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ARTIFICIAL INTELLIGENCE AS AN ENABLER OF THE HALAL BUSINESS INDUSTRY 4.0: OPPORTUNITIES, CHALLENGES, AND ETHICAL IMPLICATIONS

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Abstract: This study discusses the role of Artificial Intelligence (AI) as an enabler in the development of Halal Industry 4.0, with a focus on identifying opportunities, challenges, and accompanying ethical implications. The transformation towards Halal Industry 4.0 is characterized by digitalization and the integration of intelligent technologies that enable efficiency, transparency, and increased competitiveness of halal products and services in the global market. AI plays a strategic role in accelerating the halal certification process, supporting real-time halal supply chain management, and facilitating product innovation oriented to the needs of global Muslim consumers. Furthermore, the integration of AI in the halal industry also raises significant ethical implications, including issues of data privacy, algorithmic fairness, potential technological bias, and strengthening authority in determining halal legitimacy that must still refer to the principles of maqasid al-shariah. Thus, the adoption of AI in Halal Industry 4.0 requires a holistic approach that emphasizes not only technical efficiency but also ensures compliance with ethical, spiritual, and social values. This study uses a qualitative approach with a descriptive analytical design to examine the role of Artificial Intelligence (AI) as an enabler in the development of Halal Industry 4.0, focusing on opportunities, challenges, and ethical implications. The results indicate that the success of AI as a catalyst for global halal transformation depends on the ability of all stakeholders government, academics, industry players, and religious authorities to maximize opportunities, address challenges, and wisely manage ethical implications. With this framework, AI can be a crucial instrument in building an inclusive, globally competitive halal industry that remains rooted in sharia principles and sustainability.

Keywords: Artificial Intelligence; Halal Industry; Opportunities; Challenges.

Abstrak: *Penelitian ini membahas peran Artificial Intelligence (AI) sebagai enabler dalam pengembangan Industri Halal 4.0, dengan fokus pada identifikasi peluang, tantangan, dan implikasi etis yang menyertainya. Transformasi menuju Industri Halal 4.0 ditandai oleh digitalisasi dan integrasi teknologi cerdas yang memungkinkan efisiensi, transparansi, serta peningkatan daya saing produk dan layanan halal di pasar global. AI berperan strategis dalam mempercepat proses sertifikasi halal, mendukung pengelolaan rantai pasok halal secara real-time, serta memfasilitasi inovasi produk yang berorientasi pada kebutuhan konsumen muslim global. Lebih lanjut, integrasi AI dalam industri halal juga menimbulkan implikasi etis yang signifikan, mencakup isu privasi data, keadilan algoritmik, potensi bias teknologi, serta penguatan otoritas dalam penetapan legitimasi halal yang harus tetap merujuk pada prinsip maqasid al-shariah. Dengan demikian, adopsi AI dalam Industri Halal 4.0 memerlukan pendekatan holistik yang tidak hanya menekankan pada efisiensi teknis, tetapi juga memastikan kepatuhan terhadap nilai-nilai etis, spiritual, dan sosial. Penelitian ini menggunakan pendekatan kualitatif dengan desain deskriptif analitis untuk mengkaji peran Artificial Intelligence (AI) sebagai enabler dalam pengembangan Industri Halal 4.0, dengan fokus pada peluang, tantangan, dan implikasi etis. Dari hasil penelitian dapat diketahui bahwa keberhasilan AI sebagai katalis transformasi halal global bergantung pada kemampuan seluruh pemangku kepentingan pemerintah, akademisi, pelaku industri, dan otoritas keagamaan dalam memaksimalkan peluang, mengatasi tantangan, serta mengelola implikasi etis secara bijak. Dengan kerangka tersebut, AI dapat menjadi instrumen penting dalam membangun industri*

halal yang inklusif, berdaya saing global, dan tetap berakar pada prinsip syariah serta keberlanjutan.

Kata Kunci: *Artificial Intelligence; Industri Halal; Peluang; Tantangan*.

INTRODUCTION

The development of digital technology has brought significant changes to various sectors of human life, including the halal industry, which is now a pillar of the global economy with rapid growth. In the context of the industrial revolution 4.0, *Artificial Intelligence* (AI) is present as an enabler capable of accelerating the digital transformation of the halal industry, increasing efficiency, accuracy, and transparency in the production, distribution, and certification processes of halal products (Azwar 2025).

