Sains Insani eISSN: [0127-7871]

Halal Meets Biotech: Exploring Integration Opportunities and Challenges in Malaysian Universities

Halal Bertemu Bioteknologi: Meneroka Peluang dan Cabaran Integrasi di Universiti-Universiti Malaysia

Marina Abu Bakar[1], Afiffudin Mohammed Noor[2], Syaimak Ismail @ Mat Yusoff[3]

[1,2,3] *Senior Lecturer, Academy of Contemporary Islamic Studies (ACIS), Universiti Teknologi MARA (UiTM), Perlis, Malaysia*

Article progress
Received: 20 Oct 2024
Accepted: 10 Dec 2024
Published: 31 May 2025

*Corresponding author:
Marina Abu Bakar,
Academy of Contemporary Islamic Studies (ACIS),
Universiti Teknologi MARA (UiTM) Perlis, Perlis, Malaysia;
Email:marinab@uitm.edu.my

Abstract: The increasing demand for professionals with expertise in halal authentication within the biotechnology industry emphasizes the importance of integrating this field into academic programs in Malaysian universities. However, existing biotechnology curricula often lack dedicated courses and hands-on training related to halal authentication. Additional challenges, such as limited faculty expertise, resource limitations, and weak collaboration between academia and the halal industry, have further impeded the effective incorporation of halal education. This study examines the current landscape of halal authentication education within biotechnology programs, focusing on the opportunities and obstacles faced by Malaysian universities. Through an in-depth literature review and thematic analysis, it identifies gaps in the curriculum and proposes strategies for improvement. The findings highlight the need for specialized courses, practical training modules, interdisciplinary collaboration, and stronger industry partnerships to address resource and expertise limitations. A framework is introduced to support the development of halal authentication education, offering guidance to academic institutions, industry stakeholders, and policymakers. This research contributes to the advancement of halal education in Malaysia and provides a strategic roadmap for universities aiming to embed halal authentication into their biotechnology programs.

Keywords: Halal authentication; Biotechnology; Halal education; Halal industry; Malaysian universities.

Abstrak: Permintaan yang semakin meningkat bagi golongan profesional yang mempunyai kepakaran dalam pengesahan halal dalam industri bioteknologi menekankan kepentingan mengintegrasikan bidang ini dalam program akademik di universiti-universiti Malaysia. Walau bagaimanapun, kurikulum bioteknologi yang ada sering kali mempunyai kekurangan dari segi kursus dan latihan praktikal yang khusus berkaitan dengan pengesahan halal. Cabaran tambahan seperti kekurangan kepakaran fakulti, keterbatasan sumber dan kerjasama yang kurang kukuh antara akademia dan industri halal, telah membantutkan lagi pengintegrasian pendidikan halal dengan berkesan. Kajian ini mengkaji landskap semasa pendidikan pengesahan halal dalam program bioteknologi, dengan memberi tumpuan kepada peluang dan halangan yang dihadapi oleh universiti-universiti Malaysia. Melalui kajian literatur yang mendalam dan analisis tematik, kajian ini mengenal pasti jurang dalam kurikulum dan mencadangkan strategi untuk penambahbaikan. Dapatan kajian menekankan keperluan untuk kursus khusus, modul latihan praktikal, kerjasama antara disiplin, dan perkongsian yang lebih kukuh dengan industri untuk menangani keterbatasan sumber dan kepakaran. Rangka kerja telah diperkenalkan untuk menyokong pembangunan pendidikan pengesahan halal, memberi panduan kepada institusi akademik,

PUSAT PENGAJIAN TERAS
Centre of Core Studies
USIM Universiti Sains Islam Malaysia

pihak berkepentingan industri dan pembuat dasar. Kajian ini menyumbang kepada kemajuan pendidikan halal di Malaysia dan menyediakan pelan strategik untuk universiti yang berhasrat untuk menawarkan pengesahan halal dalam program bioteknologi mereka.

Kata kunci: Pengesahan halal; Bioteknologi; Pendidikan halal; Industri halal; Universiti Malaysia.

Introduction

In recent years, the global halal industry has experienced notable growth, primarily driven by rising demand for halal products and services among both Muslim and non-Muslim consumers. By 2022, the market size reached approximately USD 2.22 trillion, and projections indicate it could grow to USD 4.18 trillion by 2028, with a Compound Annual Growth Rate (CAGR) of 10.8% (Halal Weekly, 2023). This surge is linked to a growing Muslim population, increasing awareness of halal standards among non-Muslims, and stricter regulations on halal certification and labelling. The Asia-Pacific region continues to lead this market, benefiting from its large Muslim population and well-developed halal infrastructure. However, regions such as North America and Europe are also experiencing growth, as demand for ethically produced halal products extends beyond the Muslim consumer base (Halal Weekly, 2023; GlobeNewswire, 2023). This expansion is not confined to the food sector; it encompasses industries like pharmaceuticals, cosmetics, logistics, and finance, which has led to a demand for professionals skilled in halal compliance and certification (Ng et al., 2022; Tumiran & Mohammad, 2024).

Malaysia, with JAKIM at the forefront, plays a critical role in the global halal industry. JAKIM's rigorous certification process covers food, pharmaceuticals, and cosmetics, ensuring compliance with Islamic dietary laws. This certification, recognized internationally, has enabled Malaysian companies to broaden their global reach, particularly in the Middle East and Europe (Asa, 2017; Ab Halim et al., 2022). In 2023, JAKIM further enhanced its standards by incorporating technological advancements such as blockchain to improve traceability, addressing concerns over contamination, fraud, and inconsistent labeling. This process includes detailed audits to ensure halal products adhere to Islamic principles. Malaysia's halal economy has diversified beyond food to include sectors such as cosmetics, pharmaceuticals, logistics, and finance, including Islamic banking and takaful. The country is also leveraging its position as a center for halal tourism, promoting itself as a destination for Muslim travelers with halal-certified food, prayer facilities, and suitable accommodations. The Halal Industry Master Plan 2030 aims to strengthen the halal ecosystem by improving SME capabilities, fostering innovation, and positioning Malaysia as a global leader in halal (HDC, 2020). This initiative targets key sectors like food, pharmaceuticals, and tourism to boost GDP and enhance the competitiveness of Malaysia's halal products globally (GlobeNewswire, 2023). Furthermore, Malaysia hosts the Malaysia International Halal Showcase (MIHAS), a prominent global event highlighting halal industry innovations, reinforcing Malaysia's leadership in the sector.

