



Integrating Halal Literacy into Bioscience Education: An Integrative Literature Review for Sustainable Halal Product Awareness

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Abstract

The enforcement of mandatory halal certification in Indonesia and the growth of complex halal-related product sectors, including food, biotechnology, health products, pharmaceuticals, and digital assurance systems, have increased the urgency of scientifically grounded halal literacy. However, most discussions of halal literacy remain concentrated on consumer awareness, certification recognition, or religious knowledge, whereas its pedagogical integration into bioscience education is still fragmented. This article synthesizes literature on halal literacy and proposes a bioscience-oriented framework for science learning. An integrative literature review was conducted by charting peer-reviewed articles, official policy sources, and relevant reports on halal literacy, halal awareness, halal certification, food safety education, halal supply chains, and science education; the sources were then coded through open coding, axial grouping, and thematic synthesis. The analysis generated six interrelated dimensions: halal-thayyib conceptual understanding, scientific product reasoning, certification and label literacy, food safety literacy, experiential pedagogy, and sustainable halal ecosystem awareness. The findings show that halal literacy can function as applied scientific literacy that enables learners to analyze product ingredients, biological and chemical processes, hygiene risks, biotechnology applications, and halal assurance systems. The discussion argues that bioscience education offers a strategic site for transforming halal literacy from passive label recognition into evidence-based, ethical, and sustainability-oriented decision-making. The article contributes a conceptual framework and pedagogical agenda for integrating halal literacy into biology, chemistry, food science, health education, and biotechnology learning. Future research should validate halal bioscience literacy instruments and test classroom-based interventions across schools, madrasah, pesantren, and higher education institutions.

Keywords: bioscience education; food safety literacy; halal literacy; halal product assurance; science learning; sustainable consumption

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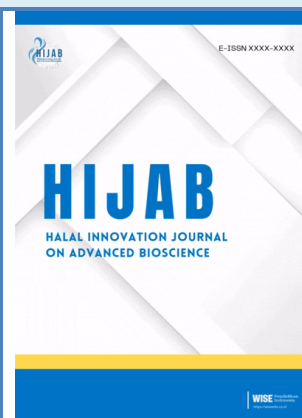
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INTRODUCTION

Halal studies have expanded from a limited concern with food permissibility into a multidisciplinary field connected with bioscience, biotechnology, food science, pharmaceuticals, cosmetics, public health, digital assurance, and sustainability. This expansion is no longer only conceptual. The State of the Global Islamic Economy 2023/24 report indicates continued growth in the Islamic economy and halal-related trade [1]. While Indonesia has entered a mandatory halal certification phase for food and beverage products, raw materials, additives, auxiliary materials, slaughtered products, and slaughtering services [2]. These empirical and regulatory developments make halal literacy a civic, scientific, regulatory, and educational competence rather than merely a matter of private religiosity..

The growing importance of halal literacy should be understood against the complexity of contemporary products. In earlier social contexts, consumers could often determine permissibility by relying on visible ingredients, community norms, and direct knowledge of producers. Today, however, many products are manufactured through long supply chains involving additives, enzymes, emulsifiers, preservatives, microbial cultures, gelatin, colorants, flavor enhancers, fermentation, biotechnology-derived materials, and cross-border logistics. These processes require more than general awareness of halal labels. They require scientific reasoning, critical reading of product information, and the ability to connect religious-ethical categories with biological, chemical, and technological evidence. For example, the halal status of gelatin depends on animal source and processing; the acceptability of enzymes depends on substrate and production system; the evaluation of fermented products requires knowledge of microorganisms and metabolites; and the assessment of cosmetics or pharmaceuticals may involve animal derivatives, alcohol-based solvents, or contamination risks. These are all bioscience-related questions.

The theoretical basis for positioning halal literacy as applied scientific literacy lies in the shared epistemic demand to evaluate evidence, claims, and risks in everyday decision-making. Scientific literacy is commonly associated with explaining phenomena scientifically, evaluating inquiry, and interpreting data and evidence in context [3]. While recent debates emphasize informed trust and the ability of non-experts to judge knowledge claims in complex public settings [4]. Halal literacy requires a comparable form of judgment because learners and consumers must assess claims made by producers, certification bodies, sellers, influencers, and digital platforms. A bioscience-oriented halal literate learner therefore needs to ask whether a product has credible certification, whether its ingredients contain halal critical points, whether production creates contamination risks, whether food safety requirements are met, and whether the product aligns with *thayyib* principles of safety, cleanliness, healthfulness, and ethical quality.

Previous halal literacy and halal awareness studies have produced important evidence, but their analytical focus remains limited for educational purposes. Consumer behavior studies show that halal certification, halal awareness, product knowledge, halal traceability, religiosity, subjective norms, and trust influence consumer intention or purchase decisions [5], [6], [7], [8], [9], [10]. However, these studies generally operationalize literacy as awareness, trust, or intention, not as a teachable competence that involves inquiry, evidence evaluation, and product reasoning. They also rarely explain how learners develop the ability to analyze ingredients, biological sources, chemical additives, microbial processes, contamination pathways, or halal assurance systems. Thus, the unresolved gap is not whether halal knowledge affects behavior, but how halal literacy can be pedagogically structured so that learners move from label recognition to scientifically grounded judgment.

