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Halal Detection Training Using AI: BRIN's Breakthrough with Smart Sensors

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Abstract

The webinar "Halal Detection Training Using AI: BRIN's Breakthrough with Smart Sensors" aims to enhance understanding of the application of modern technology in verifying product halal status. Held virtually, the training highlights the importance of detecting contaminants such as porcine gelatin—a key focus of BRIN's research. Traditional methods have limitations, driving innovation in ultra-sensitive smart optical and electronic sensors capable of detecting gelatin concentrations below 1%. The role of the "e-nose" in rapid, real-time detection is crucial, supported by deep learning integration that yields high detection accuracy (median 0.981). The webinar underscores Indonesia's strategic position in the global halal market and the importance of scientific and technological innovation in maintaining product integrity and consumer trust.

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1. INTRODUCTION

The global halal industry continues to show exponential growth, becoming an increasingly significant economic sector with projected Muslim consumer spending estimated to reach US$3.2 trillion by 2024. This growth is not limited to the food and beverage sector but also extends to Muslim-friendly tourism, lifestyle, and pharmaceuticals. Amidst this rapid development, the issue of product halal authenticity has become critically crucial and urgent. Muslim consumers worldwide are increasingly demanding assurance of the halal status of the products they consume and use, driving the need for strong and reliable verification systems.

Indonesia, as the country with the largest Muslim population in the world and the largest importer of halal food, is at the forefront of facing these challenges and opportunities. However, the complexity of global supply chains, which involve various raw materials from different parts of the world, poses a challenge in ensuring the halal status of every product component. The presence of non-halal contaminants, such as porcine gelatin commonly found in processed foods, pharmaceuticals, and cosmetics, requires accurate, fast, and efficient detection methods. This emphasizes the urgency of developing cutting-edge detection technology to maintain the integrity of halal products.

Addressing these challenges, the National Research and Innovation Agency (BRIN) has positioned itself as a key institution in halal technology research and development. One of BRIN's main focuses is the development of technology to detect critical halal materials, as agreed upon in a meeting with the National Committee for Sharia Economy and Finance (KNEKS) in 2022. This initiative is not only in line with the national sharia economic vision but also demonstrates Indonesia's commitment to becoming a global halal ecosystem hub, supported by advancements in science and technology.

In the context of contaminant detection, traditional laboratory methods such as Digital Polymerase Chain Reaction (PCR) analysis, Fourier Transform Infra-Red (FTIR), Gas Chromatography Triple quadrupole Spectrometry mass (LC/GC-MS-MS), Ultra-High Performance
Liquid Chromatography (UPLC), and Enzyme-Linked Immunosorbent Assay (ELISA) have long been used[1]. Although effective, these methods often require time, high costs, and specialized expertise, limiting their application on a fast and efficient industrial scale.

Rapid developments in the field of sensor technology and artificial intelligence (AI) offer promising solutions in halal detection. E-nose systems have shown great potential. E-noses are capable of quickly, in real-time, and more affordably detecting the adulteration of beef with pork for halal authentication[2]. This confirms the efficiency of sensor technology in identifying contaminants.

In addition, e-noses offer fast, real-time, and more affordable detection by utilizing gas sensors and data processing, strengthening the argument for the efficiency of this system[3]. The potential of Quartz Crystal Microbalance (QCM) sensors modified with PANI/NiO nanoparticles for rapid analysis in differentiating porcine and bovine gelatin has also been demonstrated[4]. These sensors have ultra-sensitive capabilities to measure differences in gelatin concentration even below 1%.

The integration of AI, especially deep learning, allows for more sophisticated and accurate analysis of sensor data, increasing the reliability of detection systems. Deep learning-based E-nose systems for porcine gelatin detection achieved a median accuracy of 0.981, a median sensitivity of 0.980, and a median AUC of 0.983[5]. These figures show the great potential of AI to significantly improve the efficiency and reliability of the halal certification process.

Thus, halal detection training that integrates AI and smart sensors becomes a strategic step to equip practitioners and industries with the latest knowledge and skills. This approach will not only strengthen the halal assurance system in Indonesia but also promote innovations that can be adopted globally, supporting a transparent and trustworthy halal supply chain in the Industry 4.0 era.

