Indonesian Journal of Electrical Engineering and Computer Science
Vol. 39, No. 2, August 2025, pp. 1280~1298
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v39.i2.pp1280-1298

Technology in halal certification: a ten-year bibliometric study

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Article Info

Article history:

Received Jan 12, 2025
Revised Mar 25, 2025
Accepted Jul 2, 2025

Keywords:

Bibliometric
Halal certification
Scopus database
Technology
VOSviewer

ABSTRACT

This study explores the role of technology in halal certification using bibliometric analysis. Based on 88 articles from the Scopus database (2014–2024), the research employs tools like Publish or Perish (PoP), Microsoft Excel, and VOSviewer to reveal the intellectual framework of relevant literature. The finding indicates a steady increase in manuscript productivity from 2014-2024 despite a declining citation trend. Journal of Islamic Marketing, Mohd Zabiedy Mohd Sulaiman, Malaysia, and the National Defence of Malaysia emerged as most prolific journal, author, country, and institution that produce the most, respectively, in publishing on the topic. The paper that has influenced other research the most is Rejeb et al.'s integrating the IoT in the halal food supply chain: a systematic literature review and research agenda. Five significant keyword clusters that frequently show up in the 88 articles examined in this study are halal supply chain, consumer behavior towards halal foods, the role of blockchain in the halal industry, the role of information technology in halal cosmetics, and halal logo in food products. This study highlights the increasing integration of technology in halal certification, emphasizing the need for continuous innovation, interdisciplinary collaboration, and alignment with industry demands to maintain relevance. Additionally, it underscores Malaysia's leadership in this field while noting the global expansion of halal research, the impact of emerging technologies like blockchain and IoT, and the need for stronger institutional collaboration to enhance transparency, traceability, and market growth.

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1. INTRODUCTION

The halal industry holds significant potential as a source of inclusive and sustainable economic growth through the development and expansion of the halal economy [1]. This potential is supported by shifting consumer trends, where halal products and services are increasingly perceived as the primary choice due to their association with high quality, cleanliness, hygiene, purity, and ethical production processes [2], [3]. This is evidenced by the growing demand for halal products and services among consumers year after year. According to the latest data released by Dinar Standard in 2023 [4], Muslim consumers, numbering approximately 2 billion globally, spent a total of US$2.29 trillion in 2022 across six economic sectors: halal food (US$1.4 trillion), halal fashion (US$318 billion), halal media and recreation (US$247 billion), halal

tourism (US$133 billion), halal pharmaceuticals (US$108 billion), and halal cosmetics (US$84 million). The increasing demand for halal products and services underscores the importance of measuring and managing halal standards within institutions or organizations [5], [6]. These standards serve as a reference for producers and providers of halal products and services to ensure compliance with halal principles [7], [8]. Consequently, regulations are needed to enhance the performance of halal product and service production while safeguarding consumer rights to access guaranteed halal products and services [9].

Halal certification or labeling is a mark issued by an authorized body in a given country, ensuring that the preparation, ingredients, production, packaging, storage, and distribution of a product comply with Shariah law [10]. The issue of halal certification and labeling is not only a concern for Muslim-majority countries but has also become a critical aspect of international trade systems. In the context of free-market systems, halal certification has emerged as a strategy to protect consumers and address globalization challenges within regional frameworks such as ASEAN-AFTA, NAFTA, the European Economic Community, and global organizations like the World Trade Organization (WTO) [11]. Possessing halal certification provides a competitive advantage for products and services compared to uncertified alternatives [12]. From a business perspective, halal certification offers differentiation that enhances consumer perceptions of product quality [13]. Additionally, halal certification enables businesses to expand their market reach, particularly in the growing muslim market, by participating in free trade and accessing international markets [14].

However, obtaining halal certification also presents challenges, particularly for businesses. One of the primary challenges is the high cost of certification and the complexity of the certification process [15]. The halal certification process involves extensive procedures, starting from the upstream stage (e.g., raw material production by farmers), raw material processing (processing industry), packaging, storage, and distribution to consumers [16]. Testing the primary ingredients used and monitoring the production process, especially for chemical-based products and imported goods, also requires specialized facilities and laboratories [17]. Therefore, governments and halal certification bodies must provide adequate support and facilitation for businesses seeking halal certification. One of the efforts by governments and halal certification bodies to simplify the certification process for businesses is through the utilization of technology. Several studies have identified the role of technology in halal certification, such as improving transparency in the halal certification process and traceability in the halal supply chain [18], reducing costs through process efficiency [19], utilizing digital media for halal certification applications [20], and leveraging digital platforms and marketplaces as marketing channels for halal products and services [21].

The current trajectory of the halal industry is particularly intriguing for practitioners and academics seeking to deepen their understanding, especially regarding the implementation of halal certification. Various studies have demonstrated a correlation between technology and halal certification. However, bibliometric studies focusing on halal certification remain scarce. To date, only one bibliometric study on halal certification has been identified, conducted by Binti Masood in 2022 [22]. However, this study addressed halal certification in general without exploring its integration with technology. Researchers have identified a gap in literature, as no comprehensive studies have examined the role of technology towards halal certification. Therefore, this study aims to be the first to map the topic of technology and halal certification using a bibliometric approach.

This study seeks to comprehensively examine the role of technology towards halal certification. An in-depth analysis of the utilization of technology in halal certification will provide valuable insights and ideas for academics and practitioners to improve the quality of halal certification for businesses and consumers in the future. This research employs bibliometric analysis on scientific papers published globally, focusing on the role of technology towards halal certification. The data query includes keywords, geographic regions, study topics, and methodologies. The objective of this study is to provide valuable knowledge and understanding of the rapid adoption of technology in halal certification across various countries. Gaining a comprehensive understanding of previous research, identifying research gaps, and assessing the level of technological integration in halal certification within the current literature are crucial for offering insights and recommendations for the future development of the halal industry. Therefore, this study aims to address the following research questions:

- RQ1: How is the development of research related to the theme of "The role of technology towards halal certification" in the world?
- RQ2: Who are the authors, organizations, and countries that write and publish the most journal articles related to the theme of "The role of technology towards halal certification" in the world?
- RQ3: What are the main areas of focus of research on the topic of "The role of technology towards halal certification" in the world?

A bibliometric analysis is conducted on all metadata pertaining to "The role of technology towards halal certification", sourced from the Scopus database, in order to obtain a thorough overview of the topic's evolution over time. Scholars have extensively employed bibliometric analysis to examine the findings of prior research by gathering metadata from the Scopus database. The metadata findings are subsequently analyzed to obtain a comprehensive summary of prior publications and identify areas of research that future scholars may explore. Furthermore, the outcomes of bibliometric analysis will offer extensive knowledge and analysis for scholars and professionals in the advancement of "The role of technology towards halal certification" topic in the next years. By reviewing previous studies, this research can identify areas that have received limited attention in technology-based halal certification research. This is crucial for academics and practitioners to develop new innovations and ensure that the applied technology effectively meets the needs of the halal industry. The findings of this study not only serve as an academic mapping but also provide recommendations for key stakeholders in the halal industry. By understanding the level of technology adoption in halal certification, this research can offer strategic insights for governments, certification bodies, and businesses to optimize the use of technology in enhancing the overall quality of halal certification globall. Overall, this study serves as a guide for understanding the evolving dynamics of technology-driven halal certification, offering a broader perspective for academics, industry players, and regulators in ensuring the reliability and effectiveness of the halal certification system in the future.

2. METHOD

The study utilizes a literature-based system mapping research (SMR) approach, specifically employing bibliometric analysis. The bibliometric study of coupling, co-citation, and direct citation is often regarded as the most dependable and precise method for mapping research literature. Furthermore, SMR has the capability to group and visually represent interrelated contributions and networks of contributors. In this study, a bibliometric approach was used by combining quantitative and qualitative analysis to provide a more holistic picture of trends and patterns in the literature. Quantitative analysis was used to analyze the number of publications, citations, and author collaborations. While qualitative analysis was used to analyze the content of the publications to identify key themes, concepts, and issues discussed including analysis derived from keywords, titles, and abstracts.