A growing body of educational literature has begun to address this gap. Cahyanto, Al Zahro, and Windayani argue that halal literacy can be integrated into science learning through multiliteracy and contextual science education [11]. Nurdin and colleagues further developed indicators of halal literacy for science classrooms by connecting halal concepts with scientific literacy, chemical literacy, consumption practice, and certification awareness [12]. Kurahman, Priatna, and Cahyanto emphasize that halal education in Islamic educational institutions should be reoriented because curriculum content often remains doctrinal and has not adequately addressed contemporary halal product problems [13]. Firdaus and colleagues show that project-based learning with halal literacy can contribute to product awareness and learning motivation in the context of plantae topics [14]. Mahmudah and colleagues report that integrating halal principles into food safety education increased knowledge and practical application among vocational pesantren students, although the integration between food safety and halal principles still required reinforcement [15]. Collectively, these studies indicate that halal literacy has clear educational relevance but has not yet been consolidated into a coherent bioscience education framework.

Bioscience education is particularly relevant because it deals directly with living systems, organisms, food chains, digestion, nutrition, health, microbes, plants, animals, ecosystems, biotechnology, and environmental interactions. These topics are not peripheral to halal issues; they are central. The concept of *thayyib*, for instance, cannot be understood without attention to food safety, hygiene, contamination, nutrition, and health. The concept of halal integrity cannot be understood without attention to production chains, biological sources, slaughtering, microbial processing, and traceability. The concept of sustainable halal consumption cannot be understood without examining environmental responsibility, waste, ethical sourcing, and responsible production. Thus, bioscience education provides the scientific foundation through which halal literacy can become evidence-based rather than merely declarative.

The integration of halal literacy into bioscience education also responds to broader educational needs in Muslim-majority societies. Students are not only future consumers but also future teachers, researchers, health workers, entrepreneurs, product developers, policy actors, and community educators. If their science education ignores halal literacy, they may learn biological and chemical concepts in isolation from the ethical and social contexts in which those concepts operate. Conversely, if halal education is separated from scientific reasoning, students may memorize rules without understanding the biological or technological mechanisms that determine product status, safety, and quality. An integrated approach can therefore connect Islamic values, scientific evidence, health awareness, and sustainable consumption in a way that is educationally meaningful and socially useful.

The urgency of such integration is intensified by digitalization. Consumers increasingly encounter product claims through e-commerce, social media, influencer marketing, QR-code certification, halal verification applications, and online marketplaces. Digital tools can improve access to halal information, but they can also amplify misinformation, overclaiming, and superficial label recognition. A study of halal literacy among college students in HIJAB found that students showed relatively strong conceptual knowledge and positive attitudes, yet their use of digital verification tools and direct inquiry to sellers remained low [16]. This suggests that halal literacy education must move beyond cognition and include practice, verification, and critical digital behavior. In bioscience learning, this can be done through label-reading tasks, product investigation, digital certification checking, laboratory observation, and socioscientific case discussion.

Based on these concerns, this article develops an integrative literature review on halal literacy in bioscience education. The study does not claim to conduct a full systematic review or meta-analysis; instead, it synthesizes conceptual, empirical, educational, policy, and review literature to construct a

framework for future research and pedagogy. The review is guided by the following question: How can halal literacy be conceptually and pedagogically integrated into bioscience education to strengthen scientific reasoning, food safety awareness, certification literacy, and sustainable halal consumption? The novelty of this article is clarified by its difference from prior works: Cahyanto et al. [11] emphasize implementation in science learning, Nurdin et al. [12] develop classroom indicators, Kurahman et al. [13] discuss curriculum reorientation, Firdaus et al. [14] examine project-based learning, and Mahmudah et al. [15] integrate halal principles with food safety practice. In contrast, this article consolidates these separate directions into a bioscience-oriented framework that links halal-thayyib concepts, scientific product reasoning, certification literacy, food safety, experiential pedagogy, and sustainability. By doing so, it offers a conceptual bridge between halal innovation, science education, product assurance, public health, and sustainability, and supports the scope of HIJAB by showing that halal innovation requires scientifically literate learners who can understand, evaluate, and practice halal principles in contemporary bioscience contexts.

METHODS

This study used an integrative literature review design. The approach was selected because the topic of halal literacy in bioscience education is interdisciplinary and distributed across several bodies of literature, including halal studies, science education, consumer behavior, food safety, supply chain management, Islamic education, biotechnology, and sustainability. An integrative review is appropriate when the goal is not merely to summarize empirical findings but to synthesize fragmented conceptual and empirical knowledge in order to generate a new framework [17], [18], [19]. The review was also informed by selected principles from PRISMA 2020, particularly transparency in identification, screening, eligibility, and inclusion, although the study is not presented as a full systematic review or meta-analysis [20].