2. METHOD

The methods outlined in the "Halal Webinar: Halal Detection Training Using AI and Smart Sensors" are specifically designed to be delivered in a virtual format. This webinar approach was chosen to maximize participant reach, allowing participation from various geographical locations and optimally utilizing digital technology for content delivery and interaction. The main goal of this webinar is to equip participants with a deep understanding of halal product detection concepts and the working principles of advanced sensor technology integrated with artificial intelligence.

This training activity doesn't just focus on theoretical material; it also integrates case studies and application demonstrations. Specifically, the webinar will discuss in detail the process of identifying non-halal contaminants, such as porcine gelatin, which has been a primary focus of the National Research and Innovation Agency (BRIN) following a 2022 meeting with the National Committee for Sharia Economy and Finance (KNEKS). All materials and demonstrations will be presented virtually, referencing the latest research and development conducted by BRIN researchers in the field of contaminant detection. This ensures that the information provided is based on current scientific findings and relevant practical applications.

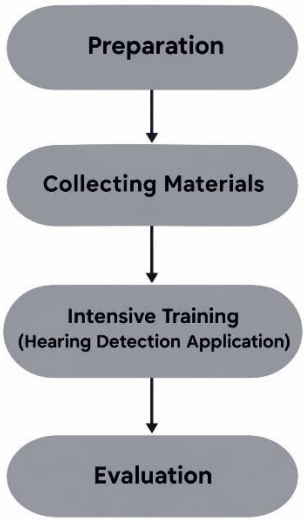


Figure 1. Research Design

2.1 Preparation Phase

The essential initial step is to obtain the necessary permits from relevant institutional authorities or collaborative partners, if any, to host a large-scale webinar. The coordination process also includes selecting the most suitable webinar platform, such as Zoom or Google Meet, which can accommodate the expected number of participants and support interactive features. Technical arrangements for stable and high-quality live streaming are also an integral part of this coordination, ensuring a seamless experience for all participants. Thorough technical preparation is critical for the successful real-time delivery of information via digital platforms.

Webinar Material Preparation: The speaker and committee teams will develop comprehensive, relevant, and easily understandable presentation materials in digital format. This includes creating informative presentation slides, developing short educational videos, and preparing software demonstrations or relevant data simulations. The materials will cover fundamental introductions to halal concepts, various types of critical contaminants (e.g., porcine gelatin), an overview of modern detection methods (including optical and electronic sensors), and an in-depth discussion on the role of artificial intelligence (AI) and deep learning in improving the accuracy and efficiency of halal detection. Systematic and datadriven material presentation is crucial for educating the audience about technological advancements.

Virtual Supporting Media Preparation: Careful virtual logistics are essential for an optimal webinar experience. This involves ensuring a stable and high-speed internet connection for speakers and the committee, as well as preparing adequate hardware (cameras, microphones, computers) and software (webinar applications, simulation software). Arrangements for streaming to other platforms like YouTube or social media (if necessary) will also be secured. Additionally, relevant virtual attributes and banners with the "Halal Webinar" theme will be created to enhance the event's professionalism and branding. Good technical readiness is a prerequisite for participants to focus on the content without being disrupted by technical issues.

2.2 Introductory Material Phase

This stage serves as a knowledge foundation for participants, ensuring they have a basic understanding before delving into more in-depth discussions on detection technology.

Basic Concept Education: The initial material presentation will focus on the fundamental concepts of halal detection, identifying various types of contaminants commonly found in products (e.g., porcine derivatives in gelatin or palm oil), and explaining the significant impact of maintaining product halal integrity for Muslim consumers. The delivery will be in simple, easily understandable language and will involve interactive Q&A sessions to gauge participants' initial knowledge and clarify any doubts. An adaptive educational approach for a diverse audience is crucial for effective knowledge transfer.

Presentation of Contaminant Case Studies via Digital Media: To make the material more concrete and engaging, the webinar will utilize storytelling or case presentation methods through digital visual aids, such as illustrations, animations, or short videos. These examples will demonstrate how contamination can occur in the product supply chain and why early detection is crucial. The showing of relevant educational videos will also be used to help participants better understand the complexity of contamination issues and the importance of technological solutions, while also keeping them engaged. The use of appealing visual media has been proven to increase information retention among participants.