The inclusive criteria for manuscript selection in this study were based on two key aspects to ensure the validity and relevance of the data. First, the selected manuscript had to be directly related to the issues being examined, which was determined through their titles, descriptions, or content. To ensure accuracy in selection, keyword choice played a crucial role, where researchers employed Boolean search techniques (e.g., AND, OR, NOT) to enable a more structured and precise search aligned with the research keywords [23]. Second, in this study, bibliometric data pertaining to the literature on "The role of technology towards halal certification" was obtained from the Scopus database. In academic research, the Scopus database is widely acknowledged as the most prominent and longstanding citation database. Its scholarly publications have provided extensive coverage, including all leading journals since 1966 [24]. Thus, this study focuses on bibliographic information on "The role of technology towards halal certification" obtained from the Scopus database. The articles were searched using the Scopus database in December 2024. In this study, the researchers focused exclusively on publications published from 2014 to December 2024, as earlier publications indexed by Scopus have not adequately addressed the role of technology towards halal certification discussions.

88 documents related to "The role of technology towards halal certification" appeared. Then, after filtering by language (English). The articles were then analysed using VOSviewer, which was developed by Van Eck and Waltman [25]. VOSviewer is capable of generating maps through suitable mapping techniques [26]. Consequently, this software can be utilized not only for displaying maps created with VOS mapping methods but also for those constructed using techniques like multidimensional scaling. Additionally, VOSviewer is compatible with a wide range of hardware and operating systems and can be launched directly from the internet. In addition, researchers also used Publish or Perish and Microsoft Excel to analyse the sources of information needed. Overall, the flow of the search strategy diagram and the database filtering process used was shown in Figure 1.

3. RESULTS AND DISCUSSION

3.1. Data statistics

Statistical data is utilized to address RQ1 by observe trends and differences in the number of articles published each year, as well as to determine whether there has been an increase or decrease in publications compared to previous years. Figure 1 presents statistical data illustrating the fluctuating trend of interest and

attention among researchers, academics, and experts in examining the "role of technology in halal certification." For instance, Figure 2 explains that research on this topic began in 2014, with no significant developments in the following year, as researchers produced only one publication in 2015. However, this number increased in 2016, with four publications addressing the topic of "The role of technology towards halal certification," resulting in a significant rise in citations, totaling 122. Nevertheless, a decline in the trend occurred in 2017, during which only two publications on "The role of technology in halal certification" were produced, yielding a total of four citations. The highest increase in publication numbers occurred in 2024, with 17 publications released in Scopus-indexed journals. Meanwhile, the highest citation increase was observed in 2018, with a total of 138 citations that year. A downward trend in citations continued in 2022, 2023, and 2024, with the peak decline occurring in 2024, where only 23 citations were recorded. Overall, over the past decade, there has been a trend of increasing publications on the topic of "The role of technology towards halal certification," albeit accompanied by a declining trend in citation numbers, particularly in 2022, 2023, and 2024.

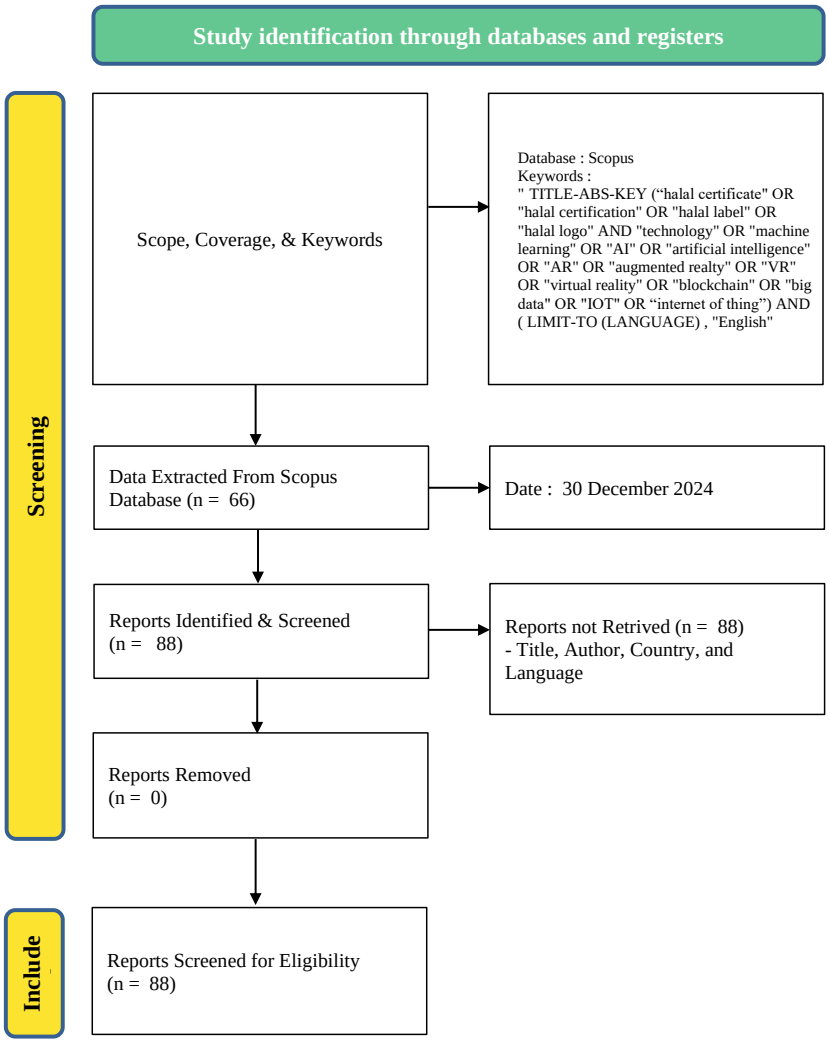

Figure 1. Flow diagram of search strategy

This study also identifies the types of manuscripts to understand research trends in the topic of "The role of technology towards halal certification" based on manuscript type. Among the total of 88 documents utilized in this research, articles dominate with 30 documents (see Figure 3). This is followed by conference papers, which account for 17 documents. Manuscripts in the form of book chapters on the topic of "The role of technology towards halal certification" are also prevalent, totaling 12 documents. Additionally, there are 6 review manuscripts and 3 conference reviews. A small number of manuscripts in the form of books discussing the topic of "The role of technology towards halal certification" amounts to one book.