Malaysia's role as a leader in the global halal industry extends to research and education, with the government promoting the importance of halal studies (Mohamed et al., 2013). The increasing global demand for halal products, valued at USD 2.22 trillion in 2022 (Halal Weekly, 2023), underscores the need to integrate halal authentication into biotechnology education, particularly in sectors like food processing, pharmaceuticals, and cosmetics (Ahmad et al., 2017). This has created a demand for skilled professionals capable of ensuring that products meet halal standards. Universities, especially in Indonesia and Malaysia, play a crucial role in fostering halal innovation and education (Risza, 2024). However, there is a gap in biotechnology curricula regarding halal authentication, leading to a shortage of professionals equipped to meet industry needs (Rahman & Ahmad, 2024). Many Malaysian universities lack comprehensive programs in halal authentication, which may hinder the halal industry's long-term growth. Additionally, aligning halal science research with the Tawhidic paradigm and incorporating Islamic values into halal education is becoming increasingly important (Hashim et al., 2024). This highlights the necessity of developing curricula that combine technical, philosophical, and ethical dimensions to produce graduates capable of

meeting industry demands. Malaysia is also the first country to propose a standardized program for halal studies, reflecting the growing demand for such programs not only in non-Muslim countries like China and India but also in the Middle East. Malaysian universities are well-positioned to capitalize on this opportunity, attracting more international students and aligning with the Ministry of Higher Education's (MOHE) vision of establishing Malaysia as a global education hub (YADIM, 2021). Against this backdrop, this study aims to analyze the current state of halal authentication education within biotechnology programs, exploring the opportunities and challenges faced by universities in Malaysia.

Halal Authentication in Biotechnology

The increasing global demand for halal products has elevated the importance of halal authentication in biotechnology. Several analytical techniques have been developed to detect non-halal substances in food, pharmaceuticals, and cosmetics, such as chromatography, spectroscopy, and molecular biology methods (Rohman et al., 2016; Nurani et al., 2022). DNA-based methods, like PCR and DNA barcoding, provide high accuracy in detecting porcine DNA and verifying halal meat (Fadhilah et al., 2021; El Sheikha et al., 2017). Additionally, biosensors offer a rapid and cost-efficient approach to halal verification (Khoshdouni Farahani & Khoshdouni Farahani, 2021). Vibrational spectroscopy, paired with chemometrics, is widely used for its practicality (Rohman et al., 2016). To comply with halal standards, biotechnology firms are also modifying their production processes (Karahalil, 2020). Researchers have even explored innovative raw materials like kombucha for use in halal drugs and cosmetics (Fadhilah et al., 2021).

Recent studies emphasize both the advancements and the hurdles in halal authentication within biotechnology. Usman et al. (2024) underline that despite technological progress, challenges remain in ensuring the consistency and dependability of halal certification methods. Dashti et al. (2024) stress the need to enhance traceability to restore trust, particularly in Muslim-majority regions. Green nanomaterials are also being integrated into halal science research, showing promise for halal applications, according to Azmi et al. (2024). Rahman & Ahmad (2024) emphasize that technological innovation is crucial in maintaining the skillsets of halal professionals and keeping up with evolving methods. Machine learning presents opportunities in halal meat authentication, but issues such as data reliability need to be addressed (Mustapha et al., 2024). Sarbani et al. (2024) propose the use of AI in halal supply chain management, aiming to foster industrial growth. Overall, while progress has been made in developing halal authentication technologies, there is still a need for greater standardization and collaboration, particularly within biotechnology.

Malaysia's halal industry also faces several obstacles in authentication and certification, such as insufficient manpower, limited auditor expertise, and challenges with certification systems (Muhammad et al., 2020). The lack of clear international standards further complicates the process (Mohd Fauzi et al., 2022; Bhari et al., 2024). In biotechnology, concerns persist over the use of non-halal ingredients in food products and the safety of genetically modified organisms (Sahilah et al., 2016; Rahman et al., 2013). Moreover, halal logistics is hindered by decentralization and limited global networking (Iberahim et al., 2012). To position Malaysia as a global leader in the halal industry, improvements in governance, research, and development are crucial (Soraji et al., 2017; Majid et al., 2015). Public-private collaboration is essential to strengthen the overall halal implementation process.

Current State of Halal Education in Malaysia

The state of halal education in Malaysia shows a significant focus on building skilled human capital for the growing halal industry. Many universities now offer programs in halal studies and biotechnology, designed to align with industry needs (Ibrahim et al., 2022; Mohd Saruan et al., 2015). These programs adopt multidisciplinary approaches, blending Shariah principles with technological knowledge to provide well-rounded education and training (Alina et al., 2013). Nonetheless, challenges remain, including a shortage of qualified professionals and the need for more specialized courses (Mohd Saruan et al., 2015). To address these gaps, universities are partnering with industry stakeholders and government agencies to develop curricula and research projects that are both relevant and innovative (Ahmad et al., 2011). The evolving education landscape also tackles new concerns, such as the impact of genetically modified organisms (GMOs) on halal certification (Rahman et al., 2013; Hafis Aliaziz & Ab Rahma,

2018). In its pursuit to become a global leader in halal education, Malaysia continues to make strides in developing expertise in this area.

