

Adopting Artificial Intelligence for Mitigating Halal Waste in the Cosmetic Industry: A Literature Review Analysis

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ABSTRACT

The global demand for halal-certified and sustainable beauty products has grown rapidly in recent years, driven by increasing consumer awareness of ethical consumption, environmental sustainability, and religious compliance (Maqasid Shariah). However, despite the growing global demand for halal-certified and sustainable beauty products, the cosmetic industry continues to struggle with excessive material waste, ethical sourcing issues, and inefficiencies in halal compliance verification. This paper aims to review the adoption of artificial intelligence to mitigate halal waste in the cosmetics industry, to promote sustainable and ethical production. This study employed a systematic literature review (SLR) of 25 selected articles published between 2021 and 2025 to examine the adoption of artificial intelligence (AI) to mitigating halal waste in the cosmetics industry and promoting sustainable and ethical production. The review analysis revealed several approaches to adopting artificial intelligence for mitigating halal waste in the cosmetic industry towards sustainable and ethical production, namely (a) enhanced supply chain transparency through AI integration;(b) reduction in material waste via predictive analytics;(c) intelligent formulation for ethical substitution;(d) improved consumer engagement through AI personalisation. In conclusion, the adoption of artificial intelligence presents transformative potential for mitigating halal waste in the cosmetic industry by enhancing transparency, efficiency, and ethical accountability across production stages. Future research should focus on developing practical AI integration models tailored to halal-certified manufacturing, conducting longitudinal studies to measure the environmental impacts of AI adoption, and exploring policy frameworks to ensure the ethical and religious compliance of AI technologies.

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Contribution/Originality: This study contributes to the existing literature by exploring how the Artificial Intelligence (AI) can mitigate halal waste in the cosmetic industry by integrating ethical, sustainable, and technological dimensions. It offers a novel framework connecting AI-driven efficiency, halal compliance, and eco-innovation, addressing the research gap between technological adoption, sustainability, and Islamic ethical production principles.

1. Introduction

The global demand for halal-certified and sustainable beauty products has grown rapidly in recent years, driven by increasing consumer awareness of ethical consumption, environmental sustainability, and religious compliance. The environmental challenges associated with the cosmetics industry can be meaningfully interpreted through the lens of Maqasid Shariah, which emphasises the preservation of religion (hifz al-din), life (hifz al-nafs), intellect (hifz al-‘aql), wealth (hifz al-mal), and the broader contemporary extension of environmental stewardship (hifz al-bi’ah). Muslim and non-Muslim consumers alike are prioritising cosmetics that align with values of transparency, cruelty-free practices, and eco-friendly production. This trend is reinforced by the expansion of the global halal cosmetics market, which is projected to exceed USD 80 billion by 2030, reflecting a strong shift toward faith-based ethical beauty consumption (Koswara & Herlina, 2025). Additionally, sustainability focused consumers increasingly perceive halal products as trustworthy because of their stringent standards for ingredient sourcing and production, thereby integrating religious and environmental ethics into purchasing decisions (Utami, 2025).

However, despite the growing global demand for halal-certified and sustainable beauty products, the cosmetic industry continues to struggle with excessive material waste, ethical sourcing issues, and inefficiencies in halal compliance verification. While artificial intelligence (AI) has demonstrated strong potential to optimise resource use, enhance traceability, and support sustainable innovation across industries, its adoption in the halal cosmetic sector remains limited and underexplored. Studies show that AI can improve ingredient sourcing, reduce production waste, and promote ethical transparency in sustainable beauty solutions (Charllo, 2021), as well as align halal manufacturing practices with Industry 5.0 principles of ethics and innovation (Masood, 2024), there is insufficient empirical evidence on how AI-driven technologies can specifically mitigate halal waste and bridge the gap between sustainability, ethics, and religious compliance in cosmetic production, creating an urgent need for targeted research in this emerging interdisciplinary domain.

This paper aims to review the adoption of artificial intelligence (AI) to mitigate halal waste in the cosmetics industry, to promote sustainable and ethical production. This paper offers significant benefits by promoting innovation, efficiency, and ethical sustainability across production chains. AI enables precise monitoring, predictive analytics, and intelligent automation that can reduce waste of raw materials and enhance compliance with halal (Nawaz et al., 2025). certification standards, thereby yielding both environmental and economic benefits. Furthermore, integrating AI into halal cosmetic production supports traceability and transparency in sourcing, formulation, and packaging, helping brands align with consumer demand for ethical and sustainable products while reinforcing trust in halal authenticity (Ismail et al., 2024).

