Agroindustrial Technology Journal Vol.7 No.2 (2023) 1-17
DOI : http://dx.doi.org/10.21111/atj.v7i2.9409

AGROINDUSTRIAL TECHNOLOGY JOURNAL
ISSN : 2599-0799 (print) ISSN : 2598-9480 (online)
Accredited SINTA 3: No.225/E/KPT/2022

ANALISIS BIBLIOMETRIK RISET PANGAN DAN PASCAPANEN DALAM MENINGKATKAN INTEGRITAS INDUSTRI MAKANAN HALAL

Bibliometric Analysis of Food and Post-Harvest Research in Enhancing the Integrity of Halal Food Industry

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Info artikel: Diterima 14 Februari 2023, Diperbaiki 16 Mei 2023, Accepted 20 Mei 2023

ABSTRACT

Halalness of products has been a global concern in recent years due to increasing awareness, especially in Muslim-populated countries. However, Indonesia, the country with the largest Muslim population in the world, is only ranked 5th in halal industry development. Therefore, producers and consumers are expected to have a deeper understanding of halal practices that can encourage the development of industries with halal-certified products. This paper aimed to systematically and quantitatively plot the output of scientific research on implementing food and postharvest technology to improve the integrity of the halal food industry. The research method was bibliometric analysis using VOSviewer as a mapping tool. This research has four stages: (i) collection of bibliometric data from the Scopus database, (ii) performance analysis using embedded Scopus analysis tool, (iii) data mapping using VOSviewer, and (iv) mapping data analysis. Out of 2,875, only 161 keywords from 455 articles met the analysis threshold. The results showed that the topic of meat received the most attention from 2008 to 2021, found in 84 articles with 878 total link strengths. Furthermore, one of the most cited research topics recently was related to modeling the theory of planned behavior with factors of Halal awareness, certification, food quality, promotion, and brand on the intention to purchase halal products by non-Muslim consumers, with 203 citations from 2013 to 2021. In general, researchers can use this study to examine trends and directions of future research topics comprehensively.

Keywords: *: Bibliometric, halal, certification, theory of planned behavior, VOSviewer*

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ABSTRAK

Kehalalan produk menjadi perhatian global dalam beberapa tahun belakangan karena peningkatan kesadaran, khususnya di negara-negara berpenduduk muslim. Sayangnya, Indonesia sebagai negara dengan populasi muslim terbesar di dunia hanya berada di peringkat ke-5 dalam perkembangan industri halal. Oleh karena itu, produsen dan konsumen diharapkan memiliki pemahaman lebih mendalam tentang praktik halal yang dapat mendorong perkembangan jumlah industri berproduk tersertifikasi halal. Paper ini bertujuan untuk memetakan secara sistematis dan kuantitatif output riset ilmiah tentang implementasi teknologi pangan dan pascapanen untuk meningkatkan integritas industri pangan halal. Metode penelitian yang digunakan adalah analisis bibliometrik dengan VOSviewer sebagai alat pemetaan. Penelitian ini memiliki empat tahapan: (i) pengumpulan data bibliometrik dari database Scopus, (ii) analisis kinerja menggunakan alat analisis di Scopus, (iii) pemetaan data dengan VOSviewer, dan (iv) analisis data pemetaan. Dari 2.875, hanya 161 keyword dari 455 artikel yang sesuai dengan ambang batas analisis. Hasil menunjukkan bahwa topik daging mendapat paling banyak atensi sejak 2008 sampai 2021, yang ditemukan di 84 artikel dengan total kuat tautan sebanyak 878. Lebih lanjut, salah satu topik riset paling banyak disitasi belakangan ini terkait dengan pemodelan teori perilaku terencana dengan faktor kesadaran halal, sertifikasi, mutu pangan, promosi, dan merk terhadap niat beli produk halal oleh konsumen non-muslim, dengan 203 sitasi dari 2013 hingga 2021. Secara umum, para peneliti dapat menggunakan studi ini untuk menguji tren dan arah topik riset yang akan datang secara kuantitatif.