Recent studies highlight how halal education is adapting to the changing needs of training, certification, and education. For example, Ilmiyah et al. (2024) emphasize the pivotal role of higher education in preparing Micro and Small Enterprises (MSEs) for mandatory halal certification in Indonesia by 2024, stressing the importance of academic support in ensuring legal compliance. Kasanah & Andari (2024) introduce the SEHATI program as an efficient certification model, particularly useful for small businesses seeking to navigate complex certification requirements. Lifelong learning and technology integration are also increasingly important in halal education, with Rahman & Ahmad (2024) emphasizing the need for professionals to stay updated with technological developments to maintain competitiveness. Their study calls for continuous education, especially given the rapid advancement of digital tools. Additionally, Masood et al. (2024) highlight the potential of using gamification and immersive technologies to enhance halal training, making the learning process more engaging and effective.

Malaysia's halal industry, however, faces several challenges, including a lack of skilled workers (Alina et al., 2013), unclear guidelines, limited international certification, and weak collaboration between different agencies (Zailani et al., 2017; Mohd Fauzi et al., 2020). There is a need to enhance halal education and training to better meet industry expectations (Ibrahim et al., 2022). While there are opportunities in sectors such as logistics, hospitality, and education within the halal market (Razalli et al., 2012; Samori & Rahman, 2013), implementing halal practices still encounters obstacles, including financial constraints and misunderstandings of halal concepts (Zailani et al., 2017). The lack of centralization and international networking within the institutional framework for halal development further complicates progress (Iberahim et al., 2012). Additionally, Muslim private universities struggle to balance their philosophical goals with market demands (Hashim, 2012). Addressing these issues while seizing available opportunities could enhance Malaysia's position as a global halal hub.

International Best Practices

Many global institutions have successfully integrated halal authentication into their academic programs, acknowledging its increasing relevance in the international market (Zain et al., 2017). Countries like Malaysia, Thailand, and Indonesia have established halal research centres and developed specialized curricula focused on halal practices (Ahmad et al., 2011). For instance, Universitas Muhammadiyah Makassar's Faculty of Medicine and Health Sciences incorporates halal-related topics into its integrated learning system (Rauf et al., 2023). To enhance competitiveness in the halal sector, strategies such as strengthening certification standards, analysing consumer behaviour, and creating halal-specific products have been adopted (Bashir et al., 2019). Multidisciplinary approaches that blend Shariah principles with technological innovations have proven beneficial to industries, NGOs, and consumers alike (Alina et al., 2013). Furthermore, the integration of halal logistics practices has been shown to improve supply chain performance (Karia, 2022). Internationalizing educational programs is essential to meet the rising demand for halal expertise across different sectors (Scarborough & Grison, 2017).

Malaysia aims to align its halal practices with international standards as part of its goal to become a global leader in the halal industry. Research underscores the significance of supply chain integration in maintaining halal food integrity (Ali et al., 2016). In the halal cosmetics industry, implementing best practices can help improve company performance while preserving product authenticity (Sin et al., 2019). Proposals to integrate Islamic financing with the halal sector aim to create a more cohesive system (Muhamed et al., 2014). Halal logistics, including practices such as physical segregation, are critical for enhancing operational efficiency (Karia, 2022). Additionally, quality assurance in halal food production is supported by practices like GMP and HACCP, ensuring the safety and integrity of halal products (Talib et al., 2008).

Opportunities and Challenges in Integrating Halal Authentication into Biotechnology Education in Malaysia

Several studies highlight both challenges and opportunities in incorporating halal authentication into biotechnology education in Malaysia. The expansion of the halal industry creates career opportunities for graduates

in sectors like government, auditing, consulting, and research (Deuraseh & Heradhyaksa, 2020). However, obstacles remain, such as unclear guidelines, insufficient international certification, and misconceptions surrounding halal practices (Mohd Fauzi et al., 2022). The demand for skilled professionals in the halal sector has led to the development of new academic standards (Ibrahim et al., 2022). Biotechnology advancements, especially in meat processing and pharmaceuticals, have raised concerns regarding halal certification (Salahudin et al., 2018). Addressing these concerns requires better governance of Genetically Modified Organisms (GMOs) (Hafis Aliaziz & Ab Rahma, 2018) and incorporating Islamic principles into biotechnology applications (Jaludin et al., 2018).

Recent research further discusses the challenges and opportunities of integrating halal authentication into biotechnology education in Malaysia. Issues include consumer skepticism about halal certifications (Ali & Ahmad, 2023), low awareness, and financial constraints in implementing halal certification (Rodzi et al., 2023). The halal meat industry, in particular, faces challenges related to adulteration and fraud due to technological advancements (Shahidan & Amid, 2023), while obtaining halal certification remains a struggle for small and medium-sized enterprises (Bakar et al., 2023). In the pharmaceutical sector, key concerns revolve around cross-contamination and regulatory compliance (Naimat et al., 2024). Despite these hurdles, there are growth opportunities in the increasing demand for halal products and the expanding sharia-compliant economy (Rizki et al., 2023). Overcoming these challenges requires collaboration between the private and public sectors (Ali & Ahmad, 2023) and the enhancement of STEM education in Malaysia (Idris et al., 2023).

The current body of research reveals significant gaps in the integration of halal authentication into biotechnology education. While notable progress has been made in developing advanced halal verification methods, such as DNA-based techniques and biosensors, there is a lack of focus on how these technologies can be seamlessly integrated into biotechnology curricula. Educational programs often do not align with the industry's evolving needs, leaving a disconnect between technological innovations and the preparedness of students to address practical challenges in the halal sector (Rahman et al., 2024). Although some Malaysian universities have introduced halal studies programs with multidisciplinary approaches, there remains a shortage of specialized courses and experts in halal biotechnology (Ahmad et al., 2024). More targeted research is needed to develop curricula that balance academic knowledge with practical applications. While international best practices in halal education are available, there is limited research on adapting these strategies to the Malaysian context. Comparative studies that assess halal education programs in different countries and propose relevant adaptations for Malaysia are noticeably lacking.