The integration of AI in the halal ecosystem not only provides economic benefits but also strengthens consumer trust through quality assurance and compliance with sharia principles. Therefore, a discussion of the opportunities, challenges, and ethical implications of implementing AI in the halal industry is highly relevant in efforts to build an adaptive, competitive and sustainable halal ecosystem in the era of globalization. The first opportunity that can be identified from the application of AI in the halal industry is increasing the accuracy and speed of the halal certification process.

Until now, halal certification often faces challenges such as limited auditors, the complexity of the global supply chain, and delays in the verification process. Through AI technology based on machine learning and big data analytics, the audit process can be carried out more efficiently by utilizing algorithms that can detect the halalness of raw materials, trace the supply chain, and verify documents automatically (Tobing 2024). This has the potential to reduce the administrative burden on halal certification bodies while accelerating the issuance of certificates, which in turn increases the competitiveness of halal products in the international market. AI can also help identify risks of irregularities in the supply chain, such as potential cross-contamination with non-halal ingredients, allowing for early prevention.

Furthermore, AI has significant potential to support halal product innovation, particularly in the food, pharmaceutical, and cosmetics sectors. Through comprehensive data analysis, AI can predict consumer trends, design product formulas tailored to the needs of the Muslim market, and optimize research and development (R&D) processes. For example, in the halal food industry, AI can be used to develop sustainable halal protein alternatives, such as plant-based meat, while taking into account sharia, nutritional, and environmental sustainability aspects. Thus, AI serves not only as a technical tool but also as a catalyst for innovation that can elevate the halal industry to a more advanced level and be responsive to global changes. Further opportunities lie in leveraging AI to increase transparency and consumer trust.

In the digital era, consumers increasingly demand transparency regarding the origin, production process, and halal status of a product (Bakar 2019). AI can support the development of a halal blockchain system that enables real-time product tracking from upstream to downstream. Through this technology, consumers can verify a product's halal status simply by scanning a QR code, which displays comprehensive data on the origin of raw materials, processing, and halal certification. This transparency not only increases Muslim consumer confidence but also broadens the appeal of halal products to non-Muslim consumers concerned with ethical, health, and environmental issues. In other words, AI can broaden the meaning of halal as a universal value aligned with global sustainability principles.

However, the application of AI in the halal industry is not without several challenges. First, there are limited digital infrastructure and technological gaps in various countries, particularly in regions with Muslim populations. Not all halal businesses, particularly micro, small, and medium enterprises (MSMEs), have the financial and technical capacity to adopt AI-based technologies (Rahman 2024). This situation has the potential to create a gap in the halal ecosystem, with only large companies with strong resources able to capitalize on AI opportunities, while smaller players are left behind. Therefore, an inclusive strategy is needed that involves support from the government, certification bodies, and the private sector to provide affordable technology access to all halal industry players. The second challenge relates to data validity and reliability. AI relies on data as the primary fuel for generating analyses and recommendations.

However, in the context of the halal industry, data related to the halal status of raw materials and supply chains is often scattered, unstandardized, and even difficult to verify. Concerns arise if AI makes decisions based on incomplete or biased data, which could lead to errors in product halal assessments. This is where robust halal data governance is crucial, including standardization of data formats, interoperability between systems, and protection of sensitive data from misuse (Battour 2022).

Furthermore, there are challenges in the form of cultural and ethical resistance to the use of AI. Some may view the use of AI in the halal certification process as diminishing the role of humans, particularly religious scholars or halal auditors. However, from a sharia perspective, decisions regarding halal status must still involve competent human authorities, while AI serves only as a tool. Therefore, an appropriate outreach approach is needed to explain the role of AI in a proportionate manner to avoid raising concerns or objections among the public. From an ethical perspective, the application of AI in the halal industry also presents complex implications. One key issue is algorithmic fairness. AI algorithms can reflect biases inherent in data, potentially leading to discrimination or unfair decisions. For example, if supply chain data favors large suppliers, small suppliers may be excluded from the digital halal ecosystem. This contradicts the Islamic principle of justice, which emphasizes inclusivity and balance. Therefore, the development of AI in the halal industry must adhere to Sharia-based ethical principles, including fairness, transparency, and social responsibility.