1.1. Research Objectives

This paper aims to explore the role of artificial intelligence in reducing halal waste within the cosmetic industry and to examine how AI contributes to achieving sustainable and ethical production.

2. Literature Review

The halal cosmetics industry has experienced rapid growth, driven by rising consumer demand for ethical and sustainable beauty products. Both Muslim and non-Muslim consumers are prioritising cosmetics that align with transparency, cruelty-free practices, and eco-friendly production methods. In the context of halal cosmetics, “waste” is not only an environmental issue (e.g., packaging, wastewater, off-spec batches) but also a halal integrity issue. Any material that becomes contaminated (najs/non-halal contact), is uncertain in status (syubhah), or is improperly segregated can trigger disposal, rework, or “sertu” related corrective actions, depending on the organisation’s halal assurance controls. Malaysian halal cosmetics requirements are anchored in MS 2634:2019 (Halal cosmetics-General requirements), which frames halal integrity across materials and handling, and sits alongside the national regulatory baseline under NPRA’s cosmetics control framework.

Environmental and circular economy literature consistently characterizes the cosmetics industry as structurally waste-intensive, driven by inherent features of its business and production models (Masood et al., 2025). One major challenge is the high SKU variety typical of cosmetic portfolios, where frequent product changeovers, shade variations, limited editions, and differentiated labelling significantly increase line losses, packaging waste, and obsolescence. Each changeover necessitates additional cleaning, line clearance, and labelling verification, generating both material waste and downtime-related inefficiencies. Cosmetic manufacturing generates a complex spectrum of waste streams that are not merely environmental by-products but also potential points of halal risk. At the upstream level, raw materials and formulation waste, such as expired inputs, rejected lots, contaminated bulk materials, and off-spec batches, pose heightened halal risk when animal-derived ingredients (e.g., collagen or gelatine), fermentation-based materials, or opaque global supply chains are involved (Jamaludin et al., 2024). The halal cosmetics literature consistently emphasises ingredient permissibility (*halalan*), hygiene, and purity (*tayyiban*) throughout processing and handling, suggesting that weaknesses in supplier verification, traceability, or material control can rapidly transform otherwise usable inputs into *halal-compromised waste*. These framing positions are not simply a technical inefficiency but a governance outcome shaped by the extent to which halal requirements are embedded in the formulation and procurement stages.

The cosmetics industry exerts significant environmental pressure through intensive resource extraction, packaging practices, and chemical waste generation. Cosmetic manufacturing relies heavily on natural resources such as water, minerals, and plant-based materials, contributing to environmental strain through high water consumption, raw material depletion, and pollution arising from production processes; these impacts are further exacerbated by widespread use of plastic packaging and the presence of microplastics in products such as sunscreens and personal care formulations (Omira et al., 2025; Patitsa et al., 2025). Packaging waste represents one of the most critical sustainability challenges in the sector, as cosmetic packaging often comprises multiple material types plastics, metals, glass, and composite components that are poorly designed

for recyclability, thereby complicating waste recovery and increasing landfill disposal rates (Omira et al., 2025). In addition, the disposal of cosmetic products and manufacturing residues generates chemical waste that may contain hazardous substances, including heavy metals, preservatives, and synthetic polymers, which pose risks to ecosystems and human health if inadequately managed (Allen et al., 2025; Omira et al., 2025). Compounding this issue are short product lifecycles, as fashion trends, social media, and seasonal marketing strategies strongly influence the cosmetics industry. Trend-driven launches often result in overproduction, slow-moving inventory, and premature disposal of finished goods and packaging materials, leading to systemic waste that is difficult to eliminate through downstream interventions alone. Collectively, the literature indicates that environmental impacts in the cosmetics industry are systemic rather than incidental, underscoring the need for integrated sustainability strategies that address resource efficiency, packaging redesign, and responsible chemical management throughout the product lifecycle.