Moreover, while challenges such as unclear guidelines and inconsistent international certification standards are recognized, there is a shortage of practical solutions to address these issues in biotechnology education. The inconsistencies in global halal certification make it difficult to implement uniform practices, particularly in the biotechnology field. Although previous studies acknowledge these challenges, they do not offer specific, actionable strategies to overcome them in an educational context. To bridge the gap between theoretical halal knowledge and its practical application, empirical research is needed to explore curriculum development, industry collaboration, and resource management. Overall, addressing these gaps requires the creation of comprehensive educational frameworks, enhanced industry-academia partnerships, and the adaptation of international best practices to better prepare graduates for the growing halal industry.

Methodology

This study utilizes a qualitative research method, primarily focusing on a literature review and thematic analysis to examine the integration of halal authentication into biotechnology education at Malaysian universities. The literature review was conducted to collect relevant research and academic materials on halal authentication, providing a theoretical base and highlighting gaps in current educational practices. From this review, key themes were identified to offer a deeper understanding of the topic. A thematic analysis was applied to gain insights into the existing educational framework, aiming to explore potential areas for enhancement and future development.

The data collection process involved a qualitative analysis of existing literature related to halal authentication and biotechnology. This literature-based approach enabled a comprehensive understanding of how halal principles are integrated into biotechnology education and the extent to which they are covered within the academic framework.

Thematic analysis was employed as a secondary method for data analysis. This approach helped to identify recurring patterns, strengths, and gaps within the current educational offerings. The findings from this analysis were used to inform the development of a framework aimed at enhancing halal authentication education in biotechnology programs.

Discussion

Analysis of Current Halal Biotechnology Programs in Malaysian Universities

Various Malaysian universities offer courses or programs in halal studies or halal industry management. These institutions provide a range of opportunities for students interested in pursuing education and research in fields related to halal studies and the halal industry. However, this analysis highlights both strengths and areas for improvement in integrating halal authentication into biotechnology education.

Curriculum Structure and Content

Some Malaysian university programs have begun including halal-related topics, but the depth and scope of this integration differ significantly. Many programs offer general courses on biotechnology, food science, and ethics, with some featuring specific modules on halal science or certification. However, dedicated courses on halal authentication are often limited. This indicates a need for more specialized coursework that directly addresses the technical and practical aspects of halal biotechnology. The literature shows that halal authentication in biotechnology is becoming increasingly important due to the global demand for halal products. Techniques like DNA-based methods and biosensors are being incorporated into biotechnology curricula to equip graduates with essential halal authentication skills (Rohman et al., 2016; Fadhilah et al., 2021). However, the inclusion of these methods across programs is inconsistent. Some universities offer specialized courses in halal science, but the overall integration of these techniques into biotechnology education is uneven, suggesting the need for a more comprehensive curriculum that includes advanced halal authentication techniques.

Alignment with Industry Needs

Aligning educational programs with the requirements of the halal industry is a key focus of this analysis. Programs that foster industry partnerships and include practical training tend to better prepare graduates for the workforce. However, not all programs have strong connections with the halal industry, potentially creating a gap between academic learning and industry expectations. Strengthening these ties through internships, cooperative programs, and industry-led workshops could increase the relevance and impact of halal biotechnology education. The alignment between academic offerings and industry needs is essential for producing graduates who meet the halal sector's demands. The literature suggests that Malaysia's halal industry faces challenges such as a shortage of skilled professionals and issues with certification systems (Muhammad et al., 2020; Sahilah et al., 2016). Despite these hurdles, the demand for experts in halal authentication, especially in areas like food processing, pharmaceuticals, and cosmetics, is increasing. Better alignment between biotechnology programs and industry needs can help bridge the gap between academic training and the industry's evolving requirements.

Interdisciplinary Collaboration

Halal biotechnology education requires collaboration across disciplines such as biotechnology, Islamic studies, ethics, and food science. While some programs attempt to connect these fields, they often lack cohesive integration. Interdisciplinary courses and collaborative research initiatives are not as widespread as they could be, leading to a compartmentalized approach. Strengthening interdisciplinary collaboration could provide students with a more holistic understanding of halal principles. The literature highlights the importance of multidisciplinary education in halal biotechnology, integrating Islamic principles with biotechnology and related fields (Alina et al., 2013). Although some Malaysian programs attempt to bridge these disciplines, the integration is often fragmented, leading to a compartmentalized educational experience. Enhancing interdisciplinary collaboration in both curriculum design and research initiatives could improve students' understanding of halal principles and their application in various

biotechnology sectors.

Faculty Expertise and Resources

The expertise of faculty and the availability of resources, such as laboratories and specialized equipment, are crucial to the success of halal biotechnology programs. Some universities face challenges in these areas, particularly a shortage of faculty members with expertise in both biotechnology and halal science. This limitation can impact the depth of instruction and the quality of practical training provided. Investment in faculty development and enhanced resources is essential to addressing these challenges. The literature identifies a shortage of faculty with dual expertise in biotechnology and halal science as a significant issue in halal biotechnology education (Alina et al., 2013; Mohd Saruan et al., 2015). Addressing this gap will require faculty development programs, recruitment of specialists, and investment in laboratory facilities to ensure that students receive comprehensive training in halal biotechnology.

Opportunities for International Collaboration

International collaboration offers a valuable opportunity for Malaysian universities to improve their halal biotechnology programs. Partnerships with global institutions can facilitate knowledge exchange, the adoption of best practices, and the development of standardized curricula that meet international standards. While some universities have initiated these collaborations, there is considerable potential for expanding such efforts to strengthen Malaysia's leadership in halal education. International collaboration is seen as a key opportunity in the literature for enhancing halal biotechnology education in Malaysia. Partnering with global institutions that excel in halal research allows Malaysian universities to engage in knowledge exchange, joint research, and curriculum standardization (Zain et al., 2017; Scarborough & Grison, 2017). Expanding these international efforts could further enhance Malaysia's standing as a leader in halal education and research, aligning with its goal of becoming a global halal hub.