Another ethical implication relates to data privacy. In an AI- and blockchain-based halal system, consumer and business data can be recorded in detail. The risk of personal data leakage is a serious issue that must be addressed with strict regulations and protections. Furthermore, there are philosophical questions about the extent to which humans should cede religious authority to machines. While AI can provide fast and accurate analysis, determining halal (permissible) or haram (forbidden) must remain the domain of humans, who possess contextual understanding, moral values, and religious authority that cannot be replaced by algorithms. Considering these opportunities, challenges, and ethical implications, it can be concluded that AI has great potential as an enabler for the realization of a more efficient, innovative, and transparent Halal *Industry 4.0.*

However, its utilization must be carried out with a wise and ethical strategy to avoid exclusivity, bias, or degradation of sharia values (Harsanto 2024). Synergistic efforts between the government, certification bodies, academia, industry, and the community are needed to develop regulations, standards, and governance mechanisms that ensure that AI truly supports sharia objectives (*maqasid al-shariah*) while aligning with global sustainability principles. Thus,

the application of AI in the halal industry is not merely a technological innovation, but also an instrument of socio-economic transformation that is ethical, inclusive, and oriented towards the welfare of humanity.

METHOD

This study uses a qualitative approach with a descriptive-analytical design to examine the role of Artificial Intelligence (AI) as an enabler in the development of Halal Industry 4.0, focusing on opportunities, challenges, and ethical implications. Qualitative methodology was chosen because it is suitable for exploring complex, multidimensional phenomena involving technological, social, economic, and religious aspects. Primary data were obtained through in-depth interviews with stakeholders, including academics, halal industry practitioners, AI technology developers, halal certification bodies, and government regulators.

A purposive sampling technique was used to select informants with relevant competencies and experience, while the interview process was conducted semi-structured to be flexible yet focused. In addition, secondary data was collected through literature review of scientific articles, industry reports, halal regulations, policy documents, and official publications of international institutions related to AI, the halal industry, and sustainable development.

The collected data were then analyzed using thematic analysis, with coding, categorization, and identification of key themes representing the opportunities, challenges, and ethical issues of AI implementation in the halal ecosystem. Data validity was maintained through triangulation of sources and methods, namely by comparing interview results, literature, and policy documents to ensure consistency of findings.

The analysis results were interpreted within the conceptual framework of Halal Industry 4.0 and the principles of *maqasid al-shariah* as an ethical foundation, thus providing academic and practical contributions to the formulation of technology-based halal industry development strategies. Thus, this methodology enables the research to produce a comprehensive understanding of how AI can be utilized as a catalyst for innovation in the halal industry, while simultaneously anticipating risks and maintaining Sharia ethical values in its implementation.

RESULT AND DISCUSSION

Opportunities for Implementing Artificial Intelligence in the Halal Industry 4.0

The development of digital technology has given birth to a new era known as the Industrial Revolution 4.0, characterized by the integration of advanced technologies such as the Internet of Things (IoT), *big data analytics* , *cloud computing*, blockchain, and especially Artificial Intelligence (AI). In this context, the halal industry, as one of the rapidly growing sectors of the global economy, has a significant opportunity to utilize artificial intelligence as a driver of transformation. AI is seen as a key *enabler* in driving the creation of Halal Industry 4.0, namely a halal ecosystem that is oriented not only towards Sharia compliance, but also towards efficiency, innovation, and sustainability (Azam 2020).

The halal industry currently encompasses various sectors, from food and beverages, pharmaceuticals, cosmetics, fashion, to tourism and finance. With a global Muslim population of more than 1.9 billion people, coupled with the increasing awareness of non-Muslim consumers towards the value of halal which is synonymous with quality, safety, and ethics, the adoption of AI in the halal ecosystem can open up extraordinary opportunities to expand the market, increase competitiveness, and create sustainable added value.

The first very important opportunity is the use of AI to optimize the halal certification process. Halal certification is a crucial aspect that determines a product's legitimacy in the eyes of Muslim consumers. However, this process often faces challenges such as lengthy bureaucracy, limited halal auditors, and the complexity of the global supply chain involving many actors. AI can offer solutions through automated document verification systems, raw material composition analysis, and detection of potential non-halal contamination using machine learning and image recognition.

For example, AI algorithms can identify chemical or additive codes in food and pharmaceutical products that have potentially questionable halal status, thereby expediting the audit process. Furthermore, AI can be used to integrate certification data from various halal institutions worldwide, which is currently fragmented, creating a more standardized and trustworthy global system. This will make the halal certification process more transparent, efficient, and reliable, ultimately increasing consumer trust and expanding the market for halal products . Beyond certification, AI also opens up significant opportunities for halal product innovation, particularly in the food, pharmaceutical, and cosmetics sectors. Through consumer data analysis, AI can predict market preference trends, enabling manufacturers to create products tailored to specific needs.