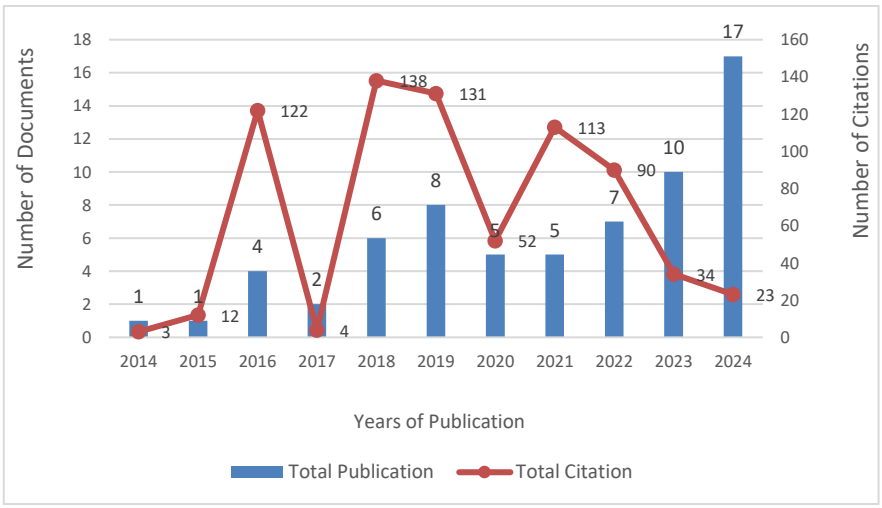

Figure 2. Number of scopus indexed documents from 2014-2024

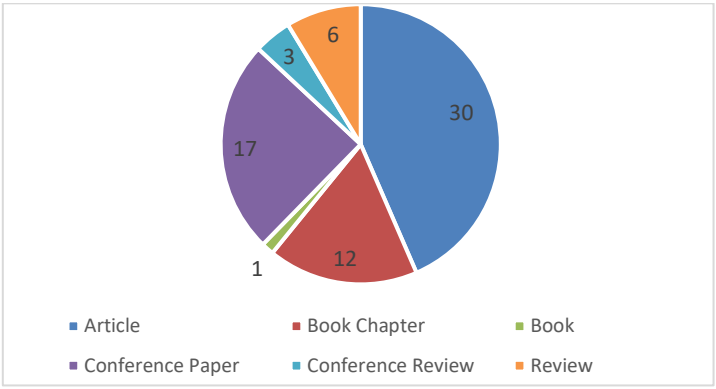

Figure 3. Number of scopus indexed documents from 2014-2024

3.1.1. What lesson can be learned?

The statistical data results provide several key insights and valuable lessons. First, although there is an increasing trend in publications on the role of technology in halal certification, the fluctuation in citation numbers indicates that not all studies achieve sustained academic impact. The peak in citations in 2018 suggests that high-quality and innovative research attracts greater attention, whereas the decline in citations in recent years may indicate topic saturation, a lack of novel contributions, or ineffective dissemination efforts. Second, the dominance of journal articles and conference papers among manuscript types indicates that this topic is actively discussed within academic and professional circles. However, the limited number of books and review articles suggests a gap in comprehensive theoretical or practical overviews. This presents an opportunity for researchers to focus more on producing high-impact literature reviews and books that consolidate knowledge in this field. Finally, the declining citation trend from 2022 to 2024 highlights the need for researchers to ensure that their studies remain relevant and widely referenced. The halal industry involves multiple stakeholders from various disciplines [27]. Therefore, interdisciplinary collaboration and aligning research with industry needs are expected to enhance both the quantity and quality of research on this topic.

3.2. Bibliometric analysis

At the bibliometric analysis stage, the Scopus database was comprehensively examined to identify and assess various correlations relevant to this study. This analysis includes identifying the most productive journals, the most influential authors, the most cited manuscripts, the most productive countries and institutions, as well as the co-occurrence network of keywords to address RQ2. The findings from each of these aspects will be discussed in detail in the following sub-sections, aiming to provide a deeper understanding of research trends and technological advancements in halal certification.

3.2.1. Most productive journals

For the bibliometric analysis of 88 Scopus-indexed papers on "The role of technology towards halal certification," we examined the correlation between articles by assessing the frequency of other articles referencing other articles in the field of halal certification studies using particular keywords. By loading files into the VOSviewer software, researchers can obtain answers to their inquiries. The available features include the ability to get results from authors, organizations, nations, multiple citations, and keywords between individual words in order to visually represent data findings. Moreover, it can also identify deficiencies, underexplored research, and often conducted research. Furthermore, the researcher examined the author's association with an organization that had an impact on the study of "The role of technology towards halal certification." The study findings indicate the participation of organizations in many countries, particularly universities, that focus on study on "The role of technology towards halal certification."

Furthermore, the results of this study allow researchers to explore the research flow related to "The role of technology towards halal certification." First, the results found the most contributing journals, which can be seen in Table 1. To find the most productive journals in this study, a collection of articles obtained from the Scopus database is extracted. Then, the researcher displays the results of VOSviewer processing according to the following Table 1. Table 1 shows ten journals that contribute the most in publishing articles that discuss the topic of "The role of technology towards halal certification." Furthermore, the results show that the Journal of Islamic Marketing is the journal that contributes the most to publishing research articles related to "The role of technology towards halal certification," with a total number of manuscripts, 5 documents, and a total citation of 82. The number of papers in the Journal of Islamic Marketing related to "The role of technology towards halal certification" is very high compared to other Scopus-indexed journals. As is known, the Journal of Islamic Marketing has the second highest H-Index, which is 55, with the current position in Quartile 1 in the Scopus database. In the second position, there is a book published by Springer Nature titled "Emerging Technology and Crisis Management in the Halal Industry: Issues and Recent Developments," which includes five manuscripts addressing the topic of "The role of technology in halal certification." The IOP Conference Series: Earth and Environmental Science ranks third, having produced three manuscripts with a total of two citations. Overall, Table 1 illustrates that, on average, the publishers of manuscripts discussing the topic of "The role of technology in halal certification" are not dominated solely by journals; rather, there are numerous conference proceedings and books that explore this topic. Interestingly, the publishers of manuscripts on this subject are predominantly sources with a scientific scope focused on technology and supply chain management. This indicates that the topic of halal certification is no longer solely dominated by discussions surrounding Islamic law or Islamic economics but has garnered significant interest from researchers across various disciplines.

Table 1. Most productive journals/books/proceeding for "The role of technology towards halal certification" topic (2014-2024)

Journal	Publisher/Country	Quartile	H-Index	Number of documents	Number of citations
Journal of Islamic Marketing	Emerald Group Publishing Ltd./United Kingdom	Quartile 1	55	5	82
Emerging Technology and Crisis Management in The Halal Industry: Issues and Recent Developments	Springer Nature/Singapore	Not assigned quartile	-	5	1
IOP Conference Series: Earth and Environmental Science	IOP Publishing Ltd./United Kingdom	Not assigned quartile	48	3	2
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	Springer/Germany	Not assigned quartile	-	2	24
International Journal on Informatics Visualization	Politeknik Negeri Padang/Indonesia	Quartile 3	15	2	6
Innovation of Food Products in Halal Supply Chain Worldwide	Elsevier Inc./Netherlands	Not assigned quartile	-	2	5
Communications in Computer and Information Science	Springer Science and Business Media Deutschland GmbH/Germany	Quartile 4	69	2	1
Halal Logistics and Supply Chain Management: Recent Trends and Issues	Taylor & Francis/United Kingdom	Not assigned quartile	-	2	1
Journal of Applied Engineering and Technological Science	Yayasan Riset dan Publikasi Intelektual (YRPI)/Indonesia	Quartile 4	8	2	0
Malaysian Journal of Consumer and Family Economics	Malaysian Consumer and Family Economics Association/Malaysia	Quartile 4	8	1	10

- What lesson can be learned?

The results of this bibliometric analysis provide several important insights. First, this study highlights that research on halal certification is not only limited to Islamic law or Islamic economics but has expanded into interdisciplinary domains such as technology and supply chain management. This is evident from the top 10 journals publishing manuscripts on this topic, which encompass a multidisciplinary research scope, including information technology, environmental science, computer science, and applied engineering. This shift indicates the increasing recognition of the technological aspects of halal certification, reflecting a broader and more integrated research approach. Second, the identification of journals with the most significant contributions, particularly the Journal of Islamic Marketing, suggests that in the context of technology adoption in halal certification processes, marketing elements play a crucial role for researchers. For some communities, halal certification remains a relatively new concept, which may result in a lack of knowledge and low awareness, particularly regarding the role and benefits of halal certification [28]. In this regard, technology plays a vital role in enhancing public understanding of the importance of halal certification in ensuring the halal integrity of consumable products [29]. Based on these findings, researchers focusing on this topic should consider targeting reputable journals in relevant disciplines to enhance academic visibility and citation potential. Additionally, the presence of books and conference proceedings alongside journal articles indicates that knowledge dissemination in this field occurs through various academic channels, providing broader opportunities for researchers to publish and share their findings.