Student Outcomes and Career Prospects

This analysis also examines the career prospects for students graduating from halal biotechnology programs. Although these programs have the potential to produce highly skilled professionals, variations in curriculum content and industry alignment may affect graduates' career outcomes. Ensuring that programs are comprehensive, up-to-date, and aligned with industry needs is crucial to preparing students for success in the global halal market. The literature emphasizes the need to produce graduates who are well-equipped to meet the practical demands of the halal industry (Deuraseh & Heradhyaksa, 2020). Programs that include practical training, industry partnerships, and interdisciplinary education are more likely to produce graduates capable of thriving in the halal sector. However, the inconsistent integration of halal content across programs may affect the uniformity of student outcomes, underscoring the need for a more standardized, industry-aligned curriculum.

Integration of Halal Authentication Components Within Programs

Incorporating halal authentication into biotechnology programs at Malaysian universities is essential for preparing graduates to meet the demands of the halal industry. While there has been progress, there is still considerable room for improvement in how these components are embedded into academic curricula.

1. Curriculum Content

Halal authentication techniques, including DNA-based methods, biosensors, and chromatography, are critical for developing students' technical skills in the halal sector (Rohman et al., 2016; Fadhilah et al., 2021). However, curriculum development is inconsistent across institutions. Although some universities offer specialized courses on halal science, these are often electives rather than core subjects. A more structured approach is necessary, where halal authentication is integrated into core biotechnology courses, ensuring comprehensive training for all students.

2. Interdisciplinary Education

The integration of halal authentication also requires collaboration across different fields, especially between biotechnology and Islamic studies. Research emphasizes the need for multidisciplinary approaches that merge Shariah knowledge with technical expertise (Alina et al., 2013). Currently, this interdisciplinary cooperation is underdeveloped in many programs, resulting in a fragmented learning experience. By promoting stronger partnerships between these areas, universities can create more well-rounded curricula that address both the technical and ethical dimensions of halal authentication.

3. Practical Training and Industry Engagement

Hands-on training and collaboration with industry are vital to successfully incorporating halal authentication into biotechnology programs. Partnering with industry can offer students practical experience in halal certification, food analysis, and product innovation (Ibrahim et al., 2022). Such collaborations can also shape curricula to reflect current industry standards and practices. However, research suggests that these partnerships are still limited, indicating a need for universities to actively pursue stronger ties with halal industry stakeholders.

4. Standardization and Accreditation

Another key aspect of integration is the need for standardizing halal authentication education. Presently, a unified curriculum that aligns with both academic and industry needs is lacking. Developing national standards for halal biotechnology education in cooperation with agencies like the Halal Industry Development Corporation (HDC) and the Department of Islamic Development Malaysia (JAKIM) could help maintain consistency and quality across programs. Additionally, accrediting these programs would increase their appeal to students domestically and internationally.

5. Faculty Development

For effective integration of halal authentication into biotechnology programs, universities must also focus on faculty development. Studies point to a shortage of instructors with expertise in both halal science and biotechnology (Alina et al., 2013). To address this, institutions should implement faculty training programs and hire specialists in halal biotechnology. By improving faculty capabilities, universities can offer students a robust and relevant education that aligns with the needs of the halal industry.

Opportunities for Enhancing Halal Authentication Education in Malaysian Universities

Integrating halal authentication into biotechnology education presents various opportunities to strengthen both academic and industry sectors in Malaysia. One significant opportunity is the increasing global demand for halal products, which calls for a workforce skilled in both Islamic principles and advanced biotechnology techniques. By offering specialized courses and research programs, universities in Malaysia can become pioneers in halal education, attracting students and researchers from around the world. Additionally, the interdisciplinary nature of halal authentication—combining religious, scientific, and technological knowledge—creates a platform for innovative educational programs. Collaborating with industry, halal certification bodies, and government agencies can further enrich the curriculum, providing students with practical experiences and insights into industry challenges.

Moreover, the growing interest in halal products outside the Muslim market provides an opportunity to internationalize halal education. By incorporating global best practices and standards, Malaysian universities can contribute to the international dialogue on halal products and potentially shape global standards. Advancements in technologies like DNA-based methods and biosensors also create opportunities to integrate cutting-edge tools into the curriculum, enhancing both the quality of education and preparing students for the ever-evolving demands of the halal industry.

Challenges in Integrating Halal Authentication in Malaysian Universities

While there are opportunities, several challenges need to be addressed for the successful integration of halal authentication into biotechnology education. A major challenge is the lack of standardized guidelines and certifications, which can result in inconsistencies in education and practice. The absence of a unified global halal standard makes it difficult to develop a curriculum that meets both local and international expectations. Additionally, there is a shortage of educators who possess expertise in both Islamic jurisprudence and biotechnology, limiting the development of comprehensive programs that cover both technical and religious aspects of halal authentication.

Financial constraints are another challenge, particularly when it comes to establishing and maintaining advanced laboratories and research facilities needed for halal authentication studies. Securing sufficient funding and resources for such specialized programs is often difficult, especially for smaller institutions. Furthermore, consumer misunderstandings or skepticism about halal concepts can pose barriers to the successful implementation of halal authentication education. The complexity of biotechnology, particularly with technologies like genetically modified organisms, can further complicate public perceptions of what qualifies as halal. Lastly, integrating halal authentication into existing biotechnology curricula may face resistance due to concerns about increased workload or changes to established educational structures. Overcoming these hurdles will require clear communication of the benefits and strategic curriculum development.

Proposed Framework for Halal Authentication in Biotechnology Education in Malaysian Universities

In response to the identified opportunities and challenges of integrating halal authentication into biotechnology education, a detailed framework is suggested. Figure 1 outlines this proposed framework for halal authentication in biotechnology programs at Malaysian universities. The framework aims to improve the quality and impact of halal biotechnology education in Malaysia, aligning it with both industry demands and international standards. Curriculum development is a key element of this framework. It is essential to create specialized courses and degree programs that integrate Islamic principles with advanced biotechnological techniques. These programs should cover crucial areas in halal authentication, including DNA-based methods, biosensors, and related technologies. Incorporating international best practices ensures that students receive a globally relevant education tailored to the diverse needs of the halal industry. Faculty development is also vital. Strengthening the training of educators who have expertise in both Islamic jurisprudence and biotechnology will enhance the educational structure. This can be facilitated through partnerships with religious institutions, biotechnology firms, and international universities, which can provide faculty with the necessary skills and knowledge.