For example, demand for healthy, low-sugar, or plant-based halal foods is increasing as people become more aware of healthy lifestyles and sustainability issues. AI can be used to design new product formulations that meet halal standards while also being environmentally friendly, utilizing predictive modeling and simulation tools. In the halal pharmaceutical industry, AI can help researchers find alternative halal ingredients to replace gelatin or enzymes derived from non-halal animals, accelerating the typically lengthy research and development (R&D) process. Similarly, in the halal cosmetics industry, AI can be used to identify combinations of natural ingredients that are halal, safe, and in line with consumer preferences, which increasingly demand environmentally friendly products. This makes AI not only a technical tool but also a catalyst for innovation, expanding the creative space of the halal industry.

Another opportunity arises in the context of halal supply chain efficiency. One of the main issues in the halal industry is the complexity of the global supply chain, which involves various suppliers, manufacturers, distributors, and retailers. Halal assurance must be ensured from upstream to downstream to ensure consumers' confidence in a product's halal status. AI can be used to develop intelligent supply chain management systems, utilizing predictive algorithms to manage inventory, minimize the risk of cross-contamination, and improve logistics efficiency.

For example, AI can monitor the temperature and transportation conditions of perishable halal products, such as meat and processed products, ensuring quality is maintained until they reach consumers (Raquib 2022). Furthermore, integrating AI with blockchain enables transparent halal traceability, where every stage of production and distribution is recorded in an immutable digital system. Consumers can easily verify a product's halal status simply by scanning a QR code, which displays comprehensive information about the origin of ingredients, the production process, and certification. This not only strengthens consumer trust but also increases the competitiveness of halal products in an increasingly competitive global market. AI also opens up significant opportunities in marketing and customer experience. By leveraging big data analytics, AI can analyze the behavior of Muslim consumers in various countries, enabling manufacturers to develop more effective and targeted marketing strategies. AI based chatbots can be used to provide customer service in appropriate local languages, including quickly and

accurately answering consumer questions about a product's halal status. AI can also be used to build halal product recommendation systems on e-commerce platforms, allowing consumers to easily find products that meet their needs.

Furthermore, AI has the potential to develop the concept of halal lifestyle personalization, where consumers are provided with a shopping experience tailored to their sharia values and preferences. Thus, AI not only improves business efficiency but also strengthens the emotional connection between consumers and halal products. In the halal tourism sector, AI can be utilized to improve sharia-compliant tourism services. AI systems can help Muslim travelers find halal-friendly destinations, such as hotels with prayer facilities, halal-certified restaurants, and prayer times integrated with travel apps.

Furthermore, AI-based facial recognition technology can be used to expedite immigration and security processes at airports, making the travel experience more convenient. By leveraging AI, halal tourism destinations can offer a more personalized, secure experience that meets the needs of the growing number of global Muslim travelers. This opens up significant opportunities for countries with potential halal tourism to increase their appeal in the global market. In the realm of Islamic finance, AI also offers the potential to drive efficiency and inclusion. Sharia compliant *fintech* can leverage AI to assess financing risks, detect potential fraud, and provide personalized financial services in accordance with Sharia principles. AI-based Sharia financial chatbots can educate customers about halal financial products, thereby improving Sharia financial literacy. Furthermore, AI based predictive analytics can help Sharia financial institutions identify profitable halal investment opportunities while minimizing the risk of Sharia non-compliance.

Thus, AI can strengthen the role of Sharia finance as a key pillar of the global halal industry. Another equally important opportunity is the use of AI in academic research and public policy related to the halal industry. Big data on halal consumption trends, consumer preferences, and global market dynamics can be analyzed using AI algorithms to generate strategic insights that support policy formulation. Governments can leverage AI to identify potential halal industry sectors, design regulations that adapt to technological developments, and monitor business compliance with halal standards. Academically, AI can be used to develop simulation models for the halal industry, enabling researchers to predict the impact of various policies or innovations on the halal ecosystem. This will accelerate knowledge development and encourage evidence-based policymaking in the halal economy. In addition to these opportunities, the application of AI in the halal industry also has strategic implications for global competitiveness (Jobin 2019). Halal products supported by AI technology will be more competitive because they are able to meet consumer demands for speed, transparency, and innovation. Countries that are able to integrate AI into their halal ecosystems will have an advantage in capturing a share of the global halal market, which is projected to continue growing.