3.2.2. Most productive authors

A bibliometric mapping of authors was obtained using VOSviewer software, as depicted in Figure 4 and Table 2. This visualisation depicts the distribution of academics' productivity in carrying out research on the subject of "The role of technology towards halal certification." The findings presented in Table 2 provide valuable insights into the list of the most productive authors who have contributed manuscripts on the topic of "The role of technology towards halal certification." The results reveal an interesting trend, where the top 10 rankings of authors researching this topic are predominantly dominated by scholars from Malaysia. Mohd Zabiedy Mohd Sulaiman from Universiti Teknologi MARA (UiTM), Malaysia, emerges as the most productive scholar, with a total of five documents and 12 citations. Following him, three scholars affiliated with the same institution-Nurulhuda Noordin, Ahmad Iqbal Hakim Suhaimi, and Wan Abdul Rahim Wan Mohd Isa-have collectively published four documents with seven citations. In addition to Universiti Teknologi MARA, other scholars from Universiti Malaysia Sabah, Universiti Malaysia Pahang, and Universiti Malaysia Terengganu have also contributed research documents on the topic of "The role of technology towards halal certification." On the other hand, Figure 3 illustrates that the visual manifestation of cluster density is represented by the size of the circles corresponding to each author. These findings suggest that focusing on significant areas for analysis provides a valuable overview of the overall structure of the bibliometric map. From Figure 3, it is possible to identify the authors who have published the highest number of papers, as each researcher typically demonstrates distinct strengths. The index categorizes authors as either sole authors or co-authors collaborating with additional researchers, resulting in the formation of multiple clusters with varying densities. Nevertheless, authors with relatively high-density clusters indicate that they have produced a greater volume of research on the topic of "The role of technology towards halal certification" compared to authors with lower-density clusters. This finding highlight that the results of these studies can serve as a valuable reference for future researchers. Statistically, there is a positive correlation between the size of an author's name and the number of publications they have produced. The most frequently published works on the topic of "The role of technology towards halal certification" are authored by Mohd Zabiedy Mohd Sulaiman and Nurulhuda Noordin.

Table 2. Most productive authors for "The role of technology towards halal certification" topic (2014-2024)

Author	Affiliation	Number of Document	Number of Citations
Mohd Zabiedy Mohd Sulaiman	Universiti Teknologi MARA, Malaysia	5	12
Nurulhuda Noordin	Universiti Teknologi MARA, Malaysia	4	7
Ahmad Iqbal Hakim Suhaimi	Universiti Teknologi MARA, Malaysia	4	7
Wan Abdul Rahim Wan Mohd Isa	Universiti Teknologi MARA, Malaysia	4	7
Baharudin Othman	Universiti Malaysia Sabah, Malaysia	2	68
Sharifudin Md Shaarani	Universiti Malaysia Sabah, Malaysia	2	68
Arsiah Bahron	Universiti Malaysia Sabah, Malaysia	2	68
Yudi Fernando	Universiti Malaysia Pahang, Malaysia	2	26
Abdul Hafaz Ngah	Universiti Malaysia Trengganu, Malaysia	2	24
Aishah Bujang	Universiti Teknologi MARA, Malaysia	2	12

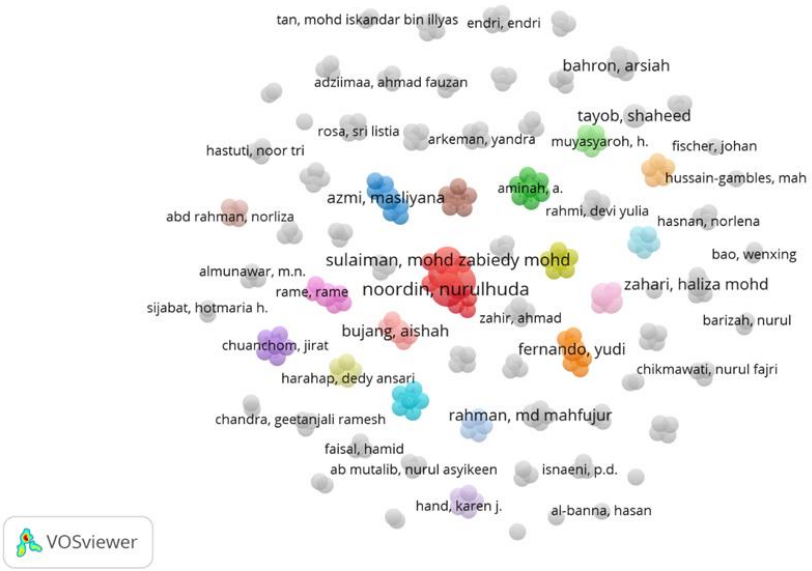

Figure 4. Bibliometric author mapping

- What lesson can be learned?

Several key insights can be drawn from these findings. First, bibliometric mapping indicates that research on "The role of technology in halal certification" is predominantly conducted by academics from Malaysia, particularly those affiliated with Universiti Teknologi MARA (UiTM) and other Malaysian institutions. This suggests that Malaysia plays a leading role in the development of research in this field, likely due to its strong focus on the halal industry and its certification processes. These findings align with the 2024 Dinar Standard report, which ranked Malaysia as the top-performing country in the halal industry based on the Global Islamic Economy Indicator (GIEI), with a total score of 193.2 [4]. Furthermore, the dominance of Malaysian academics in this research area highlights the country's proactive efforts in integrating technological advancements into the halal certification process. This demonstrates that Malaysia is not only a key player in the global halal industry but also a major contributor to academic discourse on the subject. At the same time, it underscores the importance of fostering cross-disciplinary and inter-institutional collaborations to accelerate the dissemination of knowledge and information, particularly regarding technological advancements in halal certification that have been implemented in Malaysia, to other countries.

3.2.3. Most cited manuscripts

Next, Table 3 shows the research titles that have the greatest influence and contribute to research on the topic of "The role of technology towards halal certification". The manuscript with the title "Integrating the IoT in the halal food supply chain: a systematic literature review and research agenda" written by Abderahman Rejeb Karim Rejeb, Suhaiza Zailani, Horst Treiblmaier, Karen J. Hand. is the manuscript that has the greatest influence on the topic of "The role of technology towards halal certification." The manuscript was successfully cited by 97 other documents with a ratio of 24.6 citations per year. In the second rank, the manuscript titled "Rational and practical aspects of halal and tayyib in the context of food safety," authored by Jawad Alzeer, Ulrike Rieder, and Khaled Abou Hadeed in 2018, has achieved a total of 85 citations. Following closely in third place is the most recently published manuscript among the top 10 most cited manuscripts. This manuscript, titled "Halal food sustainability between certification and blockchain: a Review," was authored by Christian Bux, Erica Varese, Vera Amicarelli, and Mariarosaria Lombardi in 2022, and it has garnered 50 citations from other documents.

- What lesson can be learned?

Several important lessons can be drawn from these findings. First, the most influential research on "The role of technology towards halal certification" tends to focus on emerging technological advancements, such as the IoT and blockchain, in relation to halal supply chains and food safety. The high citation count of the manuscript "Integrating the internet of things in the halal food supply chain: a systematic literature review and research agenda" indicates strong academic interest in leveraging technology to enhance the halal certification process. This suggests that interdisciplinary research integrating technology and halal certification has significant academic impact and practical relevance. Second, the ranking of highly cited manuscripts reveals that studies addressing both theoretical and practical aspects of halal and tayyib principles-such as "Rational and practical aspects of halal and tayyib in the context of food safety" also

receive substantial recognition. This highlights the importance of a holistic approach that goes beyond certification and considers broader food safety and sustainability aspects. Lastly, the inclusion of a relatively recent manuscript, "Halal food sustainability between certification and blockchain: a review", among the top three most cited papers within just two years of publication demonstrates the increasing relevance of blockchain technology in halal certification. This suggests that researchers should continue to explore innovative technologies that can enhance transparency, traceability, and efficiency in halal supply chains. Overall, these findings emphasize the growing intersection of technology and halal studies, presenting opportunities for further research in blockchain, IoT, and other digital solutions for improving halal certification systems.