2.3 Core Training Phase (Halal Detection Application)

This phase is the core of the webinar, where the focus shifts to practical demonstrations and the application of technology in halal detection. Presentation of Contaminant Detection Scenarios: Speakers will present realistic case scenarios for contaminant detection in halal products. For example, a scenario might focus on identifying the presence of porcine gelatin in processed products. This scenario will cover the complete stages from sample collection, the use of optical or electronic sensor technology, to

the process of interpreting the resulting data with the help of AI. A scenariobased approach helps participants understand real-world challenges and how technology can overcome them.

Discussion on Sensor and AI Applications (Virtual): Speakers will explain how relevant sensor technologies, such as e-noses or Surface Plasmon Resonance (SPR) optical sensors, work in detecting contaminants. After data is generated from sensor simulations, it will be explained in detail how this data is analyzed by artificial intelligence systems, including deep learning algorithms, to identify contaminants and provide highly accurate results. E-noses are very effective for fraud detection. Modified QCM sensors can quickly differentiate between porcine and bovine gelatin[6]. The discussion session will be wide open for participant questions and the exchange of views on the potential and challenges of practical applications of this technology across various industries. The high accuracy (median 0.981) of deep learning-based e-nose systems in detecting porcine gelatin underscores the reliability of AI in this application.

2.4 Evaluation Phase

Evaluation is a crucial component for measuring the webinar's effectiveness and the extent of improvement in participant understanding. This process is conducted quantitatively by comparing the results of pre-tests and post-tests filled out by participants before and after the webinar activity. Quantitative Measurement (Pre-test and Post-test): Participant understanding is measured by providing a series of questions relevant to the webinar material. Pre-test results, taken before the material delivery, are compared with post-tests conducted after all material sessions and discussions are complete. This score comparison directly measures the increase in participant knowledge as a result of the webinar. Success Indicators: The success of the training is assessed based on the increase in participants' average scores and their ability to answer key questions related to:

a. Basic concepts and the impact of contaminants in halal products.
b. Working principles and contributions of sensor technology (optical and electronic) in halal detection.
c. The strategic role of artificial intelligence (deep learning) in improving the accuracy, speed, and efficiency of halal contaminant detection.
d. The ability to interpret simple results from contaminant detection processes demonstrated during the webinar.

3. RESULTS AND DISCUSSION

The "Halal Webinar: Halal Detection Training Using AI and Smart Sensors" successfully led to a significant increase in participants' understanding regarding the importance of halal detection and the application of modern technology in ensuring halal product integrity. This virtually conducted webinar achieved its objective of equipping the audience with up-to-date knowledge on the role of artificial intelligence (AI) and smart sensors in verifying product halal status.

3.1 Webinar Execution

The "Halal Webinar: Halal Detection Training Using AI: BRIN's Breakthrough with Smart Sensors" was successfully held virtually on Friday, July 18, 2025, following the schedule outlined in the table below:

Table 1. Event Rundown

Activity	Time	PIC
Preparation	13:20 – 13:25 WIB	Committee
Welcome remarks from committee/PIC	13:25 – 13:35 WIB	MC
Brief introduction of speakers	13:35 – 13:45 WIB	MC
Speaker 1	13:45-14:00 WIB	Speaker
Speaker 2	14:00-14:15 WIB	Speaker
Speaker 3	14:15-14:30 WIB	Speaker
Speaker 4	14:30-14:45 WIB	Speaker
Discussion forum or Q&A	14:45-15:00 WIB	Participants
Closing	15:00-15:10 WIB	MC

The execution of this webinar took place virtually, starting with technical preparations to ensure smooth broadcasting and interaction between participants and speakers. After the opening remarks and brief introductions, the core material presentation sessions began, featuring four expert speakers who systematically delivered key information on halal detection. Topics covered included an introduction to halal contamination challenges, conventional detection methods, the potential of smart optical and electronic sensors, and the integration of artificial intelligence (deep learning) in enhancing contaminant identification accuracy. An interactive session in the form of a discussion forum and Q&A was a crucial part, allowing participants to directly interact with experts for clarification and deeper understanding of the material. The entire series of activities ran efficiently and concluded on schedule, marking the successful implementation of the webinar in delivering upto-date information on innovations in halal detection.