The review question was formulated as follows: How can halal literacy be integrated into bioscience education as an interdisciplinary competence that connects Islamic principles, scientific reasoning, food safety, certification awareness, and sustainable consumption? The publication boundary of 2015-2026 was selected because the last decade marks the rapid expansion of halal product assurance, digital verification, halal supply-chain studies, and the growing integration of halal issues into science and education research. Priority was given to 2018-2026 literature to capture recent regulatory, technological, and pedagogical developments, while older sources were retained only when they were methodological or foundational review references. Searches were finalized in June 2026 through Google Scholar discovery, Crossref/DOI tracing, publisher databases and journal repositories, official institutional websites, and reference chaining. The main search strings combined Boolean and phrase-based terms, including 'halal literacy' AND 'science learning', 'halal literacy' AND 'bioscience education', 'halal awareness' AND 'halal certification', 'halal product assurance' AND 'education', 'food safety literacy' AND 'halal', 'halal traceability' AND 'supply chain', and 'sustainable halal consumption'. The final corpus consisted of 30 traceable sources listed in the references, including peer-reviewed empirical articles, review papers, methodological literature, official reports, and policy documents relevant to halal literacy, product assurance, food safety, science education, supply chain integrity, and sustainability.

The inclusion criteria were: (1) peer-reviewed articles, review papers, or official policy documents related to halal literacy, halal awareness, halal product assurance, halal science, bioscience or science education, food safety education, halal traceability, or sustainable halal consumption; (2) publications that provide conceptual, empirical, pedagogical, regulatory, or methodological insight relevant to halal literacy; and (3) sources that can be traced through DOI, publisher page, or official institutional access. Exclusion criteria were: (1) opinion pieces without academic or policy relevance;

(2) studies discussing Islamic consumption without any connection to literacy, education, product assurance, or science; (3) inaccessible or unverifiable references; and (4) duplicate records or sources that repeated the same evidence without adding analytical value.

Data extraction was conducted through a structured charting matrix. Each selected source was coded according to author, year, type of source, context, main construct, method, educational relevance, bioscience relevance, and implication for halal literacy development. To improve analytical dependability, the coding process followed three validation steps: initial open coding of all sources, cross-checking of codes against the review question and inclusion criteria, and consensus-based refinement of categories when similar concepts appeared under different labels. An audit trail was maintained by documenting the source category, inclusion rationale, main contribution, and thematic placement of each source. The extracted information was then analyzed through thematic synthesis. First, the sources were read to identify recurring concepts and gaps. Second, concepts were clustered into preliminary codes such as halal-thayyib knowledge, product ingredient analysis, certification recognition, food safety, traceability, digital verification, experiential learning, and sustainability. Third, the codes were grouped into broader themes. Fourth, the themes were compared with existing studies to avoid merely descriptive listing and were then used to construct a conceptual framework for bioscience-oriented halal literacy.

Table 1. Review protocol and analytical boundaries

Component	Description
Review design	Integrative literature review with semi-systematic search and thematic synthesis
Main purpose	To synthesize fragmented literature and construct a bioscience-oriented halal literacy framework
Core databases/sources	Publisher pages, journal repositories, DOI records, Google Scholar discovery, official policy websites, and reference chaining
Search concepts	Halal literacy; halal awareness; halal certification; halal science literacy; bioscience education; food safety literacy; halal traceability; science learning; sustainable halal consumption
Publication focus	Mainly 2015-2026, prioritizing 2018-2026; older sources used only for methodological foundations
Synthesis method	Data charting, open coding, axial grouping, thematic interpretation, and conceptual framework development
Reporting boundary	The study is not a meta-analysis or exhaustive systematic review; it offers a transparent conceptual synthesis

Table 2. Inclusion and exclusion criteria

Criterion type	Criterion	Operational definition
Inclusion criteria	Peer-reviewed or official	Articles, reviews, reports, and official policy documents relevant to halal literacy, halal assurance, bioscience, science education, food safety, or supply chain integrity
Inclusion criteria	Traceability	Sources accessible through DOI, publisher pages, official websites, or credible repositories
Inclusion criteria	Analytical relevance	Sources that provide conceptual, empirical, pedagogical, or policy insight for halal literacy development
Exclusion criteria	Low relevance	Sources discussing Islamic consumption without connection to literacy, education, product assurance, or science
Exclusion criteria	Low verifiability	Untraceable references, promotional material, opinion articles, and duplicate records