Table 3. Most cited manuscript for "The role of technology towards halal certification" Topic (2014-2024)

Title	Number of citations	Author	Years	Citation per year
Integrating the IoT in the halal food supply chain: a systematic literature review and research agenda [19]	97	Abderahman Rejeb Karim Rejeb, Suhaiza Zailani, Horst Treiblmaier, Karen J. Hand	2021	24.6
Rational and practical aspects of Halal and Tayyib in the context of food safety	85	Jawad Alzeer, Ulrike Rieder, Khaled Abou Hadeed,	2018	12.1
Halal food sustainability between certification and blockchain: a review [30]	50	Christian Bux, Erica Varese, Vera Amicarelli, Mariarosaria Lombardi,	2022	16.7
Online traceability for halal product information: perceptions of Muslim consumers in Indonesia [31]	48	Djoko Sigit Sayogo	2018	6.9
Evaluation of knowledge, halal quality assurance practices and commitment among food industries in Malaysia [32]	38	Baharudin Othman Sharifudin Md Shaarani, Arsiah Bahron	2016	4.2
Manufacturing halal in Malaysia [33]	34	Johan Fischer	2016	3.8
The potential of ASEAN in halal certification implementation: A review [34]	30	Baharudin Othman, Sharifudin Md Shaarani, Arsiah Bahron	2016	3.3
The application of blockchain for halal product assurance: a systematic review of the current developments and future directions [35]	20	Norliza Katuk	2019	3.3
An investigation of adoption intention of halal traceability system among food SMEs [36]	14	Nitty Hirawaty Kamarulzaman, Nur Aminin Muhamad, Nolila Mohd Nawi	2022	4.7
Identifying the influence of the Halal logo on Muslim consumers' attitudes using fMRI technology [37]	13	Osama Sam Al-Kwifi, Hamid Mahmood Hamid Gelaidan, Abdulla Hamad M. A. Fetais	2020	3.3

3.2.4. Most productive countries

Moreover, the bibliometric data of journal sources below (see Figure 4 and Table 4) demonstrates the visualization of journal publisher mapping. From the diagram, it is evident that there are multiple groups of countries that have the highest number of publications focusing on the topic of "The role of technology towards halal certification". Figure above demonstrates that a larger circle of the publishing country corresponds to a higher number of papers published by that country. It is evident that Indonesia possesses the greatest circle. This indicates that Indonesia has the highest number of publications focused on the topic of "The role of technology towards halal certification" in comparison to other countries.

In the following step of the analysis, the geographical distribution of authors and countries where papers were created was taken into consideration. When compared to the results of the VOSviewer output shown in Figure 3, the findings of the analysis that are presented in Figure 5 and Table 4 are complementary. On the basis of Table 4, it is known that the country that generates the most research on the subject of "The role of technology towards halal certification" is Malaysia, with 42 documents and 415 citations. Indonesia is ranked third with total 33 documents with 168 citations. A notable difference is in the third rank where India is ranked with a total of 3 documents. This is followed by Australia, Brunei Darussalam, United States of America, Germany, and Pakistan, which has 2 documents. There are a number of countries that are located on different continents, however Indonesia and Malaysia are both located on the Asian continent, specifically Southeast Asia. The position of Malaysia and Indonesia which are ranked first and second shows linearity with the performance of the halal industry in each of these countries where according to the GIEI Index compiled by Dinar Standard in 2023, Malaysia and Indonesia are ranked first and third. It is interesting to note that there are countries, such as the Australia, United States of America, Germany, and Canada in which the majority of the population does not consist of Muslims. On the other hand, these four nations are among

the top ten countries in the world that have conducted the most research on the topic of "The role of technology towards halal certification" in the modern age.

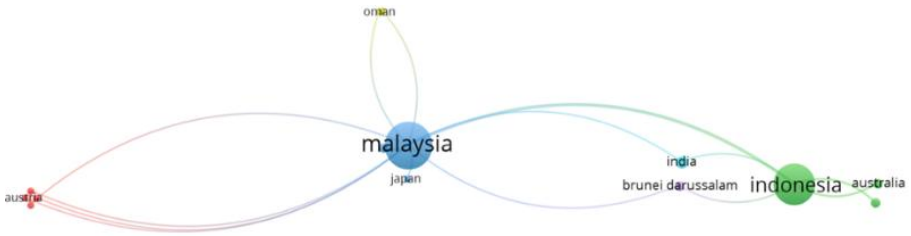

Figure 5. Bibliometric countries mapping

Table 4. Top author countries for origin for top citation for "The role of technology towards halal certification" topic (2014-2024)

Countries	Number of documents	Total citation	Link of strenght
Malaysia	42	415	14
Indonesia	33	168	10
India	3	60	2
Australia	2	12	2
Brunei Darussalam	2	2	2
United States of America	2	48	2
Germany	2	33	1
Pakistan	2	5	0
Austria	1	97	4
Canada	1	97	4

- What lesson can be learned?

Several key insights can be drawn from these findings. First, Malaysia surpasses Indonesia in terms of both the number of research documents (42) and total citations (415), reaffirming its position as the most influential contributor in this research domain. The dominance of Malaysia and Indonesia aligns with their performance in the global halal industry, as reflected in the Global Islamic Economy Indicator (GIEI) 2023, where Malaysia and Indonesia ranked first and third, respectively. Second, despite the prominence of Southeast Asian countries in this research field, it is notable that non-Muslim-majority countries, such as Australia, the United States, Germany, and Canada, also rank among the top ten contributors. This suggests that the study of technology's role in halal certification has gained traction beyond Muslim-majority nations, likely due to the increasing global demand for halal products and the need for advanced technological solutions to enhance halal supply chain transparency and traceability. Lastly, the significant disparity in research contributions beyond the top-ranked countries highlights the need for more collaboration between nations, particularly those with emerging halal markets. The relatively low publication output from countries like India, Brunei, and Pakistan—despite their sizeable Muslim populations—indicates untapped research potential. Strengthening cross-border academic collaborations and knowledge exchange between countries with strong halal industry ecosystems and those with growing halal markets could help bridge this gap and enhance global research efforts in this field.

3.2.5. Most productive institutions

When it comes to the collection of research on the topic of "The role of technology towards halal certification," Figure 6 and Table 5 highlight the organizations that the writers are affiliated with during the course of their work. When it comes to the subject of "The role of technology towards halal certification," there are eleven affiliations that stand out as having the greatest number of publications that have been indexed by Scopus. The university that holds the record for the most documents is National Defence of Malaysia, which is located in Malaysia. Specifically, there are two documents produced by National Defence of Malaysia scholars. In addition, the Szechenyi Istvan University located in Hungary, Higher Institute of Computer Science located in Tunisia, Modul University located in Austria, University of Zurich located in Switzerland, Amity University Noida located in India, University of Bari Aldo located in Italia, University of Foggia located in Italia, University of Turin located in Italia, and State University of New York located in United States of America, came in second until tenth place, respectively, with a total of one documents. The results indicates that there are a large number of authors from the eight campuses whose research focuses on

"The role of technology towards halal certification" and can be found in the Scopus database during the period 2017-2024.