Collaboration with industry is crucial for linking academic knowledge with practical experience. Universities should build partnerships with halal certification bodies and industry players to strengthen the hands-on components of halal authentication education. These partnerships can offer students opportunities for internships, research, and workshops led by industry professionals, equipping them with practical skills and insights. Promoting research and innovation is essential to advance halal authentication methods. Providing resources for innovative projects could lead to the establishment of dedicated research centers focused on halal biotechnology, where students and faculty can engage in cutting-edge research.

Public outreach initiatives are important for raising awareness about the role of halal authentication in biotechnology. Hosting public lectures, seminars, and community engagement programs can help clear misconceptions and increase public understanding of halal principles. These efforts emphasize the importance of halal authentication in maintaining product safety and integrity. Internationalizing the curriculum is another crucial aspect to position Malaysia as a leader in halal biotechnology education. By incorporating global perspectives and collaborating with international institutions, Malaysian universities can contribute to the broader global conversation on halal standards. Ongoing improvement is necessary to maintain the relevance and quality of halal authentication education. Regular curriculum reviews, industry feedback, and benchmarking against global

standards will ensure the education provided remains current and high-quality. By implementing this framework, Malaysian universities can enhance their halal authentication programs, preparing students for successful careers in the halal industry and supporting Malaysia's ambition to be a global leader in halal biotechnology.

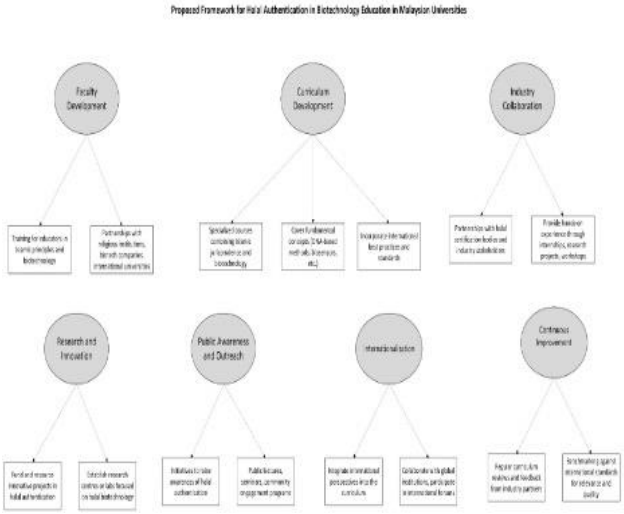

Figure 1. Proposed Framework for Halal Authentication in Biotechnology Education in Malaysian Universities.

Conclusion

Integrating halal authentication into biotechnology education is a strategic move that addresses both the current needs and prospects of the halal industry. By implementing a well-rounded framework that includes curriculum enhancement, faculty development, industry collaboration, research and innovation, public outreach, internationalization, and continuous improvement, Malaysian universities can significantly contribute to advancing halal biotechnology. The proposed framework provides substantial benefits to academia by enriching biotechnology programs with courses that blend Islamic principles with modern biotechnological methods. This approach not only improves the quality and relevance of education but also positions Malaysian institutions as leaders in the field of halal education. By developing a workforce skilled in both technical expertise and an understanding of halal principles, universities can better meet industry requirements and help Malaysia become a global halal hub. For the halal industry and policymakers, the framework offers a structured solution for addressing challenges such as certification issues and regulatory inconsistencies. Through fostering industry partnerships and influencing policy development, the framework can enhance halal authentication processes and support the production of high-quality halal products. It also aids in establishing clear standards and guidelines, reinforcing the integrity and reliability of halal certifications.

However, implementing this framework presents some challenges. These include the need for significant resources to develop and sustain specialized programs, potential resistance to change from established institutions, and difficulties in aligning diverse stakeholder interests. Additionally, the evolving nature of both biotechnology and halal standards will require ongoing revisions to keep the framework relevant. Future research is essential for refining and expanding the framework, especially in areas like curriculum design, faculty training, industry collaboration, technological innovation, and public engagement, to ensure halal authentication education stays effective and up to date. In conclusion, the integration of halal authentication into biotechnology education represents a progressive strategy that aligns with national and global trends. It offers a way to tackle existing challenges while taking advantage of new opportunities, ultimately contributing to the growth of a more robust, innovative, and globally competitive halal industry.

Acknowledgement

The researchers would like to extend their heartfelt gratitude to their colleagues at Universiti Teknologi MARA (UiTM) Perlis for their significant contributions to the development of this framework. The ideas and insights shared by these individuals have played a crucial role in shaping our approach to incorporating halal authentication into biotechnology education.

References

Ab Halim, M. A., Salleh, M. M. M., Ahmad, A. A., Ab Rahman, S., & Nusran, M. (2022). Economic growth of halal industry: Enhancing governance and halal legal framework in the ASEAN (Goal 12). In Good governance and the sustainable development goals in Southeast Asia (pp. 140-154). Routledge.

Ahmad, A. N., Rahman, R. A., Othman, M., & Abidin, U. F. U. Z. (2017). Critical success factors affecting the implementation of halal food management systems: Perspective of halal executives, consultants and auditors. Food Control, 74, 70-78. https://doi.org/10.1016/j.foodcont.2016.09.035

Ahmad, A. N., Jamil Nasri, N. S., Huda, F. H., Hashim, Y. Z. H. Y., Zulfigar, S. B., Samsudin, N., & Jamaludin, M. A. (2024). The fourth industrial revolution (IR4.0): Aligning competencies for halal executives. In Emerging technology and crisis management in the halal industry: Issues and recent developments (pp. 251-271). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-2921-1_13

Ahmad, H., Fazullah, A., Borham, A. J., Hashim, H., & Razak, M. (2011, May). Halal studies in universities: A way forward to manage halal business. In International Journal of Arts and Sciences Conference, Austria (IJAS2011) (pp. 1-9).