For example, countries such as the United Arab Emirates, Malaysia, and Saudi Arabia have begun adopting AI technology in halal certification, while Indonesia, as the country with the largest Muslim population in the world, has a significant opportunity to become a global halal industry hub through the use of digital technology. Thus, AI can be a key driver for Muslim countries to become not only consumers but also major producers in the global halal value chain. Furthermore, the opportunities for AI application in the halal industry also support the Sustainable Development Goals (SDGs) agenda. Through supply chain efficiency, environmentally friendly product innovation, and increased Islamic financial inclusion, AI can

help the halal industry contribute to sustainable development. AI-based halal products not only comply with Sharia principles but also align with sustainability principles, encompassing economic, social, and environmental dimensions. Therefore, integrating AI into the halal industry is not only a business strategy but also a tangible contribution to sustainable global development.

Challenges of AI Implementation in the Halal Industry

The development of Artificial Intelligence (AI) technology holds enormous potential for transforming the halal industry in the Industrial Revolution 4.0 era. AI can help accelerate the certification process, improve the efficiency of the halal supply chain, drive product innovation, and strengthen transparency and consumer trust. However, behind these opportunities lie a variety of complex and multidimensional challenges, encompassing technical, social, economic, regulatory, and ethical aspects. These challenges must be comprehensively understood so that the implementation of AI in the halal industry not only provides efficiency and competitiveness benefits but also remains compliant with Sharia principles, values of justice, and long-term sustainability. One major challenge is the limited and uneven digital infrastructure in many countries with large Muslim populations (Kumar 2024).

The implementation of AI requires the availability of supporting technologies such as high-speed internet networks, data centers, and high-capacity hardware. However, the reality is that digital infrastructure in several member countries of the Organization of Islamic Cooperation (OIC) still lags behind that in developed countries. This inequality creates a gap in AI utilization, with large companies in urban centers or developed countries able to adopt it quickly, while small and medium-sized enterprises (MSMEs) in underdeveloped regions struggle to keep up. In the context of the halal industry, this means that most halal MSMEs are at risk of being left behind in global competition due to limited access to digital technology. Yet, MSMEs are the backbone of the halal economy in many countries, including Indonesia and Malaysia. The next challenge relates to data validity, quality, and standards. AI works with large databases (big data) to produce accurate analyses and recommendations. In the halal industry, the required data includes information on raw materials, production processes, distribution, and certification documents.

However, the availability of global halal data is currently fragmented, unstandardized, and often unverifiable. For example, halal certification data in one country may not be recognized in another due to differences in standards and methodologies. Furthermore, data quality is often problematic, whether due to input errors, administrative negligence, or the lack of interoperability between halal institutions. If AI is forced to work with invalid or biased data, its analysis results can be misleading and pose a risk of errors in determining a product's halal status. Therefore, a major challenge for the halal industry is building a standardized, secure, and cross-border accessible data ecosystem to enable AI to work effectively. Beyond technical issues, there are also human resource (HR) challenges. The development and utilization of AI requires competent experts in digital technology, data science, and sharia knowledge.

However, the number of professionals who master this combination of two fields remains very limited. Most technology experts lack understanding of halal and sharia principles, while fiqh experts and halal auditors lack technical skills in AI. This skills gap poses a serious obstacle to creating AI systems that are compliant with sharia values. If left unchecked, the halal industry could become dependent on external parties, including technology providers from non Muslim countries who may not understand the sensitivities of halal. This raises the risk of

technology incompatibility with halal principles and raises doubts among Muslim consumers about the results of AI implementation. Another significant challenge is cultural resistance and public trust. In the context of sharia, determining a product's halal status is not merely a technical matter but also concerns sacred religious authority. Some religious scholars and consumers may view the use of AI in halal certification as replacing humans, particularly the authority of religious scholars, with machines. This could generate resistance because it is perceived as diminishing the religious significance of the halal-haram determination process. In fact, according to Islamic principles, determining law must involve contextual understanding, moral considerations, and ijtihad, which cannot be completely replaced by algorithms (M. A. Rahman 2024).