Interesting information is obtained in Table 5, which shows that the majority of the top ten organizations connected to the authors of research on the topic of "The role of technology towards halal certification" are from organizations based in countries where Muslims are not the majority of the population. This fact shows that almost everyone considers that halal certification of products and services is very important and has attracted the interest of researchers from countries where Muslims are not the majority population, such as USA, Italy, Hungary, Switzerland, and Austria. Another interesting fact is that, in addition to the number of manuscripts on the topic of "The role of technology towards halal certification" being dominated by institutions from Europe and the USA, these institutions also have a significantly high number of citations. This reflects the high quality of publications produced by researchers from European and American institutions, which are widely recognized by other researchers as key references.

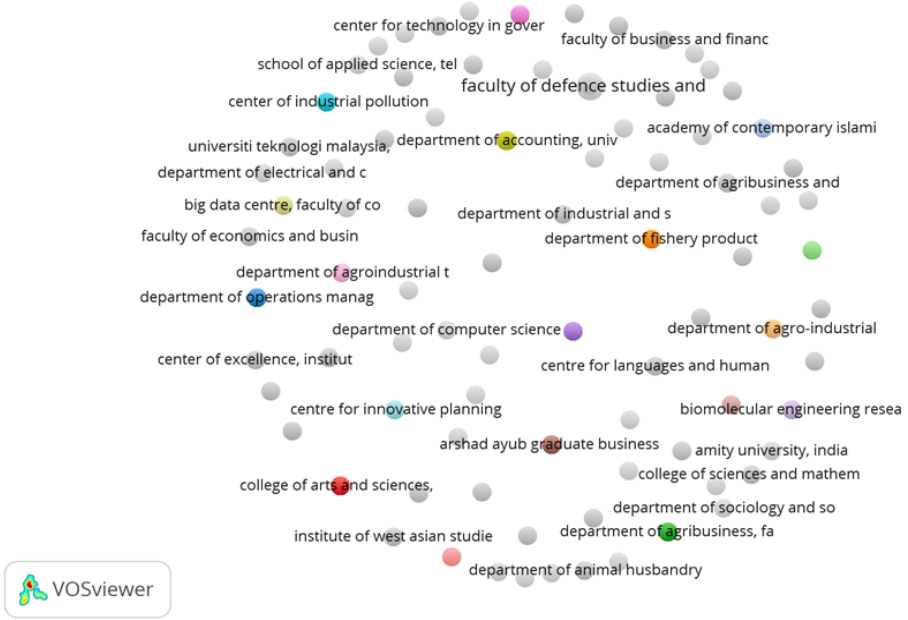

Figure 6. Bibliometric institutions mapping

Table 5. Top author affiliation for "The role of technology towards halal certification" topic (2014-2024)

Organization	Number of Document	Total Citation	Link of Strenght
National Defence of Malaysia, Malaysia	2	0	1
Szechenyi Istvan University, Hungary	1	97	4
Higher Institute of Computer Science, Tunisia	1	97	4
Modul University, Austria	1	97	4
University of Zurich, Switzerland	1	85	1
Amity University Noida, India	1	58	0
University of Bari Aldo, Italia	1	50	2
University of Foggia, Italia	1	50	2
University of Turin, Italia	1	50	2
State University of New York, United States of America	1	48	1

- What lesson can be learned?

Several key insights can be drawn from these findings. First, the bibliometric analysis highlights that research on "The role of technology towards halal certification" is not only concentrated in Muslim-majority countries but has also gained substantial academic interest in non-Muslim-majority nations. This fact is supported by various studies indicating that halal-certified products hold a higher position and are the preferred choice among non-Muslim consumers compared to non-halal-certified products [38]–[40]. Notably, institutions from Europe and the United States, such as the University of Zurich (Switzerland), Szechenyi Istvan University (Hungary), University of Bari Aldo (Italy), and the State University of New York (USA), are among the top contributors to this research area. This suggests that halal certification is recognized as an

important topic beyond religious boundaries, likely due to the global expansion of the halal industry and the increasing emphasis on food safety, quality assurance, and ethical consumerism. Second, despite the relatively low number of publications produced by these non-Muslim-majority institutions, their research outputs have high citation counts, indicating strong academic influence and recognition. This suggests that studies conducted by European and American researchers are perceived as high-quality references within the academic community. The ability of these institutions to generate highly cited publications may stem from their strong research infrastructure, interdisciplinary collaboration, and integration of advanced technological perspectives into halal certification studies. Lastly, the fact that Malaysia's National Defence University leads in the total number of indexed publications underlines Malaysia's continued leadership in halal research. However, the relatively small number of total publications among all institutions listed in Table 5 suggests that institutional engagement in this field is still scattered and lacks strong concentration in any one university or research hub. This highlights the need for greater institutional collaboration and the development of dedicated research centers focusing on halal certification and technology integration to drive more impactful and coordinated research efforts.

3.2.6. Co-occurrence network of keywords

In this study, researchers conducted an analysis and categorization of the primary themes within the phenomenon of "The role of technology towards halal certification to address RQ3. This involved examining the words that are commonly associated with the most extensively studied subjects and concepts. This analysis using VOSviewer also establishes a correlation between the most commonly used keywords in the database obtained from the Scopus database and the conceptual framework of the research topic (see in Figure 7). An analysis was conducted on the co-occurrence of the author's keywords in halal certification text. Out of a total of 108 considered keywords, 65 interconnected keywords were identified. This mapping presents the frequency of certain keywords in "The role of technology towards halal certification" theme papers during the past seven years, along with their correlation to other keywords in seven clusters. Overall, the metadata obtained from the Scopus database generates five clusters, representing five main themes: halal supply chain, consumer behavior towards halal foods, the role of blockchain in the halal industry, the role of information technology in halal cosmetics, and the halal logo in food products.

