing the market (Talib *et al.* 2017).

A recognized certification must be provided to guarantee the authenticity and integrity of halal products, thereby enhancing quality management within halal food sector. Certification functions as a measure of quality assurance and improves consumer trust and confidence in the products. By implementing strong traceability systems, organizations can monitor the origin, handling, and processing of food items. This transparency is crucial for preserving halal integrity since the concept facilitates the prompt identification and resolution of any non-compliance issues. Traceability plays an important role in enhancing the reliability and credibility of halal food products.

5 Conclusions

In conclusion, this research supported halal compliance in agri-food systems to ensure consumer confidence among the Muslim population. Halal food chain needs improved technical support in terms of quality management and technology. However, some of the limitations were undefined GA/GMP benchmarks, availability of fewer resources, and supply chain constraints. The forces seen as opportunities were technology usage, standardization, and collaboration. Several research could be conducted to evaluate the use of new-generation technology and enhanced solutions in improving halal compliance and quality of Halal food products.

Halal agrifood system was conceived as a complex web where scrupulous monitoring and quality control were applied to ensure compliance with Islamic dietary laws. Increased concerns about religion and ethics in food industry provided greater demand for halal food. However, the complexity ranged from the supply chain to different international standards and technology. The advancements in information and biological technologies such as blockchain, DNA, AI, and QMS systems offered significant potential for enhancing transparency, traceability, and halal food production.

A strong QMS accompanied by certifications showed that halal products were not compromised at the input of the supply chain during the process and up to the point of consumption. This was because stricter standards, continual reassessments, and technologies placed the sector of halal food in a better position to meet the effects of globalization and expand

the markets beyond traditional limits. The initiatives served the purpose of satisfying the religious needs of Muslim consumers in line with the trends concerning ethical and sustainable consumption.

Conflict of Interest

The authors declare no conflict of interest.

References

Ahmed A. Halal food and its importance in the global market. Journal of Food Science and Technology. 2017;54(4):931–938.
Bonne K, Verbeke W. Muslim consumer trust in halal meat status and control in Belgium. Meat Science. 2008;79(1):113–123.
Grand View Research. Halal market size, share & trends analysis report by product (food, cosmetics, pharmaceuticals), by distribution channel (online, offline), by region, and segment forecasts, 2020–2027. 2020.
Lada S, Tanakinjal GH, Amin H. Halal certification and its impact on consumer purchase intention. Journal of Islamic Marketing. 2017;8(2):246–263.
Riaz MN. Halal food production: A review of the current state and future directions. Comprehensive Reviews in Food Science and Food Safety. 2017;16(3):532–544.
Riaz MN, Chaudry MM. Halal food production. CRC Press; 2016.
Talib HHA, Ali MH, Jamaludin KR. The role of halal certification in the food supply chain. Journal of Islamic Marketing. 2017;4(1):5–19.
Tieman M. Halal risk management: Combining robustness and resilience. Journal of Islamic Marketing. 2017;8(4):461–475.
Tieman M, van der Vorst JG. Halal food chain integrity: Supply chain management and challenges. Food Control. 2015;56:54–57.
Zakaria N. The concept of halal and its application in the food industry. Journal of Halal Research. 2017;1(1):1–10.
Zulfakar MH, Anuar MM, Talib MSA. Conceptual framework on halal food supply chain integrity enhancement. Procedia–Social and Behavioral Sciences. 2014;121:58–67.