Kata kunci: Bibliometrik, halal, sertifikasi, *theory of planned behavior*, VOSviewer

INTRODUCTION

Halal is an Arabic word for something permissible according to Islamic rules (Riaz & Chaudry, 2018). The term halal to food covers all aspects starting from the field and ending at the consumer's table. Halal food must be free from all components Muslims are prohibited from consuming, known as haram. According to the Quran, unclean food includes all products derived from or contaminated with prohibited materials, such as carrion, blood, pigs, fanged animals, animals permitted but improperly slaughtered, and alcoholic beverages.

The global halal food trade is increasing along with the increase in transnational trade and the global Muslim population. By 2030, the projected growth of Muslims will reach 2.2 billion, with an average annual growth of 1.8% (Lugo et al., 2011). This will be followed by a 7% annual growth in the halal food industry which in 2011 alone was valued at US$1.4 trillion (Ahmad et al., 2011). Thus, non-Muslim countries that are part of the market by having halal certification and labeling have the potential to benefit (Demirci et al., 2016). However, there are several things to note.

Several food industry scandals have shaken consumers' confidence in the food they consume. Food scandals are generally related to issues such as food adulteration, substitution, and fraud which are usually aimed at increasing the manufacturer's profits (Grimm et al., 2014). Unlike the electronics industry, the food industry's products are the

result of combining various raw materials. Testing the status of raw materials is almost impossible after the product is finished. Thus, it makes more sense to ensure the status of raw materials before processing (Ali et al., 2017). Halal food consumers need to know how the food was produced, including what materials are used, the origin of the supply, and the manufacturer's compliance with existing halal standards. This can be pursued by strengthening the integrity of the halal food industry as a long-term solution.

Food integrity is an overarching concept related to food production. Food halalness can be seen as food integrity. Elliott (2014) defines food integrity as a guarantee that the food offered meets buyers' expectations regarding material safety and quality. In addition, the food must fulfill aspects of food production, such as how it originates, is produced, is distributed, and is honest about its elements to consumers.

Integrity in an industry affects its ability to determine critical production points, trace possible causes of events, and gain consumer confidence (Ali et al., 2014). This gave rise to various laws, regulations, and standards related to food. In addition, technology and equipment began to be developed to ensure product quality and safety (Marucheck et al., 2011). Thus, through bibliographical analysis, this paper aimed to examine some studies on food and postharvest technological interventions in enhancing the integrity of the halal food industry published worldwide to describe the global output on the topic and define current research directions.

MATERIALS AND METHODS

Bibliometric analysis was used to summarize the current state of the art of existing or emerging research topics. Based on the bibliometric data, this quantitative method was used to identify the direction and pattern of development and literature structure in a particular field (Kusuma & Jamaludin, 2022). The bibliometric data can include article attributes (i.e., authors, publications, citations, and publisher keywords) and their relationship.

Data collection

The data for this study were collected from the Scopus database, as suggested by Nobanee et al. (2021). The study used Scopus as a bibliometric resource because it was considered by many researchers to be the largest database of citations and abstracts from peer-reviewed literature. Scopus is also one of the most massive and well-known databases in various research fields (Guz & Rushchitsky, 2009).

Our research focused on all research on food and postharvest interventions in the halal food industry from early 2008 to late 2021 in peer-reviewed journals, especially in the fields of agricultural and biological

science and engineering. The search process was carried out in November 2022. Therefore, we decided to exclude the 2022 article because every retrieval from that period would risk including incomplete bibliometric data. For filter processing, articles written in languages other than English were excluded.

