

[HTSL#165]

# Biosensor Applications in Ensuring Sustainable Practices in the Halal Food Industry

Md Mahfujur Rahman

Institute of Halal Management, Islamic Business School, Universiti Utara Malaysia, Changlun, 06050 Bukit Kayu Hitam, Kedah, Malaysia

\*Corresponding author's e-mail: dr\_mahfuj@yahoo.co.uk; mahfuj@uum.edu.my

## ABSTRACT

The halal food industry is committed to ensuring sustainable practices that align with Islamic dietary laws and promote food safety. Biosensors, which are analytical devices that combine biospecific recognition systems with physical or electrochemical signaling, have emerged as valuable tools for achieving these goals. Thus, the article here provides the applications of biosensors in ensuring sustainable practices in the halal food industry. Biosensors offer rapid and accurate detection of non-halal ingredients and enable the identification of potential contaminants that violate halal standards. Biosensors can be integrated into smart food packaging systems, providing real-time monitoring of food quality parameters and reducing food waste. Additionally, biosensors contribute to the detection of pathogens, toxins, and other contaminants in food products, enhancing food safety and preventing harm to consumers. Thus, biosensors have significant applications in ensuring sustainable practices in the halal food industry through monitoring food quality, preventing contamination, and promoting food safety. By addressing challenges and advancing biosensor technologies, the industry can further enhance sustainability, and protect consumer health and the environment.

**Keywords:** Biosensor; Halal food; Industry; Sustainability

## 1 Introduction

The halal food industry has been growing rapidly in recent years, with an increasing demand for halal products worldwide. Ensuring that food products meet halal standards is crucial for the industry's sustainability and growth. One of the challenges in halal food production is the detection of non-halal ingredients, such as pork, which can contaminate food products during processing or handling. To address this challenge, biosensors with nanomaterials have emerged as a promising technology for the rapid and accurate detection of halal compounds and non-halal ingredients in food products [1-4]. Biosensors are biological-based detectors that can identify minor elements in food products, providing fast and reliable results [3]. The application of biosensors in the halal food industry is a new era in food authentication platforms, providing a portable and cost-effective solution for halal authenticity and verification [4]. In this context, this article aims to explore the potential of biosensor applications for ensuring sustainable practices in the halal food industry.



## 2 Methodology

The aim of this article was to explore biosensors and their applications in promoting sustainability within the halal food industry. To accomplish this, we conducted a comprehensive review of relevant literature, utilizing databases such as Scopus and Google Scholar. Given the limited availability of full-length research articles specifically focused on biosensors and the sustainability of the halal food industry, our study also encompassed review papers, proceeding papers, book chapters, and other related materials.

## 3 Biosensors and their use in food industry

There are different types of biosensors used in the food industry based on the method of signal transduction.

*Electrochemical biosensors:* These biosensors use electrodes to detect changes in electrical properties resulting from the interaction between the biological component and the analyte [5]. They are commonly used to detect glucose, lactate, and other metabolites in food products [6].

*Optical biosensors:* These biosensors use light to detect changes in the biological component resulting from the interaction with the analyte [5]. They are commonly used to detect pathogens, toxins, and other contaminants in food products [7].

*Thermometric biosensors:* These biosensors use temperature changes to detect the presence of an analyte [8]. They are commonly used to detect the freshness of produce and other food products.

*Piezoelectric biosensors:* These biosensors use changes in mass or density to detect the presence of an analyte. They are commonly used to detect pathogens and other contaminants in food products.

*Magnetic biosensors:* These biosensors use magnetic fields to detect changes in the biological component resulting from the interaction with the analyte [9]. They are commonly used to detect pathogens and other contaminants in food products.

## 4 Biosensors and Islamic 3Ps sustainability of the halal food industry

The role of biosensors in halal industrial sustainability aligns with the Islamic perspective of promoting halal practices and ensuring the well-being of mankind, competitiveness, and God's blessing. Biosensors can play a crucial role in achieving sustainability goals in the halal food industry by ensuring product and service excellence, promoting sustainable and competitive practices and complying with religious requirements. The 3 Ps of sustainability – people, planet, and profit, the triple bottom line framework emphasizes considering social, environmental, and financial aspects in business practices. From an Islamic perspective, the sustainability of the planet is emphasized, and biosensors contribute to this by promoting a green environment, practising 3R activities (reduce, reuse, recycle), employing green transportation systems, and ensuring the safety of goods throughout the supply chain [10]. In

terms of profit, align with Islamic teachings of upholding good actions and moral practices and contributing to customer loyalty [11]. Regarding people, biosensors contribute to upholding good actions and moral practices, avoiding sins, and promoting employee commitment and responsibility at work. These align with Islamic principles of moral conduct, fulfilling responsibilities, and maintaining ethical behaviour [12]. Thus, biosensors may contribute to ensuring product and service excellence, complying with religious requirements, promoting sustainable practices, and maximizing the interests of the firm and the public.