Ali, M. H., Makhbul, Z. M., Tan, K. H., & Ngah, A. H. (2016). Augmenting halal food integrity through supply chain integration. Jurnal Pengurusan, 48(3), 21-31.

Ali, M. Q., & Ahmad, N. A. (2023). The factors that affect halal food and food products awareness and different challenges: An overview. Journal of Agribusiness Marketing, January, 82-95.

Alina, A. R., Rafida, A. N., Syamsul, H. K. M. W., Mashitoh, A. S., & Yusop, M. H. M. (2013). The academia's multidisciplinary approaches in providing education, scientific training and services to the Malaysian halal industry. Middle-East Journal of Scientific Research, 13, 79-84.

Asa, R. S. (2017). Malaysian halal certification: Its religious significance and economic value. Jurnal Syariah, 25(1), 137-156.

Azmi, N. A. N., Noor, N. M., Elgharbawy, A. A., Moniruzzaman, M., & Kaharudin, N. (2024). Green nanomaterials in halal applications. In Solving halal industry issues through research in halal sciences (pp. 117-143). Springer Nature Singapore.

Bakar, S. Z., Zamani, S. N., Ahmad, H. M., & Prasetyaningsih, E. (2023). Challenges in the implementation of halal certification among small medium enterprises (SMEs). Russian Law Journal, 11(4s), 365-371.

Bashir, K. M. I., Kim, J. S., Mohibbullah, M., Sohn, J. H., & Choi, J. S. (2019). Strategies for improving the competitiveness of Korean seafood companies in the overseas halal food market. Journal of Islamic Marketing, 10(2), 606-632.

Bhari, A., Mazuki, N. M., & Khotib, N. A. M. (2024). An overview of issues on the halal logo and halal authority body for the halal cosmetics and personal care industry. Al-Qanatir: International Journal of Islamic Studies, 33(2), 240-248.

Dashti, L. A., Jackson, T., West, A., & Jackson, L. (2024). Enhancing halal food traceability: A model for rebuilding trust and integrity in Muslim countries. Journal of Islamic Marketing, 34(2), 67-78.

Deuraseh, N., & Heradhyaksa, B. (2020). Potential occupation in halal industry for reinforcement sharia economic law. Diponegoro Law Review, 5(2), 156-171.

El Sheikha, A. F., Mokhtar, N. F. K., Amie, C., Lamasudin, D. U., Isa, N. M., & Mustafa, S. (2017). Authentication technologies using DNA-based approaches for meats and halal meats determination. Food Biotechnology, 31(4), 281-315.

Fadhilah, F. R., Rezaldi, F., Fadillah, M. F., Fathurohim, M. F., & Setiawan, U. (2021). Narrative review: Metode analisis produk vaksin yang aman dan halal berdasarkan perspektif bioteknologi. International Journal Mathla'ul Anwar of Halal Issues, 1(1), 64-80.

GlobeNewswire. (2023). Halal cosmetics market set to reach US$113.05 billion by 2032, growing at a CAGR of

12.1%. Retrieved from https://www.globenewswire.com/en/news-release/2024/08/20/2932823/0/en/Halal-Cosmetics-Market-Set-to-Reach-US-113-05-Billion-by-2032-Growing-at-a-CAGR-of-12-1-Polaris-Market-Research-PMR.html

Hafis Aliaziz, M., & Ab Rahma, S. (2018). Review of the issues and governance of genetically modified organisms in Malaysia. International Journal of Engineering Technology, 7(178), 10-14419.

Halal Weekly. (2023). Global halal food market analysis and growth forecast 2023-2028. Retrieved from https://www.halalweekly.com/2023/07/18/global-halal-food-market-analysis-and-growth-forecast-2023-2028/

Hashim, R. (2012). Muslim private higher educational institutions in Malaysia: Issues and challenges. ICR Journal, 3(3), 474-488.

Hashim, Y. Z. H. Y., Ahmad, A. N., Ahmad, I. A. Z., Samsudin, N., & Abbas, P. (2024). Exploring halal science research: Do they meet the tawhidic paradigm? Do they need Islamization of knowledge? Journal of Fatwa Management and Research, 29(1), 1-22.

Halal Development Corporation (HDC). (2020). Halal industry master plan 2030. Retrieved from https://www.hdcglobal.com/wp-content/uploads/2020/02/Halal-Industri-Master-Plan-2030.pdf

Iberahim, H., Kamaruddin, R., & Shabudin, A. (2012, September). Halal development system: The institutional framework, issues, and challenges for halal logistics. In 2012, IEEE Symposium on Business, Engineering and Industrial Applications (pp. 760-765). IEEE.

Ibrahim, M. I., Jamaludin, M. A., Zubairi, A. M., Muflih, B. K., & Hashim, Y. Z. H. Y. (2022). Development of framework for halal studies program evaluation. Halalsphere, 2(1), 98-105.

Idris, R., Govindasamy, P., & Nachiappan, S. (2023). Challenge and obstacles of STEM education in Malaysia. International Journal of Academic Research in Business and Social Sciences, 13(4), 820-828.

Ilmiyah, Z., Junaidy, A. B., Musyafa'ah, N. L., Maziyyah, R., Syatta, I. M., & Nurtifara, D. (2024). Higher education existence in guarding mandatory halal 2024, for micro and small enterprises (MSEs) in positive legal perspectives in Indonesia. In 4th International Conference on Halal Development (4th ICHaD 2023) (pp. 89-100). Atlantis Press.

Jaludin, R. O., Man, S., & Baharuddin, M. (2018). Halal issues in biotechnology applications against selected pharmaceutical products. Jurnal Islam dan Masyarakat Kontemporari, 19(1), 74-90.