Search strategy

On the Scopus Website (http://scopus.com/), using the combination of search parameters in the document search field, the search query string was obtained as follows: (TITLE-ABS-KEY (food OR post-harvest* OR postharvest*)) AND (TITLE-ABS-KEY (halal)) AND (TITLE-ABS-KEY (technolog* OR treatment OR procedure OR method OR innovat* OR control* OR process* OR handl* OR manag* OR analysis OR development OR system OR industr*)) AND NOT (TITLE-ABS-KEY (medic*)) AND (LIMIT-TO (LANGUAGE , "english")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (SUBJAREA , "agri") OR LIMIT-TO (SUBJAREA , "comp") OR LIMIT-TO (SUBJAREA , "engi") OR LIMIT-TO (SUBJAREA , "bioc") OR LIMIT-TO (SUBJAREA , "envi") OR LIMIT-TO (SUBJAREA , "deci") OR LIMIT-TO (SUBJAREA , "vete") OR LIMIT-TO (SUBJAREA , "mult")) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")).

As shown in the strings, “food”, “postharvest”, “halal”, “technology”, “development”, and “industry”, along with similar terms, were the main keywords of interest. However, the term medic was excluded from the search data because the halal concern is also widely researched in the medical and pharmaceutical industries. The reason for removing these terms was to filter out all unnecessary keywords that may be included in the data analysis, which may distract from the purpose of the study scope. In the context of this research, the bibliometric analysis only focused on global research outputs related to food and postharvest technological innovations to improve the Integrity of the halal food industry. Exactly 455 publications were retrieved from the Scopus database. Each

publication includes the following information: author, country of author, author's keywords, document title, the title of the source, year of publication, research area, and the number of citations. All data was downloaded in ".csv" format.

Bibliometric analysis

This study adopted three effective techniques: performance analysis, science mapping, and network mapping. Performance analysis is a descriptive method for evaluating publications and citation-related metrics (e.g., evaluation of the total number of publications and citations, h-index). Meanwhile, bibliometric mapping analyses the strength of relationships among different article attributes, such as item co-occurrence and total link strength. The results of bibliometric mapping can be improved through network analysis.

The performance analysis was supported by Scopus data consisting of total publications, the number of publications per year active, and total annual citations, which can be easily determined through h-index. The h-index is equivalent to the maximum number of i articles cited in a set of n calculated publication years with at least i citations (Tamala et al., 2022). In this study, these parameters were calculated with the help of an analytical tool embedded in the Scopus system. Whereas bibliometric and network mapping was performed using pre-extracted files from data sources and free software called VOSviewer (version 1.6.18).

RESULTS AND DISCUSSION

Publication output and growth trend

Performance analysis was conducted to evaluate publication performance in terms of publication output by author, affiliated institution, country, and growth trend over the years. This study presented the number of publications per year, the total citations per year, the h-index, and the most cited articles.

The annual frequency of publication of scientific articles can indicate the publication performance in specific fields. Figure (1) described the annual publication rate of articles from 2008 to 2021 for a total of 455 publications. The data peaked in 2018 and 2020 with 65 publications and of these articles were the most published in the International Journal of Supply Chain Management and British Food Journal.

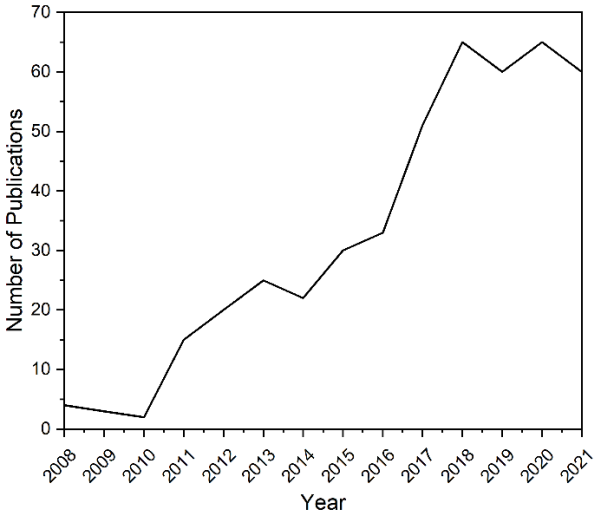

Figure 1. Annual publication growth of bibliometric papers from 2008 to 2021.