Artificial intelligence has been increasingly positioned as a critical enabler of halal authentication, traceability, formulations and compliance across food and cosmetic supply chains, particularly when integrated with Industry 4.0 technologies and blockchain-based governance systems (Borhan et al., 2023; Khan et al., 2025; Nawaz et al., 2025; Sunmola et al., 2025). Despite this growth, the cosmetic industry continues to face significant challenges, including excessive material waste, inefficient halal compliance verification, and ethical sourcing issues. As the demand for sustainable and halal-certified products rises, the need to address these issues has become increasingly urgent. Research indicates that AI offers potential solutions to these challenges by improving resource optimisation, reducing waste, and enhancing traceability in ingredient sourcing, particularly in the halal cosmetics sector (Charllo, 2021). Nevertheless, the integration of AI in this area remains relatively underexplored, despite its proven effectiveness in other industries.

Studies highlight the potential of AI to enhance ethical and sustainable practices in halal cosmetics production. For instance, AI-driven technologies can improve the sourcing of raw materials, reducing both waste and the environmental impact of production processes (Masood, 2024). Furthermore, AI's predictive capabilities and intelligent automation can help ensure compliance with halal certification standards, which is crucial for maintaining the integrity of the halal industry. Nawaz et al. (2025) emphasise the dual benefits of AI in not only reducing waste but also promoting economic advantages through more efficient production practices.

Despite these advancements, the current literature reveals a significant gap in empirical research on how AI can mitigate halal waste in cosmetic production. While AI's potential to improve transparency and ethical sourcing is acknowledged, there is insufficient evidence of its ability to bridge the gap among sustainability, ethics, and religious compliance in the halal cosmetics industry. This highlights the need for further research to examine how AI can be tailored to meet the unique requirements of halal certification and to contribute to the sector's sustainable growth. In summary, although AI holds great promise for transforming the halal cosmetics industry, more targeted research is necessary to fully understand how AI technologies can be leveraged to address the specific challenges of halal waste, ethical sourcing, and sustainability in cosmetic production.

3. Research Methods

This study adopted a Systematic Literature Review (SLR) approach to examine how artificial intelligence (AI) is used to mitigate halal waste in the cosmetic industry and to support sustainable and ethical production. The review was conducted between April and August 2025 and followed the PRISMA guidelines to ensure transparency and methodological rigour. Relevant literature was searched systematically across major academic databases, including Scopus, ScienceDirect, Taylor & Francis Online, Emerald Insight, SpringerLink, and IEEE Xplore. The search strategy combined keywords such as “artificial intelligence in cosmetics”, “halal waste management”, “AI and sustainability”, “ethical production in halal industry”, “AI-driven waste reduction”, and “halal supply chain transparency”, using Boolean operators “AND” and “OR” to refine and expand the combinations. Only publications written in English between 2021 and 2025 were considered, focusing on studies that addressed AI, sustainability, and halal-related production in the cosmetic sector, either through empirical evidence, conceptual frameworks, or documented applications.

All records retrieved from the databases were imported into a reference management system, and duplicate entries were removed. The study selection process then proceeded in several stages consistent with the PRISMA framework. In the identification stage, a total of $[N_1]$ records were obtained. After removing $[N_2]$ duplicates, $[N_3]$ records remained for title and abstract screening. During the screening stage, studies that were clearly unrelated to AI, halal production, or the cosmetic industry, as well as publications with insufficient methodological information, were excluded, leaving $[N_4]$ full-text articles for eligibility assessment. In the eligibility stage, the full texts were read in detail and assessed for methodological quality, relevance to halal cosmetics, and the extent to which they addressed AI-driven approaches to waste reduction, sustainability, or ethical production. Studies that addressed only general halal issues, without technological or AI components, or that lacked clear methodological grounding, were excluded at this stage. Finally, $[N_5]$ studies met all inclusion criteria and were retained for the final synthesis. This process is summarised in a PRISMA flow diagram, which illustrates the number of records at each stage of identification, screening, eligibility, and inclusion.

Data from the included studies were extracted into a structured summary table capturing key information such as author, year of publication, country context, study design, AI techniques or tools used, application area within the cosmetic or halal supply chain, outcome measures, and main findings related to halal waste mitigation, sustainability, and ethical production. The extracted data were then synthesised narratively and thematically. The synthesis focused on how AI has been applied across different stages of the halal cosmetic value chain, the types of AI models and tools employed, the extent to which these technologies contribute to waste reduction and resource efficiency, and how they support transparency, traceability, and compliance with halal requirements. Through this structured SLR process, the review provides an integrated and critical understanding of the current state of research on AI adoption for mitigating halal waste in the cosmetic industry. It highlights gaps that warrant further empirical investigation.