## **5 Biosensor and sustainability of halal food production**

Biosensor can play in halal food production sustainability by the ability of the food production process to be halal. Where halal ingredients, enzymes, microbial products, and Shari'ah-compliant reconfiguration of genetic material can be analyzed by the biosensor which will promote halal food sustainability by following ways:

*Halal ingredients:* The use of halal ingredients in food production can help to ensure that food is produced in a way that is consistent with Islamic principles. This can include using ingredients that are free from haram (forbidden) substances, such as pork or alcohol. By using halal ingredients, food producers can appeal to Muslim consumers and promote sustainable food production practices [13].

*Enzymes:* The use of microbial enzymes compatible with halal food production can eliminates the use of animal-derived enzymes, which can be a concern for halal consumers. In addition, enzymes can help to improve the quality, freshness, and shelf life of food products, which can reduce food waste and promote sustainability.

*Microbial products:* Microbial products, such as probiotics and prebiotics, can also play a role in promoting food sustainability. These products can help to improve the nutritional value of food, reduce food waste, and promote sustainable food production practices [14].

*Shari'ah-compliant reconfiguration of genetic material:* The reconfiguration of genetic material can be used to produce food products that are consistent with Islamic principles. For example, genetic modification can be used to produce halal meat products that are free from haram substances. By using Shari'ah-compliant reconfiguration of genetic material, food producers can appeal to Muslim consumers and promote sustainable food production practices [14].

## **6 Biosensor and sustainability enhancement of the halal food industry**

Biosensors can play a significant role in enhancing halal food industrial sustainability. Here are some ways in which biosensors can contribute to halal food industrial sustainability:

*Detection of pathogens, antibiotic and contaminants:* Biosensors can detect and measure various compounds such as toxic substances (pesticide residue, heavy metals, fertilizers, etc.) in food [15]. They can also be used as a rapid method for the detection of non-halal ingredients in

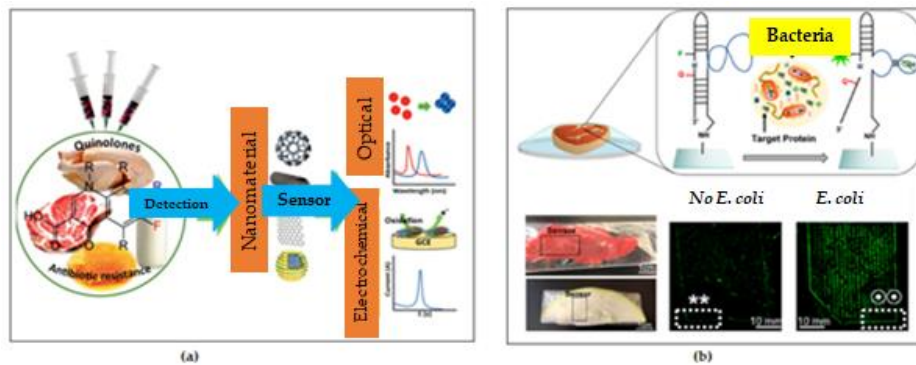
food products. Furthermore, by using biosensors to detect antibiotics such the quinolones (**Figure 1.a**) [16] and microbial (**Figure 1.b**) [17] can ensure that their products are safe for consumption and meet halal standards.

*Quality control:* Biosensors can be used to monitor the quality of food products throughout the production process. They can detect changes in pH, temperature, and other factors that can affect the quality of the final product. By using biosensors for quality control, food producers can ensure that their products meet halal standards and are of high quality.

*Sustainable agriculture:* Biosensors can also be used in sustainable agriculture practices. By using biosensors in agriculture, halal food producers can reduce waste, increase efficiency, and promote sustainable practices.

*Waste reduction:* Biosensors can be used to monitor food waste and identify areas where waste can be reduced. For example, they can be used to detect spoilage in food products and optimize storage conditions to reduce waste.

*Supply chain management:* Biosensors can also be used to monitor the supply chain and ensure that food products are transported and stored under appropriate conditions. They can detect changes in temperature, humidity, and other factors that can affect the quality of the final product [18].