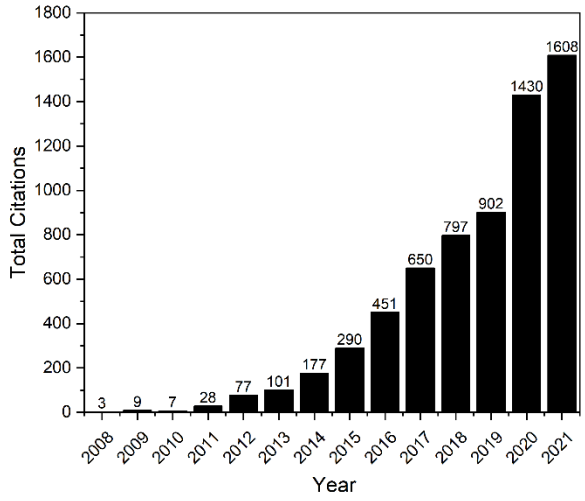

Figure 2. Annual total citations trend of the bibliometric articles from 2008 to 2021.

The number of publications was irrelevant if other studies did not cite. Thus, the total number of annual citations received by articles was also evaluated. In Figure (2), it can be seen that there was an increasing trend in the total number of citations per year, from only 3 in 2008 to 1608 in 2021. The total number of annual citations experienced a significant spike in 2020 along with the outbreak of the Covid 19 pandemic around the world, and the issue of the halal food industries was getting hotter.

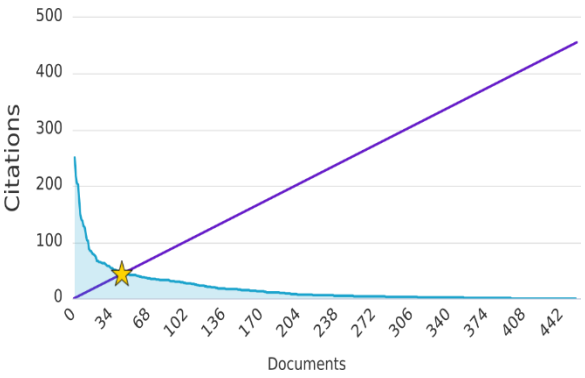

Figure 3. h-graph of the document collection.

The productivity and impact of a collection of search results articles can be displayed using an h-graph, as shown in Figure (3). The h-index was used as a numerical indicator that shows the influence and productivity of the collection of articles on search query results on Scopus. Based on the data, the h-index for the collection of articles was 44, which means that 44 of the 455 articles have been cited at least 44 times

Furthermore, the most cited articles from the document collection were shown in Table (1). The results show that the article by Karim and Bhat (2008) on effort to find alternative gelatin for the halal food industry was the most cited, with 251 total citations. However, when a comparative analysis was conducted on the average number of citations per year for the top ten articles, it was found that the articles on gelatin were still inferior to other articles on determination of halal purchase intention among non-muslim. For a span of only 9 years, from 2013 to 2021, the consumer behavior studies article by Aziz and Chok (2013) could produce 203 citations or 25.4 citations per year. In contrast, it took 14 years for alternative gelatin articles to produce 251 citations.

There was growing interest in finding out an in-depth understanding of consumer buying attitudes towards halal food that is dynamic and sustainable. The study of consumer behavior is an integral part of a marketing strategy because it allows

marketers to understand and predict how consumers will act in the future (Schiffman & Kanuk, 2004). For the interest of this research, the review conducted Aziz and Chok (2013) will be helpful for many researchers and food manufacturers because an in-depth understanding of the buying attitudes of non-Muslim consumers can strengthen the position of the halal market.