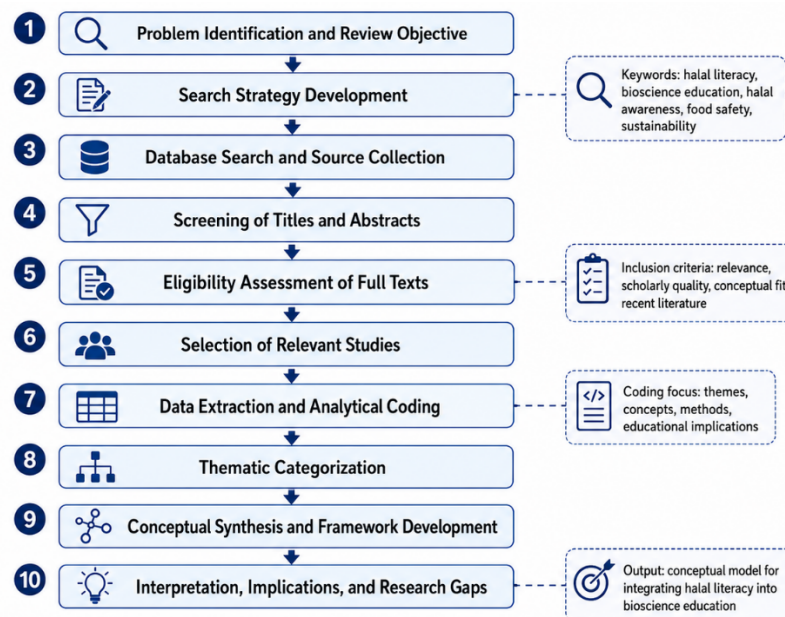


Figure 1. Integrative literature review flow used for conceptual synthesis.

RESULT AND DISCUSSIONS

The reviewed literature indicates that halal literacy is a multidimensional competence. It is not limited to knowing the binary distinction between halal and haram, nor is it limited to recognizing the official halal logo. In educational terms, halal literacy includes knowledge, attitude, critical reasoning, verification behavior, and ethical decision-making. In bioscience contexts, it also includes the ability to interpret ingredients, identify halal critical points, understand biological and chemical processes, evaluate hygiene and contamination risks, and connect halal principles with *thayyib* values. This result is consistent with studies that frame halal literacy as involving conceptual understanding, certification awareness, product analysis, and consumption behavior [11], [12], [16], [21].

The first thematic finding is the importance of halal-*thayyib* conceptual literacy. Studies in Islamic education argue that halal education must not be reduced to doctrinal *fiqh* content because contemporary halal problems involve products, technologies, and social systems that require broader literacy [13]. In bioscience education, this means that learners need to understand halal, haram, *syubhat*, *najis*, and *thayyib* as concepts that can be analyzed through scientific evidence and ethical reasoning. *Thayyib* is especially important because it expands the discussion from permissibility to safety, hygiene, nutrition, quality, and public health.

The second finding concerns scientific product reasoning. Science learning provides direct entry points for halal literacy through topics such as digestive systems, nutrition, *plantae*, microorganisms, biotechnology, fermentation, enzymes, additives, contamination, environmental health, and food processing. Cahyanto and colleagues emphasize that halal literacy can be implemented through science learning because science topics naturally involve materials and processes related to halal consumption [11]. Nurdin and colleagues further propose indicators that connect halal literacy with science and chemistry literacy, suggesting that students should not only know halal concepts but also evaluate product labels and apply knowledge in everyday consumption [12].

The third finding highlights certification and traceability literacy. Studies on consumer behavior show that halal certification and awareness influence purchase intention and product decisions [5], [6], [7], [8], [9], [10]. Jannah and Al-Banna demonstrate that halal awareness influences

consumer purchase intention and business actors' halal traceability practices, while knowledge and certification are important determinants of awareness [7]. This means that halal literacy should include the ability to understand certification systems, verify labels, recognize certification numbers, and appreciate the role of traceability in protecting halal integrity. In Indonesia, this competence is increasingly important because mandatory halal certification creates a practical need for consumers, students, and producers to understand the halal assurance system [2], [22].

The fourth finding is the need to integrate halal literacy with food safety literacy. Food safety education studies show that knowledge, attitudes, and practices can improve through educational interventions, but behavioral translation often requires repeated practice and contextual reinforcement [23], [24], [25], [26]. Mahmudah and colleagues found that integrating halal principles into food safety education increased student knowledge and practical application; however, the modest gain in the integration of halal and food safety knowledge suggested that students may still perceive both domains as separate [15]. This finding is crucial because halal and *thayyib* should be treated as mutually reinforcing principles. A food product may be legally permissible but still unsafe if contaminated, unhygienic, or nutritionally harmful.

The fifth finding relates to pedagogy. Halal literacy is more likely to develop when students engage with real products, cases, labels, experiments, and community contexts. Project-based learning, label-reading exercises, food safety audits, case-based discussions, digital verification practices, and local product investigations can help students connect classroom concepts with everyday decisions [14], [15]. This pedagogical direction aligns with socioscientific issue-based science education, which encourages learners to examine scientific problems that have ethical, social, and policy dimensions [27]. Halal product evaluation is a socioscientific issue because it requires scientific knowledge, religious values, regulatory literacy, and consumer judgment.

The sixth finding concerns sustainability and halal ecosystem awareness. Halal supply chain literature shows that halal integrity depends on traceability, logistics, documentation, risk management, and sustainability practices [28], [29]. Kurniawati and Cakravastia identify halal integrity, limited adoption, and the underdevelopment of sustainability-oriented halal supply chain research as major issues [28]. Chagalima's bibliometric analysis shows that halal supply chain research clusters around consumer behavior, blockchain, food integrity, logistics, traceability, and sustainability [29]. These findings suggest that halal literacy in bioscience education should also introduce students to the wider ecosystem of production, distribution, environmental responsibility, and ethical sourcing.