Therefore, while AI can speed up and simplify the process, social acceptance of its use remains a serious challenge. Socialization, digital literacy, and clarification of AI's role as a tool, not a substitute for religious authority, are crucial to avoid misunderstandings and rejection. In terms of implementation costs, AI adoption also faces significant challenges. AI technology, particularly those based on machine learning and deep learning, requires significant investments in infrastructure, hardware, software, and system maintenance. While large companies may be able to afford these costs, halal MSMEs will struggle. This has the potential to create a digital divide between large and small players, with only multinational companies able to leverage AI to strengthen their competitiveness, while MSMEs are left behind. This situation could weaken the halal ecosystem as a whole, as MSMEs are the largest contributors to the global halal industry.

Therefore, a crucial challenge is how to create inclusive financing schemes to enable MSMEs to access AI technology, for example through subsidy programs, tax incentives, or cloud based technology sharing models. In addition to technical and economic challenges, there are also regulatory and governance challenges. Regulations related to AI are still relatively new and vary across countries. There are no international standards specifically governing the application of AI in the halal industry (Zhou 2022). This creates the risk of legal uncertainty for businesses. For example, who is responsible if an AI system incorrectly verifies a product's halal status? Does the responsibility lie with the manufacturer, the technology provider, or the certification body? Without clear regulations, legal risks can hinder AI adoption because businesses worry about potential sanctions or lawsuits. Furthermore, governance concerns the integration of AI with diverse global halal standards. Currently, there are hundreds of halal certification bodies worldwide with varying standards, making the implementation of AI across countries extremely complex. Another equally significant challenge is the issue of data security and privacy.

The implementation of AI in the halal industry often involves the collection of sensitive data from consumers, suppliers, and production processes. This data can include personal consumer information, company trade secrets, or valuable halal certification documents. The risk of data breaches is a real threat, especially if systems are not equipped with adequate cybersecurity protection. If halal certification data is leaked or manipulated, consumer trust in the halal industry could be undermined. Furthermore, privacy issues also relate to consumers' right to control their personal data. Therefore, the application of AI in the halal industry must be accompanied by strict data governance, including encryption, access authorization, and compliance with personal data protection regulations. Beyond technical, social, economic, and regulatory issues, there are also ethical and philosophical challenges under Sharia law. One key

ethical issue is the potential for algorithmic bias. AI learns from data, so if the data used contains bias, AI decisions will also be biased. In the halal context, algorithmic bias can have serious consequences, such as favoring large suppliers with comprehensive data, while marginalizing smaller suppliers with limited data (F. Alamsyah 2022).

This contradicts the Islamic principle of justice, which emphasizes inclusivity. Another ethical challenge is the potential for dehumanization, where sacred, religiously considered halal decisions are replaced by cold machine calculations. Yet, the maqasid al-shariah emphasizes the protection of religion, life, intellect, posterity, and property, which requires human wisdom in its implementation. Therefore, the application of AI should be positioned as a tool, not a substitute, for religious authority and moral values. Furthermore, challenges arise in the context of global collaboration. The halal industry is cross-border, with supply chains involving actors from various parts of the world.

However, levels of technological readiness, regulation, and public acceptance of AI vary. Developed countries may be more prepared to integrate AI into halal certification, while developing countries lag behind. This disparity can create a fragmented halal market, with only some products meeting AI-based digital standards, while others do not. This fragmentation can hinder the creation of an integrated global halal market, despite the primary goal of the halal industry being to build an interconnected ecosystem. Therefore, international collaboration presents a unique challenge, both in terms of standards harmonization, capacity building, and technology transfer.

Finally, an often overlooked challenge is the issue of environmental sustainability in the application of AI. The use of AI requires significant energy, particularly in the training process of deep learning models, which consumes significant computing power. If not balanced with renewable energy sources, the application of AI can actually increase the carbon footprint, which contradicts the principles of sustainability and the goals of the SDGs. The halal industry, synonymous with ethical values and social responsibility, should also consider the environmental impact of technology use. Therefore, the challenge is how to ensure that AI implementation in the halal industry is carried out in an environmentally friendly manner, for example by utilizing green data centers *or* energy-efficient technology.

Ethical Implications of AI Integration in the Halal Industry

The integration of Artificial Intelligence (AI) in the Halal Industry has significant impacts, not only technical and economic, but also touching on ethical, social, and religious dimensions. Ethics plays a fundamental role in the halal industry because the entire halal business framework is built on sharia principles, namely compliance with Islamic law and an orientation towards *maqasid al-shariah*, which guarantees the protection of religion, life, intellect, descendants, and property. The increasingly widespread application of AI, whether in halal certification, supply chain management, production standards monitoring, or consumer interactions, demands an in-depth study of its potential ethical implications. Without strong regulations and ethical guidelines, the use of AI has the potential to create moral dilemmas, algorithmic bias, privacy vulnerabilities, and even conflicts of authority between religious institutions and digital technology.