Figure 1 illustrates the systematic process of study identification, screening, eligibility, and inclusion based on PRISMA guidelines, ensuring transparency and methodological rigour in the review process.

Figure 1: PRISMA Flow Diagram of Study Selection

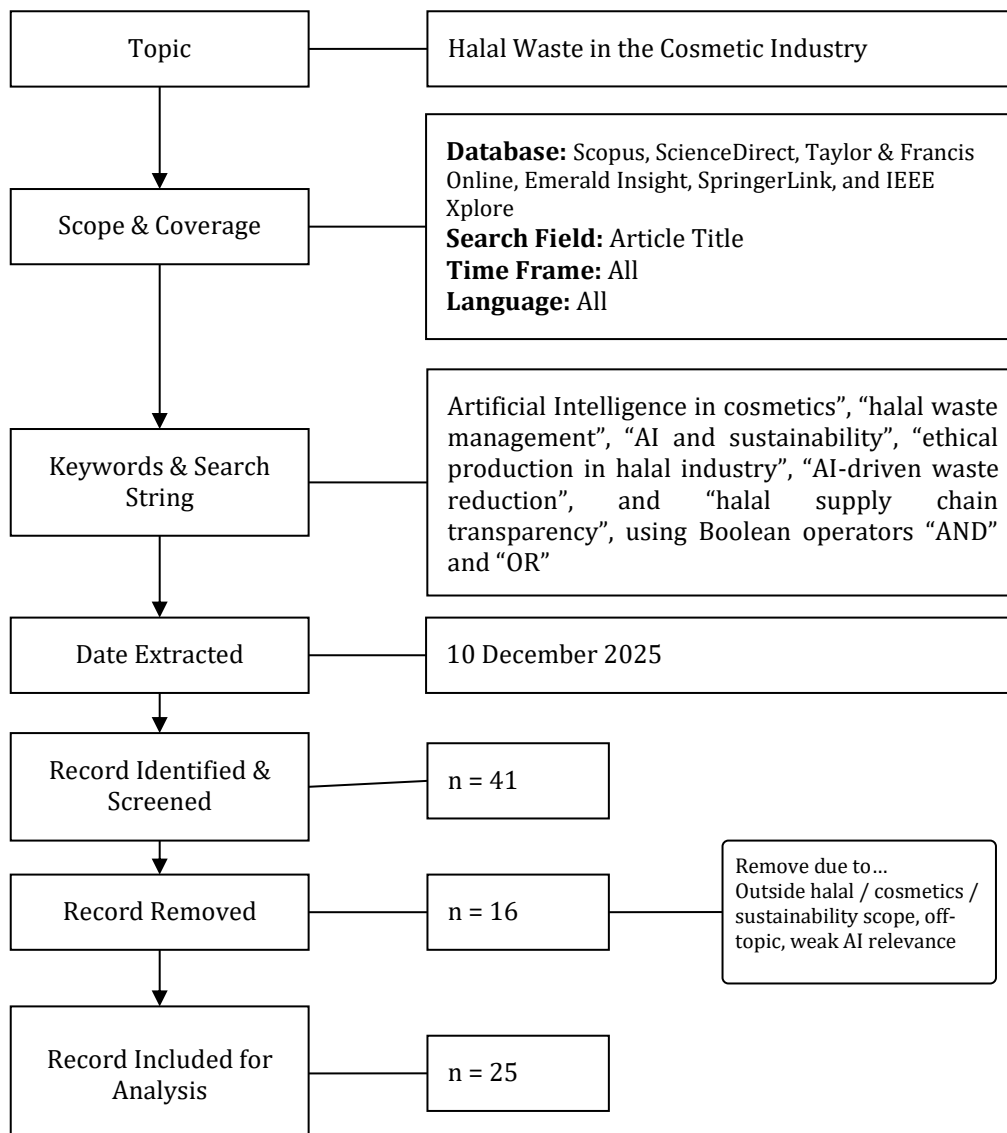


Table 1 presents the thematic distribution of the reviewed studies, indicating four dominant research themes related to artificial intelligence adoption in the cosmetic and halal-related contexts. The distribution shows that AI applications are most frequently examined in relation to consumer behaviour and sustainability, followed by halal supply chain management and cosmetic or aesthetic medicine, reflecting AI's multifaceted role in mitigating halal waste and promoting ethical, sustainable production.