Table 3. Evidence map of the reviewed literature

Evidence cluster	Representative sources	Main contribution to synthesis	Relevance to bioscience education
Halal literacy and education	Cahyanto et al.; Nurdin et al.; Kurahman et al.; Aisyah et al.; Cintiati et al.	Halal literacy needs conceptual, scientific, and practical indicators; current curriculum remains fragmented	High
Pedagogical intervention	Firdaus et al.; Mahmudah et al.	Project-based and experiential learning can connect halal awareness with motivation, product analysis, and food safety	High
Consumer behavior	Septiani and Ridlwan; Afendi; Jannah and Al-Banna; Bashir; Aslan; Bonne and Verbeke	Awareness, certification, product knowledge, religiosity, trust, and subjective norms shape purchase intention	Medium

Evidence cluster	Representative sources	Main contribution to synthesis	Relevance to bioscience education
Food safety education	Young et al.; Insfran-Rivarola et al.; Ghaffari et al.; Berglund et al.	Educational interventions improve knowledge and practice but need reinforcement to sustain behavior	High
Supply chain and sustainability	Kurniawati and Cakravastia; Changgalima; Ab Rashid and Bojei	Halal integrity depends on traceability, logistics, risk management, and sustainability-oriented assurance	Medium
Science literacy and SSI	OECD; Osborne et al.; Viehmann et al.	Halal product evaluation can be treated as a socioscientific issue requiring evidence-based and ethical reasoning	High

Table 4. Proposed dimensions of bioscience-oriented halal literacy

Dimension	Core competence	Bioscience connection	Suggested learning activity
Halal-thayyib conceptual understanding	Halal, haram, syubhat, najis, thayyib, maqasid	Digestive system, nutrition, hygiene, health, environmental quality	Concept mapping; guided reading; ethical reflection
Scientific product reasoning	Analyzing ingredients and production processes	Additives, enzymes, gelatin, microbes, fermentation, biotechnology	Product investigation; laboratory observation; ingredient tracing
Certification and label literacy	Understanding labels, certification numbers, claims, and digital verification	Product assurance and quality control	Label-reading workshop; QR-code verification; product comparison
Food safety literacy	Connecting halal with safety, contamination, cleanliness, and risk	Microbiology, public health, storage, food handling	School canteen audit; hygiene checklist; food safety demonstration
Experiential pedagogy	Learning through real products and cases	Science process skills and socioscientific reasoning	Project-based learning; case study; debate; reflective journal
Sustainable halal ecosystem awareness	Understanding supply chain, traceability, sustainability, and consumer responsibility	Ecology, agriculture, waste, packaging, logistics	Farm-to-table mapping; sustainability case analysis

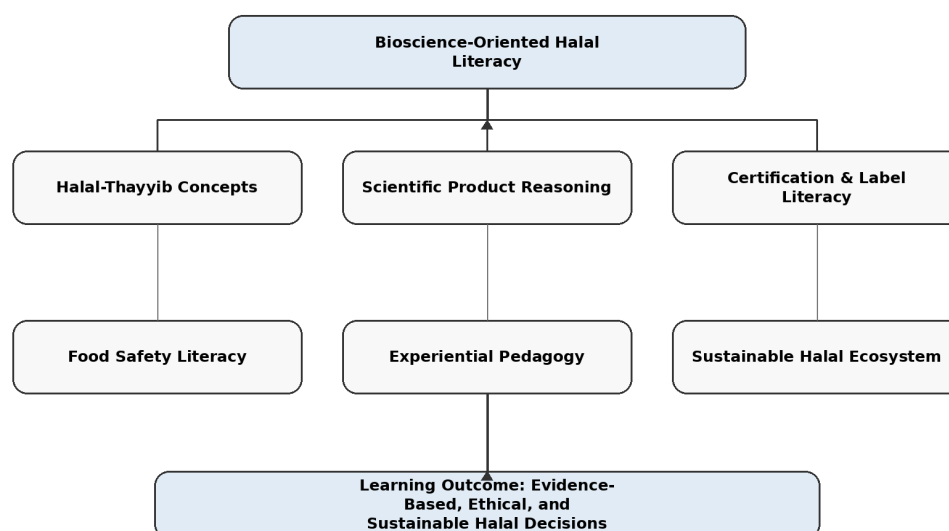


Figure 2. Conceptual framework for integrating halal literacy into bioscience education

Discussion

The synthesis advances a theoretical argument that halal literacy should be understood as an epistemic and practical competence within bioscience education, not only as religious compliance or market-oriented product awareness. This argument challenges the common assumption that stronger recognition of halal labels is sufficient to produce responsible halal behavior. Many halal critical points are embedded in biological and chemical processes, including animal-derived ingredients, microbial fermentation, enzymes, additives, contamination routes, sanitation, and quality assurance. Therefore, learners cannot evaluate halal issues in food, cosmetics, pharmaceuticals, or biotechnology solely by memorizing rules; they need scientific reasoning that enables them to interpret product evidence and assess claims. At the same time, bioscience education becomes more socially and ethically meaningful when biological and chemical concepts are connected to halal-thayyib values, consumer protection, and sustainable product decisions.