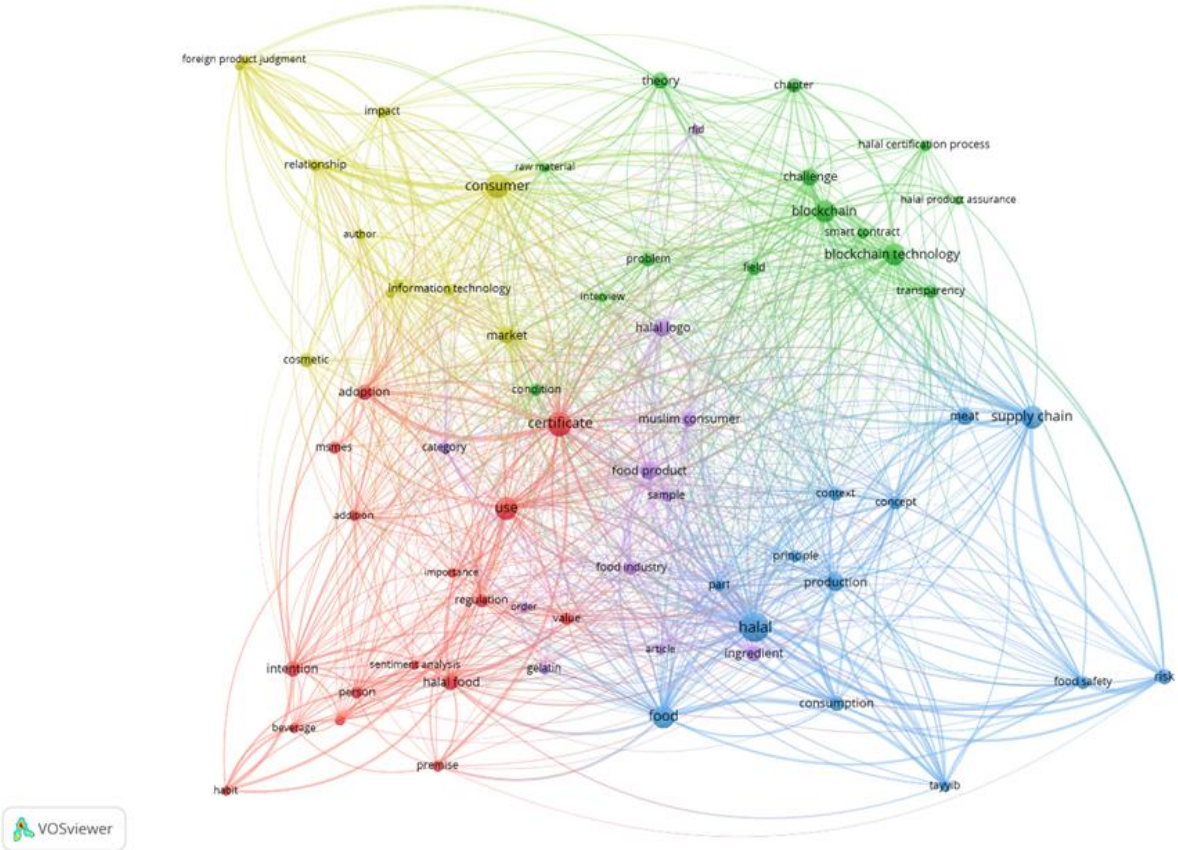

Figure 7. Co-occurrence network of keywords

To facilitate a better understanding of the co-occurrence network visualization of keywords presented in Table 7, this study also summarizes the keywords that have appeared and are related to the topic "The Role of Technology in Halal Certification" during the 2014–2024 period in Table 6. Table 6 presents the results of a co-occurrence network analysis, offering key insights into the main themes and emerging research trends identified across various academic literatures. These themes are further categorized into five clusters based on the contextual proximity of co-occurring keywords.

A. Cluster 1: halal supply chain

Cluster 1 focuses on the halal supply chain. The study by Hidayati *et al.* [41] explains that a halal product must meet halal standards, which are achieved through effective supply chain management. Additionally, halal certification serves as a guarantee that all processes within the supply chain comply with halal principles. However, the development of the halal supply chain faces various challenges. For instance, the post-COVID-19 pandemic in 2020 impacted access to capital, process and technology efficiency, market reach (demand and supply), and the ability to meet market absorption capacity. Furthermore, the implementation of large-scale social restrictions (PSBB) required most activities to be conducted from home, which affected production activities, disrupted the supply chain of halal raw materials, limited market access, and reduced consumer purchasing power [29]. Halal warehousing has also emerged as a critical solution to improving the quality of the halal supply chain, particularly in ensuring food safety.

Table 6. Co-occurrences network keywords of "The role of technology towards halal certification" topic (2014-2024)

Cluster	Theme	Keywords
Cluster 1 in blue	Halal supply chain	Halal, Food, Supply chain, Production, Meat, Consumption, Principle, Context, Concept, Part, Tayyib, Food safety, Risk
Cluster 2 in red	Consumer behaviour towards halal foods	Certificate, Halal food, Use, Adoption, MSMEs, Addition, Importance, Regulation, Value, Premise, Sentiment analysis, Intention, Person, Beverage, Habit
Cluster 3 in green	The role of blockchain in halal industry	Blockchain, Blockchain technology, Smart contract, Transparency, Theory, Chapter, Raw material, Problem, Interview, Condition, Field, Halal product assurance, Halal certification process, Challange
Cluster 4 in yellow	The role of information technology in halal cosmetics	Consumer, Information technology, Market, Cosmetic, Author, Foreign product judgement, Relationship, Impact
Cluster 5 in purple	Halal logo in food products	Halal logo, Muslim consumer, Category, Food product, Sample, Food industry, Order, Gelatin, Article, Ingredient

B. Cluster 2: consumer behaviour towards halal foods

Cluster 2 focuses on consumer behavior towards halal foods. The findings of this study indicate that halal certification ownership significantly influences consumer behavior. For instance, a study by Sayogo (2018) revealed that if Muslim consumers in Indonesia can easily trace halal products online, it facilitates their decision-making process, as they perceive halal principles as both useful and essential [31]. Furthermore, consumers tend to prefer products labeled with halal and non-halal logos [37]. These findings align with Al-Banna's research, which demonstrates that the behavior of purchasing halal food online is driven by perceived usefulness and religiosity.

C. Cluster 3: the role of blockchain in halal industry

Cluster 3 focuses on the role of blockchain in halal industry. The supply chain flow in the halal industry is highly complex. Weak oversight of food safety and halal compliance within the supply chain system remains one of the significant challenges faced by all stakeholders involved in the halal industry [42]. To address this issue, several studies have proposed the use of blockchain technology to strengthen food safety and halal compliance monitoring systems, particularly in the food industry. Blockchain is designed to track information related to halal assurance implementation at every stage of the poultry-based food production chain, from farmers, slaughterhouses, distributors, to food processing industries [43]. Furthermore, blockchain enables users to assess all transactions simultaneously and in real-time, ensuring transparency, security, authenticity, and auditability [44]. Blockchain can also be utilized to store and verify halal certificates. In the halal certification issuance process, blockchain can be employed to track the halal application process and integrated as an alternative to the current system by applying multiple signatures in smart contracts for each party involved [45].

D. Cluster 4: the role of information technology in halal cosmetics

Cluster 4 focuses on the role information technology in halal cosmetics. Information and communication technology (ICT) plays a crucial role in facilitating smart food security policies by driving positive changes in consumer behavior, particularly in supporting halal and healthy consumption [8], [31]. For Muslims, ICT can assist in verifying the halal status of a product, alleviating consumer concerns about its compliance with Islamic principles [46]. To ensure access to halal food, which is essential for every Muslim to avoid consuming haram products, individuals can utilize websites to maintain the cleanliness and halal integrity of food products. Moreover, ICT serves as a valuable tool for marketing and providing information to consumers.

E. Cluster 5: halal logo in food products

The circulation of products with counterfeit or questionable halal logos has raised concerns about halal compliance and integrity, particularly among small and medium-sized enterprises (SMEs) in the food sector [36]. To address this issue, various technologies have been developed to help consumers validate the authenticity of halal logos on products. For instance, in the study by Nasir et al., an RFID-based validation system was developed and implemented in retail locations, enabling consumers to verify the halal status of their food products [47]. Through traceability systems, consumers can track and trace the movement of food products available in the market. The purpose of such research is to investigate the factors influencing the intention of food SMEs to adopt halal traceability systems.

Overlay visualization provides information on the temporal appearance of keywords based on the year of publication (see Figure 8). Newer keywords are typically displayed in different colors (e.g., brighter colors such as yellow), while older keywords are shown in darker colors (e.g., blue). Figure 8 illustrates that the smart contract technology offered by blockchain has emerged as the most frequently used recent keyword by researchers focusing on the topic "The role of technology towards halal certification" during the 2023–2024 period.