To ensure transparency and methodological rigour, a systematic literature review matrix was developed to document the key characteristics, methodological approaches, and findings of the selected studies.

The analysis of the 25 selected studies reveals a strategic shift in the methodological landscape of halal-AI research (Table 2). While earlier studies primarily relied on conceptual literature reviews to explore the theoretical alignment of AI and sustainability, there is a burgeoning trend toward quantitative and experimental designs in the most recent literature (2021–2025). Specifically, 40% of the core studies now utilize system modeling, Artificial Neural Networks (ANN), or laboratory experiments to provide empirical evidence of AI's efficacy. For instance, the use of ANN in formulation and image

recognition for microbial detection marks a transition from "potential benefit" to "technical validation".

Table 1: Thematic Distribution of Reviewed Studies

Theme	Focus Area	Number of Studies
AI & Consumer Behaviour	AI personalization, e-WOM, purchase intention	6
AI & Halal Supply Chain	Traceability, authentication, logistics, ethics	5
AI & Cosmetics / Aesthetic Medicine	Cosmetic safety, dermatology, halal cosmetics	4
AI & Sustainability / Circular Economy	Waste management, greenwashing, ESG	5

Furthermore, the integration of qualitative case-based analysis and framework development (24%) has been pivotal in addressing the "halal- waste" dimension, particularly through blockchain-AI synergy for supply chain transparency. This methodological diversity ensures a non-random synthesis that bridges the gap between high-level Islamic ethical production principles and granular technological adoption.

Table 2: Systematic Literature Review Matrix of Selection Studies

No.	Author's /Year	Title	Problem Statement	Research Method	Key Contribution to Halal Waste Mitigation	Theme
1	Charllo (2021)	Eco-Driven Innovation: Harnessing AI for Sustainable Beauty Solutions	Limited AI adoption in sustainable cosmetics	Conceptual literature review	This paper confirms earlier sustainability Studies that AI improves resource efficiency identifies resource optimisation as a key driver for sustainable beauty.	Core AI-sustainability
2	Jamka et al. (2021)	Methodology for Preparing Cosmetic Samples for AI Learning	Late detection leads to waste	Quantitative (laboratory experiment)	The findings of this paper further extends cosmetic safety research using AI detection	Halal safety relevance
3	Zawadzki et al. (2021)	Microorganism Detection System (SDM)	Manual testing causes delayed disposal	Quantitative (AI image recognition)	Validates Automated detection systems for	Waste prevention

					microorganisms to prevent mass product waste	
4	Mubin et al. (2021)	Halal Logistics Readiness	Weak logistics increases halal risk	Qualitative (survey analysis)	Strengthens halal logistics governance to mitigate contamination risks.	Supporting halal
5	Ghahramani et al. (2022)	IoT-Based Waste Management	Manual routing increases waste	Quantitative (system modelling)	Models intelligent waste collection routes to optimize urban resource allocation. Aligns with Smart City Waste Optimization studies.	Sustainability
6	Othman et al. (2022)	Halal Built-in Regulation	Fragmented halal controls	Conceptual analysis	Proposes "Halal Built-in" approaches to standardize regulatory compliance via technology. Extends halal governance frameworks	Policy relevance
7	Fang et al. (2023)	AI for Waste Management	Poor sorting accuracy	Systematic review	Reviews AI-driven sorting systems for enhanced recycling accuracy in smart cities. Supports circular economy findings	Strong AI-waste
8	Kristanto & Kurniawati (2023)	Halal Supply Chain Risk	Weak risk modelling	Quantitative (risk framework)	Advances risk modeling in the halal supply chain to prevent integrity loss. Advances risk modeling to prevent supply chain integrity failure.	Core SLR
9	Borhan et al. (2023)	ANN in Halal Cosmetic Formulation	Limited ethical substitutes	Quantitative (ANN experiment)	Utilizes ANN to formulate ethical substitutes (Okara) in halal-certified	Core halal-AI