A major implication of this review is that halal literacy must move beyond label recognition. Label recognition is necessary, but it is insufficient. Students should learn to ask why certification is needed, how the certification process protects consumers, what can compromise halal integrity, and how scientific evidence contributes to verification. Consumer studies demonstrate that halal awareness, certification, knowledge, subjective norms, and trust influence product intention [5], [6], [7], [8], [9], [10]. Yet these studies also imply that consumers may rely heavily on external symbols without understanding the underlying processes. Bioscience education can address this limitation by teaching students to analyze ingredients and production contexts before accepting claims. For example, a biology lesson on digestive systems can include analysis of food ingredients and nutrition; a microbiology lesson can examine fermentation and contamination; a chemistry lesson can discuss emulsifiers, solvents, and additives; and a biotechnology lesson can evaluate enzymes, genetically modified organisms, and authentication technologies.

The review also shows that halal literacy should be linked with thayyib literacy. Halal without thayyib can produce a narrow compliance mentality, while thayyib without halal can overlook religious-ethical obligations. Integrating both concepts allows students to understand that responsible consumption includes permissibility, safety, health, cleanliness, quality, environmental responsibility, and social accountability. Food safety education literature supports this argument because educational interventions can improve knowledge and practice, but durable behavior requires contextual, practical, and repeated learning [30], [23], [24], [25], [26]. Mahmudah and colleagues provide a relevant example by showing that halal and food safety education improved knowledge but still needed stronger integration in practice [13]. Bioscience learning can address this gap by combining conceptual instruction with observation, experimentation, and real-life product analysis.

Another important discussion point is curriculum location. Halal literacy should not be placed exclusively within Islamic religious education. Religious education provides theological and legal foundations, but it cannot fully explain biological and chemical mechanisms behind contemporary products. Likewise, science education provides empirical reasoning but may ignore the religious and ethical significance of consumption. An interdisciplinary model is therefore needed. In schools and madrasah, halal literacy can be embedded across biology, chemistry, health education, entrepreneurship, environmental science, and Islamic education. In higher education, it can be developed through food science, biotechnology, pharmacy, nutrition, public health, science education, and halal industry courses. In pesantren and vocational schools, it can be linked to food processing, culinary practice, entrepreneurship, and hygiene training.

The proposed framework also has implications for teacher preparation. Teachers need both content knowledge and pedagogical knowledge to integrate halal literacy into bioscience learning. A

teacher who understands halal concepts but lacks bioscience knowledge may present halal literacy as moral advice without scientific depth. A science teacher who understands biology or chemistry but lacks halal literacy may miss the ethical and religious dimensions of product evaluation. Therefore, teacher professional development should cover halal product assurance, halal critical points, food safety, product-label analysis, digital verification, case-based learning, and socioscientific discussion. This aligns with the need for structured halal literacy education reported in the HIJAB study of college students [30].

The sustainability dimension strengthens the relevance of halal literacy to the scope of halal innovation. Halal innovation is not limited to producing certified products. It also requires public understanding, transparent supply chains, responsible consumption, and ethical production. Halal supply chain studies demonstrate that integrity, traceability, logistics, and sustainability remain important research challenges [28], [29], [30]. These issues can be introduced in bioscience education through discussions of farm-to-table systems, ecological impacts of food production, animal welfare, microbial safety, packaging, waste, and digital traceability. Such learning can help students understand that halal products are part of an ecosystem involving science, regulation, ethics, economy, and environment.

The relationship between halal literacy and socioscientific issue-based learning is also significant. Socioscientific issues require learners to reason about problems that are scientifically complex and socially value-laden [27]. Halal product evaluation fits this model because it involves scientific uncertainty, ethical values, regulatory trust, consumer protection, and public health. For instance, students may discuss whether a product with ambiguous ingredients should be consumed, how consumers should respond to uncertified imported food, how producers should manage cross-contamination, or how digital halal verification can prevent misinformation. These tasks cultivate argumentation, evidence evaluation, ethical reasoning, and decision-making.

From a research perspective, this review identifies several gaps. First, empirical classroom studies on halal literacy in bioscience education are still limited. Existing studies provide promising examples, but most are small-scale, descriptive, or context-specific. Second, validated instruments for measuring bioscience-oriented halal literacy are still underdeveloped. Existing indicators offer an important foundation [12], but further psychometric validation is needed across educational levels. Third, little is known about how halal literacy develops over time, how it interacts with scientific literacy, and how it influences actual consumer behavior. Fourth, digital halal literacy remains underexplored, especially in relation to QR-code verification, halal databases, e-commerce, and misinformation. Fifth, more research is needed on biotechnology and pharmaceutical contexts, where halal critical points can be more complex than ordinary food-label analysis.