Karahalil, E. (2020). Principles of halal-compliant fermentations: Microbial alternatives for the halal food industry. Trends in Food Science & Technology, 98, 1-9.

Karia, N. (2022). Halal logistics: Practices, integration and performance of logistics service providers. Journal of Islamic Marketing, 13(1), 100-118.

Kasanah, N., & Andari, R. N. (2024). SEHATI program: A flexible model for effective halal certification. Harmoni, 23(1), 122-145.

Khoshdouni Farahani, Z., & Khoshdouni Farahani, F. (2021). Biosensors as a rapid method for detection of non-halal ingredients in food products. Human, Health and Halal Metrics, 1(2), 94-103.

Majid, M. A. A., Abidin, I. H. Z., Majid, H. A. M. A., & Chik, C. T. (2015). Issues of halal food implementation in Malaysia. Journal of Applied Environmental and Biological Sciences, 5(6), 50-56.

Masood, A., Anim, N. A. H. M., & Ismail, A. (2024). Transforming halal training through gamification and immersive technology to empower talents. The Journal of Muamalat and Islamic Finance Research, 70-81.

Muhamed, N. A., Ramli, N. M., Abd Aziz, S., & Yaakub, N. A. (2014). Integrating Islamic financing and halal industry: A survey on current practices of the selected Malaysian authority bodies. Asian Social Science, 10(17), 120-126.

Muhammad, M. A., Elistina, A. B., & Ahmad, S. O. (2020). The challenges faced by halal certification authorities in managing the halal certification process in Malaysia. Food Research, 4(1), 170-178.

Mustapha, A., Ishak, I., Zaki, N. N. M., Ismail-Fitry, M. R., Arshad, S., & Sazili, A. Q. (2024). Application of machine learning approach on halal meat authentication principle, challenges, and prospects: A review. Heliyon.

https://doi.org/10.1016/j.heliyon.2024.e13689

Naimat, N., Ahmad Mustafa, M. S., Nasrijal, N. M., & Mahat, I. R. (2024). Challenges and opportunities in the halal pharmaceutical industry in Malaysia. Information Management and Business Review, 15(4), 73-78.

Ng, P. C., Ahmad Ruslan, N. A. S., Chin, L. X., Ahmad, M., Abu Hanifah, S., Abdullah, Z., & Khor, S. M. (2022). Recent advances in halal food authentication: Challenges and strategies. Journal of Food Science, 87(1), 8-35.

Nurani, L. H., Riswanto, F. D. O., Windarsih, A., Edityaningrum, C. A., Guntarti, A., & Rohman, A. (2022). Use of chromatographic-based techniques and chemometrics for halal authentication of food products: A review. International Journal of Food Properties, 25(1), 1399-1416.

Rahman, M. M., & Ahmad, Z. (2024). Lifelong learning and technological advancement in the halal industry: Navigating the digital age embracing technological advancements for lifelong learning. In Embracing technological advancements for lifelong learning (pp. 186-216). IGI Global.

Rahman, S. A., Rahman, A. A., & Aliaziz, M. H. (2013). Genetically modified organisms (GMOs) and the issue of safety and halal in Malaysia. Australian Journal of Basic and Applied Sciences, 7(12), 238-244.

Rohman, A., Arsanti, L., Erwanto, Y., & Pranoto, Y. (2016). The use of vibrational spectroscopy and chemometrics in the anlysis of pig derivatives for halal authentication. International Food Research Journal, 23(5), 1839-1848.

Risza, H. (2024). The role of universities in pioneering halal product innovation and education in Indonesia. AL-ISHLAH: Jurnal Pendidikan, 16(2), 821-829.

Salahudin, A., Ramli, M. A., Zulkepli, M. I., & Razak, M. I. (2018). Issues in halal meat product and authentication technology from Islamic perspectives. The International Journal of Academic Research in Business and Social Sciences, 7, 1305-1315.

Shahidan, N., & Amid, A. (2023). Challenges faced by halal meat industry: A review. Halalpshere, 3(1), 55-63.

Sin, M. A. M., Razalli, M. R., & Ismail, R. M. (2019). The search of best practices of Malaysian halal cosmetics industry to improve firm performance. International Journal of Islamic Marketing and Branding, 4(3-4), 212-227.

Soraji, A. J., Awang, M. D., & Yusoff, A. N. M. (2017). Malaysia halal trust: Between reality and challenges. International E-Journal of Advances in Social Sciences, 3(7), 197-204.

Talib, H. A., Ali, K. M., Jamaludin, K. R., & Rijal, K. (2008, May). Quality assurance in halal food manufacturing in Malaysia: A preliminary study. In Proceedings of International Conference on Mechanical & Manufacturing Engineering (ICME2008) (pp. 21-23).

Tumiran, M. A., & Mohammad, N. (2024). The prospects of a halal food safety academic program in Malaysian higher education: A review. International Journal of Advanced Research in Education and Society, 6(2), 835-846.

Usman, I., Sana, S., Afzaal, M., Imran, A., Saeed, F., Ahmed, A., & Khan, M. R. (2024). Advances and challenges in conventional and modern techniques for halal food authentication: A review. Food Science & Nutrition, 12(3), 1430-1443.

Yayasan Dakwah Islamiah Malaysia (YADIM). (2021). Malaysia yang pertama wujudkan standard program pengajian halal. Retrieved from https://www.yadim.com.my/v2/malaysia-yang-pertama-wujudkan-standard-program-pengajian-halal/

Zailani, S., Iranmanesh, M., Aziz, A. A., & Kanapathy, K. (2017). Halal logistics opportunities and challenges. Journal of Islamic Marketing, 8(1), 127-139.

Zain, N. M., Muhamad, N. H., Yaacob, A. B., & Ahmad, S. M. (2017). Halal science curriculum and research: Development among organisation of Islamic cooperation (OIC) countries. International Journal of Asian Social Science, 7, 718-727.