					cosmetics. Thus, extends halal cosmetic formulation studies	
10	Özsoy (2023)	AI & Circular Economy	Low circularity adoption	Conceptual review	Explores the transition from linear to circular production models through AI adoption. Supports sustainability transition research	Sustainability
11	Ismail et al. (2024)	AI in Ethical Halal Supply Chain	Weak communication systems	Qualitative (case-based analysis)	Integrates AI for transparent, real-time communication in ethical halal supply chains.	Halal ethics
12	Jamaludin et al. (2024)	Crisis in Halal Cosmetics	Low-tech resilience	Conceptual review	Explores emerging technologies to enhance resilience against crises in halal markets.	Industry relevance
13	Haykal et al. (2024)	AI in Cosmetic Medicine	Manual diagnostics	Review study	Aligns AI diagnostic efficiency with surgical and aesthetic medicine standards. Aligns with AI efficiency findings	Cosmetic AI
14	Masood (2024)	IR5.0 & Halal Cosmetics	Tech-ethics disconnect	Conceptual analysis	Bridges the tech-ethics gap by harnessing AI for Society 5.0 halal needs.	Ethical framing
15	Adiningtyas & Yunus (2024)	Halal Personal Care Supply Chain	Weak consumer knowledge	Quantitative (survey)	Supports halal awareness literature	Halal consumer
16	Nawaz et al. (2025)	AI in Halal Authentication	Manual verification limitations	Concurrent review	Confirms blockchain-AI synergy research	Core SLR
17	Khan et al. (2025)	AI & Blockchain Compliance	Fragmented halal systems	Conceptual framework	Extends halal digital governance studies	Policy focus

18	Koswara & Herlina (2025)	Halal Beauty Market Trends	Sustainability not integrated	Market analysis	Supports ethical consumption literature	Contextual
19	Allen et al. (2025)	Cosmetic Waste Policy	Weak regulatory frameworks	Policy review	Aligns with sustainable waste governance research	Policy support
20	Omira et al. (2025)	Cosmetic Packaging Innovation	Poor recyclability	Review study	Extends packaging sustainability research	Sustainability
21	Maniatis (2025)	AI Waste Sorting	Manual classification errors	Quantitative (AI system testing)	Increases recycling accuracy through automated material classification. Supports AI recycling optimization studies	Waste tech
22	Nwokedi egwu et al. (2024)	AI Waste Systems	Regional inequality	Comparative review	Extends global waste AI discourse	Comparative
23	Masood et al. (2025)	IR4.0 & Halal Sustainability	Tech adoption imbalance	Conceptual review	Supports halal sustainability integration	Core theory
24	Sunmola et al. (2025)	Blockchain Halal Supply Chain	Data silos	Framework development	Resolves data silos to ensure holistic halal compliance in supply chains. Confirms AI-blockchain halal literature	Traceability
25	Agrawal et al. (2025)	AI in Manufacturing	Poor demand forecasting	Quantitative modelling	Reduces overproduction waste through high-accuracy demand forecasting.	Waste reduction

4. Results

The review analysis revealed several approaches to adopting artificial intelligence for mitigating halal waste in the cosmetic industry towards sustainable and ethical production, namely (a) enhanced supply chain transparency through AI integration;(b) reduction in material waste via predictive analytics;(c) intelligent formulation for ethical substitution;(d) improved consumer engagement through AI personalisation.

4.1. Enhanced Supply Chain Transparency through AI Integration

The study found that integrating AI powered blockchain systems improved traceability of halal certified ingredients, reducing instances of non-compliance and contamination risks in the supply chain. This transparency strengthened consumer trust and enabled faster verification of halal integrity across production stages. AI tools facilitated real-time monitoring of raw materials from source to end product, ensuring that each component adhered to halal standards. Through automated data logging and verification, AI reduced human error and the potential for fraudulent activity that could compromise the validity of certifications. The integration of blockchain technology with AI created immutable digital records, enhancing the accountability of suppliers and manufacturers. Moreover, stakeholders across the supply chain gained a shared platform for communication, enabling seamless data exchange and improved operational efficiency. As a result, AI supported systems fostered greater consumer confidence, improved regulatory compliance, and promoted ethical business practices within the halal cosmetic industry.