Therefore, discussing ethical implications is crucial to ensure that AI integration in the halal industry not only supports efficiency and innovation but also maintains the authenticity of sharia values (Wirtz 2023). One of the key ethical issues in the application of AI is the potential for algorithmic bias. AI operates based on the data used to train the model. Therefore, if the data

used is unrepresentative, biased, or limited to a specific context, the AI's decisions can be discriminatory and unfair. In the halal industry, this can occur, for example, when AI systems are used to assess the halalness of raw materials or verify a product's halal certification. If the data used only covers the standards of a single certification authority, the results may ignore the varying interpretations of Islamic jurisprudence (fiqh) that apply across countries. This type of algorithmic bias has the potential to disadvantage small producers, MSMEs, or countries with differing halal standards, while also reducing the inclusiveness of the global halal industry.

From an Islamic ethical perspective, this type of injustice (*zulm*) is unacceptable, necessitating mechanisms to ensure algorithmic fairness in AI systems. Furthermore, issues of data privacy and information security also pose highly relevant ethical implications. The application of AI in the halal industry often involves the collection of large amounts of data, including data on production, distribution, and supply chains, as well as on Muslim consumer preferences. This data, if not carefully managed, can be misused by both internal and external parties.

For example, a data leak related to a company's raw materials could harm business actors and lead to unfair competition. On the other hand, excessive exploitation of Muslim consumer data for commercial gain could violate the Islamic principle of privacy protection. Within the framework of Sharia ethics, maintaining data confidentiality and security is part of a mandate, so halal industry players utilizing AI must ensure high cybersecurity standards and transparent, ethical data governance. Ethical implications also arise in the context of religious authority and technological legitimacy.

In practice, halal certification has traditionally been carried out by religious institutions or authorities with Islamic legal authority. The presence of AI in the certification process, for example through automated systems that assess the halalness of ingredients or algorithms that classify halal products, raises questions: can AI decisions replace religious edicts (fatwas) from Islamic scholars? What is the religious legitimacy of machine-generated decisions? These questions are crucial because the halal industry is not only about administrative compliance but also about the spiritual beliefs of the Muslim community. If AI is perceived as determining halalness without human involvement and the authority of Islamic scholars, a legitimacy crisis could emerge that undermines consumer trust.

Therefore, AI integration should be viewed as a tool to enhance efficiency, while religious authorities retain a primary role in making the final decision regarding a product's halal status. Another equally important ethical implication is the risk of dehumanization in the halal industry. With the advent of AI, many processes in production, distribution, and even customer service can be automated. While this increases efficiency, there is a risk of marginalizing human values in halal business interactions.

For example, in buying and selling practices, Islamic ethics emphasize honesty, transparency, and goodwill in human interactions. If entire transactions are replaced by algorithms without a human touch, the ethical dimension of those interactions could potentially be lost (Klinova 2021). This raises the question of whether technological efficiency can replace the ethical quality of human interaction. Therefore, AI should be positioned to support human values, not replace them. Furthermore, the integration of AI in the halal industry also raises an ethical dilemma related to the gap in technological access. Developed countries with robust digital infrastructure can quickly adopt AI technology in their halal industries, while developing countries or halal MSMEs may be left behind. This inequality could create a new divide in the

global halal ecosystem, with only large companies with access to advanced technology able to meet new AI-based standards. From an Islamic social justice perspective, this could exacerbate economic inequality and disadvantage vulnerable groups.

Therefore, the implementation of AI in the halal industry must be accompanied by policies that ensure inclusivity and equitable access for all parties, so that digital transformation does not widen the gap. From an Islamic business ethics perspective, the application of AI also has implications for the principles of transparency (*shiddiq*) and responsibility (*amanah*). AI often functions as a "black box" system, where the decision making process is not fully transparent to users. In the context of the halal industry, this is problematic because Muslim consumers have the right to know the basis for a product's decision to be considered halal. If an AI system declares an ingredient non-halal without providing a clear explanation, the decision could create confusion and undermine consumer trust.