**Figure 1:** (a) Application of biosensor for detection of antibiotic [16] and (b) microbial contamination [17]

## 7 Conclusions

The application of biosensors in the halal food industry plays a vital role in ensuring sustainable practices. By aligning with the Islamic perspective and emphasizing essential aspects such as well-being, competitiveness, and God's blessing, biosensors contribute to product and service excellence, promote sustainable and competitive practices, and comply with religious requirements. Moreover, biosensors contribute to the 3 Ps of sustainability, including profit, planet, and people. By promoting a green environment, practicing 3R activities, and ensuring the safety of goods throughout the supply chain. With the added benefits of maximizing profit, ensuring customer loyalty, and upholding good actions and moral practices, biosensors offer a promising solution to enhance sustainability, protect consumer health, and maintain compliance with halal standards in the food industry.

## Acknowledgments

The authors would like to acknowledge Doctors Feed Ltd, Bangladesh, and Universiti Utara Malaysia Research opportunity with the Grant Number RI 10010030/SO 21153 for the support in this work.

## References

1. Ali, M.E., Rahman, M.M., Hamid, S.B.A. and Hashim, U., Nanoscale DNA Sensing-Potential and Prospects. *Advanced Materials Research*, **2014**, 925, 486-489.
2. Mortas, M., Awad, N. and Ayvaz, H., Adulteration detection technologies used for halal/kosher food products: an overview. *Discover Food*. **2022**, 2, 15.
3. Lubis, H.N., Mohd-Naim, N.F., Alizul, N.N. and Ahmed, M.U., From market to food plate: Current trusted technology and innovations in halal food analysis. *Trends in Food Science & Technology*. **2016**, 58, 55-68.
4. Ng, Pei Chi, Nur Amy Syahira Ahmad Ruslan, Ling Xuan Chin, Musa Ahmad, Sharina Abu Hanifah, Zanariah Abdullah, and Sook Mei Khor. "Recent advances in halal food authentication: Challenges and strategies. *Journal of Food Science*. **2022**, 1, 8-35.
5. Aggarwal, S., Sehgal, S., & Tandon, W. Biosensors-types and application in food processing industry. *J. Postharvest. Technol.* 2021 9, 1-19.
6. Terry, L. A., White, S. F., & Tigwell, L. J. The application of biosensors to fresh produce and the wider food industry. *Journal of agricultural and food chemistry*. **2005**, 53, 1309-1316.
7. Murugaboopathi, G., Parthasarathy, V., Chellaram, C., Anand, T. P., & Vinurajkumar, S. Applications of biosensors in food industry. *Biosciences Biotechnology Research Asia*. **2013**, 10, 711-714.
8. Mehrotra, P. Biosensors and their applications—A review. *Journal of oral biology and craniofacial research*. **2016**, 6, 153-159.
9. Zhang, C., Huang, L., Pu, H., & Sun, D. W. Magnetic surface-enhanced Raman scattering (MagSERS) biosensors for microbial food safety: Fundamentals and applications. *Trends in Food Science & Technology*, **2021**, 113, 366-381.
10. Salleh, M. M., & Harun, E. H. Halal food supply chain (hfsc) and sustainability concept. *Journal of Islamic, Social, Economics and Development*. **2022**, 7, 26-34.
11. Zain, S., Adesta, E. Y. T., Ismail, A. F., & Ahmad, Z. Sustainable Manufacturing Framework from Islamic Perspective. In IOP Conference Series: Materials Science and Engineering, (2017, March) (Vol. 184, No. 1, p. 012054). IOP Publishing.
12. Mabkhot, H.. Factors affecting the sustainability of halal product performance: Malaysian evidence. *Sustainability*. **2023**, 15, 1850.
13. Mohd Hatta, F.A., Mat Ali, Q.A., Mohd Kashim, M.I.A., Othman, R., Abd Mutalib, S. and Mohd Nor, N.H., Recent Advances in Halal Bioactive Materials for Intelligent Food Packaging Indicator. *Foods*. **2023**, 12, 2387.
14. Khattak, J.Z.K., Mir, A., Anwar, Z., Abbas, G., Khattak, H.Z.K. and Ismatullah, H., Concept of halal food and biotechnology. *Advance Journal of Food Science and Technology*. **2011**, 3, 385-389.
15. Mello, L.D. and Kubota, L.T., Review of the use of biosensors as analytical tools in the food and drink industries. *Food chemistry*. **2022**, 77, 237-256.
16. Majdinasab, M., Mitsubayashi, K. and Marty, J.L., Optical and electrochemical sensors and biosensors for the detection of quinolones. *Trends in biotechnology*. **2019**, 37, 898-915.
17. Wang, X., Luo, Y., Huang, K., & Cheng, N. Biosensor for agriculture and food safety: Recent advances and future perspectives. *Advanced Agrochem*. **2022**, 1, 3-6.
18. Neethirajan, S., Ragavan, V., Weng, X. and Chand, R., Biosensors for sustainable food engineering: challenges and perspectives. *Biosensors*, **2018**, 8, 23.