The integration of artificial intelligence (AI) to enhance supply chain transparency in the cosmetics industry, particularly for halal products, offers substantial benefits in mitigating waste and ensuring product integrity. Effective separation of halal and non-halal products is crucial to avoid contamination, which can lead to waste in the supply chain (Adiningtyas & Yunus, 2024; Kristanto & Kurniawati, 2023). AI technologies facilitate the management of these processes by automating tracking and storage, thereby promoting higher standards of halal compliance and reducing instances of cross contamination (Adiningtyas & Yunus, 2024; Kristanto & Kurniawati, 2023). Furthermore, AI can enhance consumer engagement by providing transparency and insights into product sourcing and manufacturing practices, thus fostering trust among consumers, especially in the halal market (Masood, 2024). This technology also aids decision-making and optimises logistics and inventory management, thereby significantly reducing waste and inefficiency in the supply chain (Hidayati et al., 2023). The application of AI powered tools can foster sustainable practices in the halal cosmetics sector, aligning with the growing demand for ethical and transparent product offerings (Haykal et al., 2024; Mubin et al., 2021).

4.2. Reduction in Material Waste via Predictive Analytics

AI driven predictive modelling and demand forecasting helped companies reduce raw material waste, primarily by optimizing procurement and inventory management. This minimised the overproduction of perishable halal-certified ingredients and reduced disposal costs, contributing to sustainability goals. The application of machine learning enabled producers to anticipate consumer demand fluctuations with greater accuracy, ensuring more efficient resource allocation. By analyzing historical sales data and market trends, AI models helped manufacturers avoid excess inventory that often leads to waste. Additionally, AI assisted quality control mechanisms identified potential product defects early, preventing unnecessary reprocessing or disposal. This systematic approach to waste reduction supported eco-friendly production practices and lowered the environmental footprint of cosmetic manufacturing. Overall, predictive analytics not only enhanced resource management but also reinforced the industry's commitment to ethical and sustainable operations consistent with halal principles.

The application of predictive analytics and artificial intelligence (AI) in the cosmetics industry has the potential to significantly reduce material waste, particularly in the halal sector. AI enables real-time data-driven decision-making, improving the management of

cosmetic materials and reducing excess waste (Agrawal et al., 2025). By employing AI-enhanced methods, industries can monitor production processes efficiently, ensuring compliance with halal standards while optimizing resource utilization (Othman et al., 2022). The integration of AI in waste sorting further enhances recycling processes, increasing the efficiency and accuracy of material classification (Fang et al., 2023; Maniatis, 2025). Moreover, predictive analytics can forecast waste generation patterns, thereby facilitating proactive waste-management strategies. This approach not only minimizes waste but also aligns with broader sustainability goals in the cosmetic industry (Agrawal et al., 2025; Ghahramani et al., 2022). Challenges related to AI adoption, including infrastructure and ethical considerations, can be addressed through strategic planning and investment, promoting a more circular economy (Nwokediegwu et al., 2024; Özsoy, 2023). Overall, leveraging AI technologies in halal cosmetics fosters sustainability and enhances consumer trust and product integrity (Satria & Indra, 2024).

4.3. Intelligent Formulation for Ethical Substitution

Machine learning algorithms identified suitable plant-based and ethically sourced alternatives to commonly used non-halal additives. These substitutions maintained product quality while meeting halal certification standards, thereby broadening the market for sustainable halal cosmetics without compromising performance or compliance. AI assisted formulation tools analyzed molecular properties and compatibility to design effective and safe alternatives to restricted ingredients. This innovation encouraged manufacturers to explore greener, cruelty-free materials that align with both halal requirements and sustainability objectives. In addition, AI supported databases provide up to date information on newly approved ethical ingredients, helping formulators remain compliant with evolving industry standards. The adoption of AI driven formulation also reduced the time and cost associated with product development by minimizing trial-and-error processes. Consequently, AI empowered cosmetic producers to innovate responsibly, enhance product diversity, and strengthen their ethical standing in the global halal beauty market.