Therefore, the principle of transparency demands that AI systems used in the halal industry be explainable. This aligns with the Islamic principle of *tabyin* (clear explanation), which emphasizes the importance of information transparency. Furthermore, ethical implications also relate to environmental impacts. AI can help improve production efficiency and reduce waste, but at the same time, implementing this technology requires significant energy consumption, especially when using energy-intensive data centers (Jamaludin 2025).

From an Islamic ethical perspective, preserving the environment is part of humanity's mandate as caliphs on earth. If the application of AI actually increases the carbon footprint and exacerbates environmental damage, it contradicts the principles of sustainability taught in Islam. Therefore, the integration of AI in the halal industry must consider the use of environmentally friendly technology and align with eco-halal principles. Ethical implications can also be seen from the aspect of corporate social responsibility. Halal companies utilizing AI are required not only to pursue business efficiency but also to uphold social values, such as fair job creation, community empowerment, and equitable distribution of benefits. If the use of AI actually leads to mass unemployment in the halal sector due to the replacement of many jobs by machines, ethical issues will arise in the form of worker marginalization.

In Islam, the principles of distributive justice and social welfare must be prioritized, so halal companies using AI need to adopt workforce reskilling and upskilling strategies to ensure digital transformation can proceed without compromising workers' rights. Furthermore, there are ethical issues related to accountability. If an AI system in the halal industry makes a mistake, for example, misclassifying a haram ingredient as halal, the question arises: who is responsible: the AI developer, the company owner, the certification body, or the regulator ?, This lack of clarity in responsibility can raise serious legal and ethical issues.

From an Islamic perspective, every decision affecting Muslims carries a moral and religious dimension of responsibility. Therefore, a clear accountability system is needed to ensure that the application of AI in the halal industry remains under human control and complies with the principles of sharia responsibility. Furthermore, the integration of AI in the halal industry also raises ethical implications related to the legitimacy of international law (Ali 2025).

Halal standards vary across countries, while AI operates on the principle of data unification and standardization. If AI is used globally without considering the diversity of halal standards, ethical questions arise about who has the right to determine applicable halal standards. Are these standards determined by the country with the greatest technological power, or by global consensus? From an Islamic perspective, the plurality of Islamic jurisprudence is

legitimate and recognized, so the application of AI should not negate this diversity. This demands a global dialogue between Islamic scholars, regulators, and technology developers to ensure that the AI systems used are inclusive and respectful of differences. Ultimately, all of these ethical implications point to the urgent need for ethical governance in the application of AI in the halal industry (N. &. Ismail 2025). This governance must encompass the principles of sharia, human rights, social justice, and environmental sustainability. Clear regulations, a strict code of ethics, and collaboration between religious institutions, government, academia, and the technology industry are key requirements for AI to function as an enabler that strengthens the halal industry without compromising ethical values. Thus, the integration of AI in the halal industry can be a unique example of how advanced technology can be combined with spiritual and ethical values to create a business ecosystem that is fair, sustainable, and meaningful for humanity.

CONCLUSION

Artificial Intelligence (AI) holds significant potential as a key enabler in shaping and strengthening Halal Industry 4.0, where digitalization, automation, and the integration of intelligent technology are strategic elements in addressing global dynamics. In terms of opportunities, AI can improve operational efficiency, accelerate the halal certification process, ensure supply chain transparency, and expand halal market access through more adaptive product and service innovations. Furthermore, the use of AI can also strengthen the competitiveness of the halal industry internationally by providing accurate and real-time data-driven solutions, thereby increasing global consumer confidence in halal products. However, the implementation of AI in the halal ecosystem is not without complex challenges, such as limited digital infrastructure, technological literacy gaps, data validity standards, and resistance from some authorities and the public to the use of technology perceived as potentially displacing the authentic role of humans in determining halal status. These challenges demand an adaptive strategy involving synergy between government, industry, academia, and religious scholars so that AI can be integrated in an inclusive and equitable manner. Furthermore, the integration of AI in the halal industry also raises ethical implications that must be anticipated, particularly regarding data privacy, algorithmic fairness, technological bias, and the authority in determining halal legitimacy, which should remain based on the principles of *maqasid al-shariah*. Therefore, the application of AI should not merely pursue technical efficiency, but must also consider ethical, spiritual, and social aspects. This overall analysis confirms that the success of AI as an enabler of Halal Industry 4.0 can only be achieved if opportunities are maximized, challenges are addressed collaboratively, and ethical implications are managed wisely. With this approach, AI can become a catalyst for halal transformation that is not only globally competitive but also remains aligned with sharia values and sustainability.

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