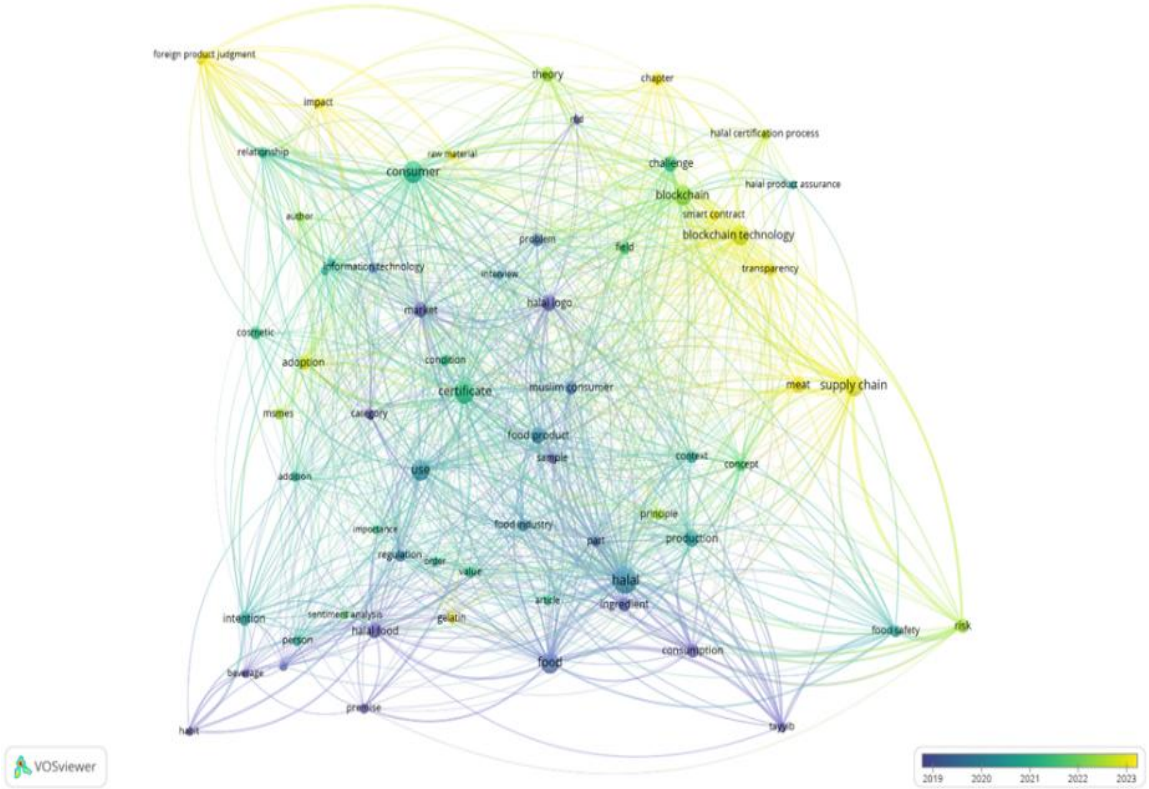

Figure 8. Overlay visualization of keywords

F. What lesson can be learned?

The findings of this study provide several key insights. First, the bibliometric analysis reveals five main themes related to the role of technology in halal certification: the halal supply chain, consumer behavior towards halal foods, the role of blockchain in the halal industry, the role of information technology in halal

cosmetics, and the halal logo in food products [48]. These themes highlight the multidisciplinary nature of research in this domain, emphasizing the intersection of supply chain management, consumer studies, emerging technologies, and regulatory compliance. The analysis of the halal supply chain underscores the importance of effective supply chain management in ensuring halal compliance. Challenges such as disruptions caused by the COVID-19 pandemic, limitations in market access, and inefficiencies in process and technology indicate the need for continuous innovation, particularly in halal warehousing and logistics.

The research on consumer behavior towards halal foods demonstrates that halal certification significantly influences purchasing decisions. Digital traceability and online accessibility of halal product information enhance consumer confidence, reinforcing the growing importance of transparency in halal certification. The findings on blockchain technology suggest that it serves as a promising solution for strengthening food safety and halal compliance. Blockchain's ability to provide real-time tracking, authentication, and auditability ensures greater transparency in the halal industry [49]. Furthermore, blockchain can be utilized to verify and store halal certificates, optimizing the certification process through smart contracts.

The role of information technology in halal cosmetics highlights the impact of ICT in supporting halal product verification and marketing. Digital platforms help consumers access reliable halal information, ensuring compliance with Islamic principles and promoting awareness of halal cosmetics [50], [51]. Finally, research on halal logos in food products highlights the challenges posed by counterfeit halal labels. Technologies such as RFID-based validation systems and halal traceability mechanisms are crucial in ensuring the authenticity and integrity of halal certifications. Overall, these findings demonstrate the evolving landscape of halal certification, where technological advancements play a pivotal role in enhancing transparency, compliance, and consumer trust.

4. CONCLUSION

The findings of this study broaden the horizon on how technology plays a role in the halal industry, particularly in improving the performance and quality of the halal certification issuance process. The findings of this study also reveal a dynamic trend in the literature on the topic "the role of technology towards halal certification" within the Scopus database from 2014 to 2024. The most significant contributions to this theme were made by authors from Indonesia and Malaysia. However, publications and institutions from non-Muslim majority countries, such as the USA, Italy, Hungary, Switzerland, and Austria, also emerged as key contributors to publications on the topic "The role of technology towards halal certification," with a high citation rate. Based on the analysis of 88 articles published in Scopus-indexed journals on the topic "The role of technology towards halal certification," five main clusters were identified. These clusters include halal supply chain, consumer behavior towards halal foods, the role of blockchain in the halal industry, the role of information technology in halal cosmetics, and halal logo in food products.

The findings of this study emphasize the growing intersection between technology and halal certification, highlighting several key implications. First, the fluctuating citation trends suggest that researchers must continuously innovate and contribute novel insights to maintain academic impact. This underscores the importance of interdisciplinary collaboration and aligning research with industry needs to ensure relevance and visibility. Second, the dominance of journal articles and conference papers indicates active academic discourse on this topic, yet the limited number of books and review articles presents an opportunity for researchers to consolidate knowledge into comprehensive references. This could enhance the theoretical and practical understanding of halal certification, benefiting both scholars and industry practitioners. Furthermore, the findings reveal that Malaysia leads global research efforts in this field, emphasizing the country's role as a key contributor to both academic and industrial advancements in halal certification. However, the presence of non-Muslim-majority countries in the top contributors list indicates that the halal industry is gaining recognition beyond religious boundaries, driven by global demand for food safety, ethical consumerism, and supply chain transparency. Additionally, the analysis highlights the significant impact of emerging technologies such as blockchain and the IoT in improving halal certification processes. These innovations offer solutions for enhancing transparency, traceability, and compliance, providing practical implications for businesses and policymakers aiming to strengthen halal assurance systems. Lastly, the study underscores the need for stronger institutional collaboration and dedicated research centers focused on halal certification and technology integration. By fostering knowledge exchange across countries and disciplines, future research can bridge gaps, expand the halal market globally, and drive technological advancements that benefit both academia and industry.

While this study offers significant contributions, it has several limitations. The data selection for this study was determined by three search queries conducted on titles, abstracts, and keywords. However, it is important to note that this method may have excluded papers that did not explicitly include the research

keywords in all fields of study. Nevertheless, the likelihood of this occurrence is minimal and has a negligible impact on the study's findings. Additionally, this study did not examine the titles and abstracts of papers to ensure that all documents exclusively focused on the topic "The role of technology towards halal certification." As a result, it is conceivable that articles discussing other topics were not included. Despite this, the findings from the most productive journals and influential articles indicate that all information is related to the topic "The role of technology towards halal certification." This demonstrates that the data examined specifically focused on articles addressing this topic. Furthermore, the collected manuscripts were exclusively sourced from the Scopus database, which consists of publications authored by Indonesian researchers. Indonesian researchers have made valuable contributions to the global literature. Therefore, future research should explore the use of alternative databases such as Web of Science, Dimensions, and Google Scholar.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to Universitas Negeri Surabaya for the material and non-material support provided throughout the course of this research. The authors also extend their appreciation to Universiti Teknologi MARA (UiTM) for the valuable collaboration and academic partnership that contributed significantly to the completion of this study.

FUNDING INFORMATION

The authors declare that no funding was received from any individual, institution, or funding agency for the conduct of this study or the preparation of this manuscript.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
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R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Authors state no conflict of interest.

INFORMED CONSENT

We confirm that informed consent was obtained from all individuals included in this study, and that their privacy rights have been fully respected in accordance with applicable ethical and legal standards.

ETHICAL APPROVAL

The research involving human participants has complied with all relevant national regulations and institutional policies, in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board (IRB) or an equivalent ethics committee.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [YPT], upon reasonable request.

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