3.2 Evaluation of Activity Results

The effectiveness of the webinar activity was quantitatively measured by comparing the results of the pre-test, completed by participants before the event, and the post-test, completed after the event concluded. This evaluation aimed to measure the impact of the material delivery on participants' knowledge levels. Overall, the evaluation results showed a positive increase in understanding. This was reflected in the rise of participants' average scores from 93.09 in the pre-test to 95.45 in the post-test. This improvement is visually illustrated in Figure 2:

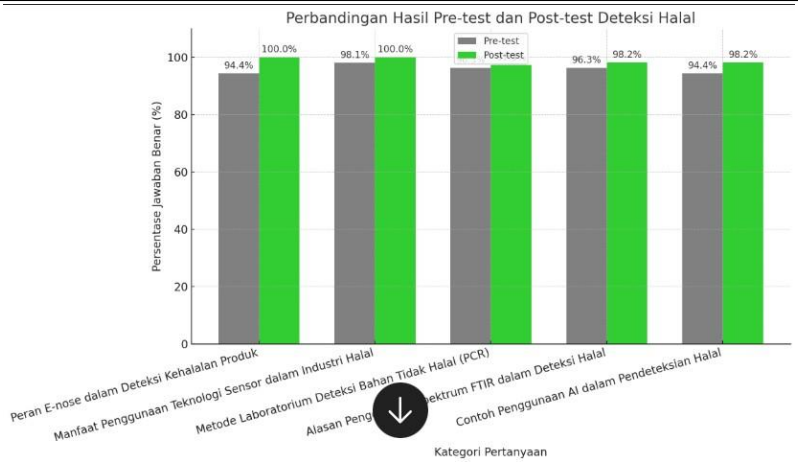


Figure 2. Comparison of pre-test and post-test results

To conduct a more in-depth analysis, the level of participant understanding for five key questions, sourced from the main material, was identified. These five questions covered conceptual to technical aspects of halal detection using AI. The pre-test and post-test analysis results from a total of 108 respondents (for the pre-test) and 111 respondents (for the post-test) are presented in Table 2 and Table 3, and further discussed in the discussion section:

Table 2. Pre-test Answers

No	Question	Correct Answer	Number of Correct Answers	Correct Percentage
1	What material often poses a challenge in halal detection due to its animal origin?	Gelatin	107 / 108	99.10%
2	One advantage of using AI in halal detection is…	Fast and accurate process	94 / 108	87.00%
3	In AI systems for halal detection, the preprocessing stage usually includes...	Data filtering, normalization, and noise removal	101 / 108	93.50%
4	What is the purpose of material classification with AI technology in the halal context?	Determining the halal or haram status of a material	103 / 108	95.40%
5	One AI method used to differentiate porcine and bovine gelatin is...	CNN (Convolutional Neural Network)	77 / 108	71.30%

Table 3. Post-test Answers

No	Question	Correct Answer	Number of Correct Answers	Correct Percentage
1	What laboratory method is commonly used for detecting non-halal ingredients?	Polymerase Chain Reaction (PCR)	108 / 111	97.30%
2	One benefit of using sensor technology in the halal industry is...	Rapid identification of microingredients in food	111 / 111	100%

3	What is the role of "E-nose" in detecting the halal status of products?	Detecting specific odors for material identification	111 / 111	100%
4	Why is the use of FTIR (Fourier Transform Infrared) spectrum suitable for halal detection?	Because it can specifically identify organic compounds	109 / 111	98.20%
5	Examples of AI use in halal detection include...	Classifying products based on spectrum	102 / 108	94.40%

3.3 Discussion

The evaluation data provides several important insights into the enhanced understanding of webinar participants. The high initial scores on general questions, such as the challenges of gelatin (99.1% on the pre-test), indicate that participants already possessed a strong basic awareness of halal issues and the role of technology in general. However, the most notable finding from the pre-test data was a knowledge gap in more technical aspects. The question regarding a specific AI method, namely CNN (Convolutional Neural Network), was only understood by 71.3% of participants (pretest). This figure was the lowest compared to other questions, indicating that participants' understanding was still limited to general AI concepts, not its technical implementation.