The novelty of this article is therefore conceptual and pedagogical. It proposes that halal literacy should be treated as an interdisciplinary competence within bioscience education. This competence includes six dimensions: halal-thayyib conceptual understanding, scientific product reasoning, certification and label literacy, food safety literacy, experiential pedagogy, and sustainable halal ecosystem awareness. The framework contributes to halal innovation studies by showing that innovation must be supported by education. Without scientifically literate consumers and future professionals, halal certification may remain a formal symbol rather than a deeply understood practice. With strong bioscience-oriented halal literacy, learners can become critical consumers, ethical product developers, and informed participants in the halal ecosystem.

Nevertheless, this article has limitations. As an integrative review, it synthesizes diverse sources but does not provide the exhaustive search, database-specific screening, or risk-of-bias assessment expected in a full systematic review. The synthesis is interpretive and conceptual, so it should be tested empirically. Future studies should conduct systematic reviews with database-defined

search protocols, develop validated instruments, design classroom interventions, compare learning models, and examine the long-term effects of halal literacy on scientific reasoning and consumption behavior

CONCLUSION

This integrative literature review concludes that halal literacy can be meaningfully integrated into bioscience education as an interdisciplinary competence that connects Islamic principles, scientific reasoning, product assurance, food safety, and sustainable consumption. The synthesis identifies six dimensions of bioscience-oriented halal literacy: halal-thayyib conceptual understanding, scientific product reasoning, certification and label literacy, food safety literacy, experiential pedagogy, and sustainable halal ecosystem awareness. The review shows that bioscience education offers a strategic context for transforming halal literacy from passive awareness of labels into critical, evidence-based, and ethical decision-making. This framework contributes to halal innovation by positioning education as a foundation for product assurance, public health, consumer protection, and sustainability. Future empirical studies should validate measurement instruments, test classroom interventions, and explore how halal literacy influences students' scientific literacy, digital verification behavior, and responsible consumption practices.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- [1] DinarStandard, "State of the Global Islamic Economy Report 2023/24," 2023, *Dubai*.
- [2] Badan Penyelenggara Jaminan Produk Halal (BPJPH), "Phasing Period Ends, Halal Certification Obligation Takes Effect Starting," 2026.
- [3] OECD, *PISA 2022 Assessment and Analytical Framework*. Paris: OECD Publishing, 2023. doi: 10.1787/dfe0bf9c-en.
- [4] J. Osborne, "Science Literacy in the Twenty-First Century: Informed Trust and the Competent Outsider," *Int. J. Sci. Educ.*, 2024, doi: 10.1080/09500693.2024.2331980.
- [5] D. Septiani and A. A. Ridlwan, "The Effects of Halal Certification and Halal Awareness on Purchase Intention of Halal Food Products in Indonesia," *Indones. J. Halal Res.*, vol. 2, no. 2, pp. 55–60, 2020, doi: 10.15575/ijhar.v2i2.6657.