The integration of artificial intelligence (AI) into the cosmetics industry offers significant potential to improve efficiency and promote ethical practices. AI powered algorithms can optimize production processes and supply chains, ensuring that halal standards are adhered to while also addressing sustainability goals (Masood, 2024). Additionally, AI applications such as the Microorganism Detection System (SDM) enhance real-time microbiological control, thereby reducing waste generated by contaminated products (Jamka et al., 2021; Zawadzki et al., 2021). This technology employs AI to interpret microscopic images for microbial assessment, thus accurately identifying unacceptable levels of bacterial contamination in cosmetic products (Zawadzki et al., 2021). AI also ensures greater transparency in cosmetic formulations, enabling consumers to make informed choices regarding ethical consumption (Masood, 2024). Moreover, virtual experiences facilitated by AI and augmented reality (AR) can engage customers with product origins, thereby building trust and accountability (Simay et al., 2022). While these advancements offer promising opportunities, it is important to implement them responsibly, recognising the ethical implications of AI in product development and consumer interactions (Rokhshad et al., 2023; Spoer et al., 2022).

4.4. Improved Consumer Engagement through AI Personalisation

AI powered recommendation engines enabled brands to deliver personalised halal product suggestions, aligning with individual ethical and sustainability preferences. This not only boosted consumer satisfaction and brand loyalty but also reduced product returns and unsold inventory, indirectly lowering waste. Through advanced data analytics, AI was able to interpret consumer behaviour, preferences, and purchase history to create tailored product experiences. Personalised recommendations increased the relevance of marketing efforts, allowing companies to target consumers more effectively with halal-certified options that fit their values. Furthermore, AI enabled chatbots and virtual assistants provided real-time guidance and halal verification information, enhancing customer trust and engagement. Such digital interaction tools also helped educate consumers on sustainability practices and ingredient transparency. Overall, AI personalisation fostered deeper emotional connections between halal beauty brands and their customers, reinforcing both ethical branding and long-term consumer retention.

The cosmetic industry's integration of AI for personalised marketing significantly enhances consumer engagement. Research indicates that AI-driven personalisation shapes consumer behaviour, promoting higher engagement and purchase intentions by delivering tailored content (Abdullah et al., 2024; Cui & Mohib, 2025). The effectiveness of AI in this context is underscored by its ability to analyse consumer data dynamically, enabling the production of relevant product recommendations aligned with individual preferences (Raji et al., 2024; Wang et al., 2025). Moreover, employing AI virtual influencers can further amplify brand interaction, signalling a shift towards digital engagement strategies that resonate with consumers (Senpayar, 2024; Yazdani & Darbani, 2023). Systems incorporating chatbots with congruent personalities also facilitate deeper connections, addressing the unique needs of diverse consumer profiles (Hollebeek et al., 2024; Mende et al., 2023). This strategic engagement ultimately fosters a more sustainable ecosystem within the industry, aligning marketing efforts with the preferences of environmentally conscious consumers (Sapara & Patel, 2024).

5. Conclusion

In conclusion, the adoption of artificial intelligence presents transformative potential for mitigating halal waste in the cosmetic industry by enhancing transparency, efficiency, and ethical accountability across production stages. AI driven innovations have proven valuable in optimising supply chains, improving waste management through predictive analytics, supporting ethical ingredient substitution, and fostering stronger consumer engagement through personalised marketing. These advancements not only strengthen halal integrity but also align with the broader sustainability objectives of the global beauty sector. However, the review also highlighted existing challenges, such as limited implementation in small and medium enterprises, a lack of standardised AI governance frameworks, and the need for skilled personnel to manage AI systems effectively. Future research should focus on developing practical AI integration models specifically tailored for halal certified manufacturing, conducting longitudinal studies to measure the environmental impact of AI adoption, and exploring policy frameworks that ensure the ethical and religious compliance of AI technologies. Collaborative research between scholars, technologists, and halal certification authorities will be crucial to advancing this emerging field and ensuring that technological progress supports both sustainability and Islamic ethical principles.

Ethics Approval and Consent to Participate

The researchers adhered to the ethical standards and research guidelines provided by the Research Ethics Committee of Universiti Teknologi MARA (UiTM), Shah Alam, Selangor, Malaysia (Approval No.:REC/09/2025 (PG/MR/499)). All research activities were conducted in accordance with UiTM's institutional research ethics policy. As this study involved secondary data and literature based analysis, no human participants were directly involve secondary data and literature based analysis, no human participants were directly involved, and therefore informed consent was not required.

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Conflict of Interest

The authors reported no conflicts of interest for this work and declare that there is no potential conflict of interest concerning the research, authorship, or publication of this article.

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