A comparison with the post-test results clearly demonstrates the webinar's effectiveness in bridging this knowledge gap. The increase in the average score on the post-test (from 93.09 to 95.45, as shown in Figure 2) strongly indicates that the detailed, case study-based material successfully improved participants' overall understanding. More specifically, on the post-test, questions regarding "One benefit of using sensor technology in the halal industry is" and "What is the role of 'E-nose' in detecting the halal status of products?" achieved 100% correct answers, showing a highly effective transfer of knowledge in these areas. Similarly, the question about "What laboratory method is commonly used for detecting non-halal ingredients?" achieved 97.3% correct answers, and "Why is the use of FTIR spectrum suitable for halal detection?" achieved 98.2% correct answers.

Although a specific question about CNN was not explicitly present in the provided post-test, the overall improved understanding of AI's benefits ("Classifying products based on spectrum" with 94.4% correct on the post-test) indicates that the material on AI and machine learning implementation was well absorbed. In her presentation, Prof. Dr. Rifda Naufalin specifically discussed the example of detecting porcine gelatin using FTIR/NIR spectra, with the data classified by machine learning methods like SVM (Support Vector Machine) and CNN. She also emphasized that these methods can differentiate gelatin from porcine, bovine, or fish sources with an accuracy of 90-98%. This webinar proved not only to refresh participants' general knowledge but also to be effective in transferring specific and in-depth technical knowledge, including the relevance of AI in spectrum classification for halal detection. Thus, this community service activity successfully achieved its goal of increasing public literacy regarding the utilization of advanced technology within the halal ecosystem.

3.4 Dokumentation



Figure 3. Speaker 1

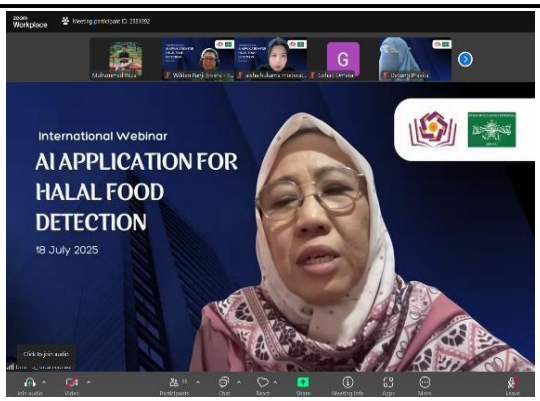


Figure 4. Speaker 2



Figure 5. Speaker 3



Figure 6. Speaker4

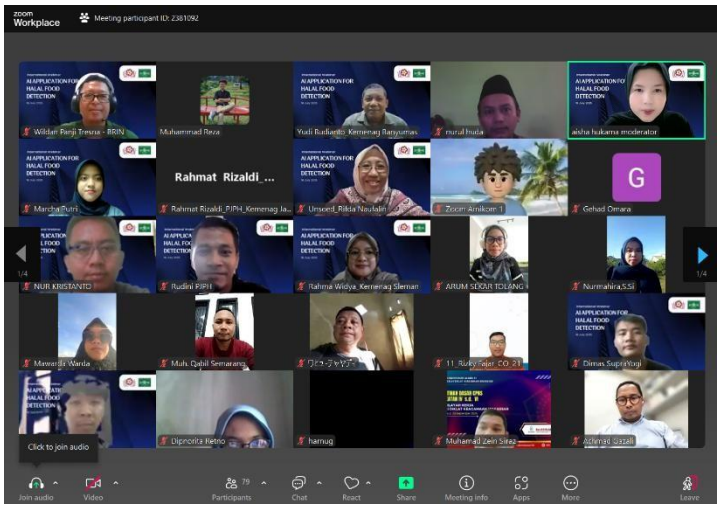


Figure 7. Participant

4. CONCLUSION

The webinar "Halal Detection Using AI: BRIN's Breakthrough with Smart Sensors" successfully affirmed that the halal supply chain is a strategic economic sector that requires continuous scientific and technological innovation. This training demonstrated that the development of contaminant

detection, such as for gelatin, is crucial, given that smart optical and electronic sensors, supported by AI, possess ultra-sensitive capabilities in identifying concentration differences below 1%. The significant increase in participant understanding achieved through this webinar underscores the effectiveness of a technology-based educational approach. This innovation is fundamental for maintaining the integrity of halal products in the global market, strengthening consumer trust, and positioning Indonesia as a leader in halal technology.

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