- [6] A. Afendi, "The Effect of Halal Certification, Halal Awareness and Product Knowledge on Purchase Decisions for Halal Fashion Products," *J. Digit. Mark. Halal Ind.*, vol. 2, no. 2, 2020, doi: 10.21580/jdmhi.2020.2.2.6160.
- [7] S. M. Jannah and H. Al-Banna, "Halal Awareness and Halal Traceability: Muslim Consumers' and Entrepreneurs' Perspectives," *J. Islam. Monet. Econ. Financ.*, vol. 7, no. 2, pp. 285–316, 2021, doi: 10.21098/jimf.v7i2.1328.
- [8] A. M. Bashir, "Effect of Halal Awareness, Halal Logo and Attitude on Foreign Consumers' Purchase Intention," *Br. Food J.*, vol. 121, no. 9, pp. 1998–2015, 2019, doi: 10.1108/BFJ-01-2019-0011.
- [9] K. Bonne and W. Verbeke, "Muslim Consumers' Motivations Toward Halal Food Consumption: Exploring Attitudes and Consumption Dynamics," *Appetite*, vol. 147, p. 104547, 2020, doi: 10.1016/j.appet.2020.104547.
- [10] H. Aslan, "The Influence of Halal Awareness, Halal Certificate, Subjective Norms, Perceived Behavioral Control, Attitude and Trust on Purchase Intention of Culinary Products Among Muslim Consumers in Turkey," *Int. J. Gastron. Food Sci.*, vol. 32, p. 100726, 2023, doi: 10.1016/j.ijgfs.2023.100726.
- [11] T. Cahyanto, I. R. Al Zahro, and N. Windayani, "Konsep dan Implementasi Literasi Halal pada Pembelajaran {IPA}," *J. Penelit. Sains dan Pendidik*, vol. 3, no. 2, pp. 158–172, 2023, doi: 10.23971/jpsp.v3i2.7237.
- [12] M. A. Nurdin, D. M. Anwar, T. Cahyanto, and N. Windayani, "Pengembangan Indikator Literasi Halal: Dari Teori ke Ruang Kelas Pembelajaran {IPA}," *Indones. J. Halal*, vol. 7, no. 1, pp. 45–54, 2024, doi: 10.14710/halal.v7i1.22790.
- [13] O. T. Kurahman, T. Priatna, and T. Cahyanto, "Reorientation of Halal Literacy Education Development in the Curriculum of Islamic Educational Institutions: An Alternative Concept," *Edukasi Islam. J. Pendidik. Islam*, vol. 12, no. 1, 2023, doi: 10.30868/ei.v12i01.3190.
- [14] M. T. Firdaus, A. W. Fitrianto, and D. Suherman, "Product Awareness and Learning Motivation on Plantae Topics Through Project-Based Learning with Halal Literacy," *JPBIO (Jurnal Pendidik. Biol.)*, vol. 9, no. 2, pp. 332–345, 2024, doi: 10.31932/jpbio.v9i2.4008.
- [15] N. A. Mahmudah, A. W. Putra, D. Kurniawan, N. A. Mardiana, A. Widigdyo, and P. Purnomo, "Integrating Halal Principles to Strengthen Food Safety Literacy Among Vocational Pesantren School Students in Blitar Regency," *J. Community Serv. Empower.*, vol. 6, no. 3, pp. 426–434, 2025, doi: 10.22219/jcse.v6i3.42170.
- [16] I. Aisyah, T. Cahyanto, and N. Windayani, "Exploring Halal Literacy Learning in High School Students," *J. Ilmu Pendidik*, vol. 21, no. 2, 2024, doi: 10.17509/jik.v21i2.68545.
- [17] H. Snyder, "Literature review as a research methodology : An overview and guidelines," *J. Bus. Res.*, vol. 104, no. March, pp. 333–339, 2019, doi: 10.1016/j.jbusres.2019.07.039.
- [18] R. Whittemore and K. Knafl, "The Integrative Review: Updated Methodology," *J. Adv. Nurs.*, vol. 52, no. 5, pp. 546–553, 2005, doi: 10.1111/j.1365-2648.2005.03621.x.
- [19] R. J. Torraco, "Writing Integrative Literature Reviews: Using the Past and Present to Explore the Future," *Hum. Resour. Dev. Rev.*, vol. 15, no. 4, pp. 404–428, 2016, doi: 10.1177/1534484316671606.
- [20] E. A. Akl *et al.*, "Extension of the PRISMA 2020 statement for living systematic reviews (PRISMA-LSR): checklist and explanation," *Bmj*, 2024, doi: 10.1136/bmj-2024-079183.
- [21] A. J. Kesuma and D. A. Saputri, "Evaluation of Halal Literacy Among Teaching Staff Based on the Dimensions of Knowledge, Attitude, and Practice," *Halal Innov. J. Adv. Biosci.*, vol. 1, no. 1, pp. 43–51, 2025.
- [22] Badan Penyelenggara Jaminan Produk Halal (BPJPH), "Law Number 33 of 2014 Concerning Halal Product Assurance," 2026.
- [23] I. Young and others, "A Systematic Review and Meta-Analysis of the Effectiveness of Food Safety Education Interventions for Consumers in Developed Countries," *BMC Public Health*, vol. 15, p. 822, 2015, doi: 10.1186/s12889-015-2171-x.
- [24] A. Insfran-Rivarola and others, "A Systematic Review and Meta-Analysis of the Effects of Food Safety and Hygiene Training on Food Handlers," *Foods*, vol. 9, no. 9, p. 1169, 2020,

- doi: 10.3390/foods9091169.
- [25] M. Ghaffari, Y. Mehrabi, S. Rakhshanderou, A. Safari-Moradabadi, and S. Z. Jafarian, "Effectiveness of a Health Intervention Based on {WHO} Food Safety Manual in Iran," *BMC Public Health*, vol. 20, p. 401, 2020, doi: 10.1186/s12889-020-08541-8.
 - [26] Z. Berglund, S. Simsek, and Y. Feng, "Effectiveness of Online Food-Safety Educational Programs: A Systematic Review, Random-Effects Meta-Analysis, and Thematic Synthesis," *Foods*, vol. 13, no. 5, p. 794, 2024, doi: 10.3390/foods13050794.
 - [27] C. Viehmann, J. M. Fernández Cárdenas, and C. G. Reynaga Peña, "The Use of Socioscientific Issues in Science Lessons: A Scoping Review," *Sustainability*, vol. 16, no. 14, p. 5827, Jul. 2024, doi: 10.3390/su16145827.
 - [28] D. A. Kurniawati and A. Cakravastia, "A Review of Halal Supply Chain Research: Sustainability and Operations Research Perspective," *Clean. Logist. Supply Chain*, vol. 6, p. 100096, 2023, doi: 10.1016/j.clscn.2023.100096.
 - [29] I. A. Changalima, "Halal Supply Chain Management: A Bibliometric Analysis of the 100 Most-Cited Publications from Scopus-Indexed Journals," *Soc. Sci. & Humanit. Open*, vol. 10, p. 101248, 2024, doi: 10.1016/j.ssaho.2024.101248.
 - [30] N. Ab Rashid and J. Bojei, "The Relationship Between Halal Traceability System Adoption and Environmental Factors on Halal Food Supply Chain Integrity in Malaysia," *J. Islam. Mark.*, vol. 11, no. 1, pp. 117–142, 2020, doi: 10.1108/JIMA-01-2018-0016.