Table 1. Most cited article on halal food industries

	Document Title	Authors	Publication Year	Journal Tittle	Impact Factor	Total Citations	Average Citation
1	Gelatin alternatives for the food industry: recent developments, challenges and prospects	Karim A.A., Bhat R.	2008	Trends in Food Science and Technology	18.1	251	19.3
2	Nonmeat protein alternatives as meat extenders and meat analogs	Asgar M.A., Fazilah A., Huda N., Bhat R., Karim A.A.	2010	Comprehensive Reviews in Food Science and Food Safety	15.8	218	19.8
3	Analysis of pork adulteration in beef meatball using Fourier transform infrared (FTIR) spectroscopy	Rohman A., Sismindari, Erwanto Y., Che Man Y.B.	2011	Meat Science	10.4	205	20.5
4	The Role of Halal Awareness, Halal Certification, and Marketing Components in Determining Halal Purchase Intention Among Non-Muslims in Malaysia: A Structural Equation Modeling Approach	Aziz Y.A., Chok N.V.	2013	Journal of International Food and Agribusiness Marketing	3.6	203	25.4
5	Halal authenticity issues in meat and meat products	Nakyinsige K., Man Y.B.C., Sazili A.Q.	2012	Meat Science	10.4	178	19.8
6	Review: Gelatin, source, extraction and industrial applications	Mariod A.A., Adam H.F.	2013	Acta Scientiarum Polonorum, Technologia Alimentaria	2.6	150	18.8
7	Muslim consumer trust in halal meat status and control in Belgium	Bonne K., Verbeke W.	2008	Meat Science	10.4	141	10.8
8	Multiplex PCR assay for the detection of five meat species forbidden in Islamic foods	Ali M.E., Razzak M.A., Hamid S.B.A.,	2015	Food Chemistry	13.1	138	23.0
9	Meat authentication: A new HPLC-MS/MS based method for the fast and sensitive detection of horse and pork in highly processed food	Von Bargen C., Brockmeyer J., Humpf H.-U.	2014	Journal of Agricultural and Food Chemistry	8.6	129	18.4
10	Molecular assay to fraud identification of meat products	Doosti A., Ghasemi Dehkordi P.	2014	Journal of Food Science and Technology	3.8	127	18.1

The study offered insight into using the Theory of Planned Behavior (TPB) as a guide for predicting human social behavior. TPB has been widely recognized and applied to food-related studies (Verbeke & Vackier, 2004) and halal food studies (Bonne & Verbeke, 2008b). In TPB, three components influence human attitudes toward behavior. These components are attitudes, subjective norms, and behavior control. Aziz and Chok (2013) effectively describe the relationship between halal components (halal awareness and halal certification) and marketing determinants (product quality, marketing promotion, and brand), and consumer purchase intentions.

Research by Aziz and Chok (2013) proved that halal certification as proof of product authentication determined the purchase intention of non-Muslim consumers more than awareness of the halal concept. The non-Muslim community recognized the benefits of halal products, so they adopt halal food as a lifestyle choice. So manufacturers need to increase awareness of halal products by providing sufficient and exciting information, especially about halal certification. This can be done through promotions to encourage more consumers to buy their products. In addition, it is also essential for food manufacturers to maintain the brand reputation of their products because a brand is a predictor of product quality.

However, one of the main challenges in this study was the exclusion of food safety elements from measuring food quality. It could reduce the strength of the construction of food quality, which was marked by the insignificant quality of food in influencing the purchase intention of halal consumers. Food safety is considered the most basic and prominent aspect of food quality for the public interest (Canavari et al., 2010). Thus, it was suggested by Aziz and Chok (2013) that the future direction of this research interest was to model Muslim perceptions of food consumption, especially halal meat, by involving measurement of other aspects of the quality of halal food, including food safety. This effort will significantly contribute to the provision of comprehensive literature for manufacturers to strengthen the position of their halal products for both Muslim and non-Muslim consumers.

Mapping analysis on bibliometric data

Co-authorship and co-occurrence mapping were used to analyze the bibliometric data. Co-authorship relates to the interaction of authors, contributing countries, or affiliates to develop research fields, while co-occurrence refers to the relationship between keywords. In co-occurrence mapping, all keywords were used as a unit of analysis with a full counting method and combining synonyms and their plurals. This study also established some

limitations in the analysis. For example, a minimum of five (5) keyword occurrences was set as a limiting factor. So, out of 2,875 keywords from 455 articles, only 161 keywords met the threshold.

Each keyword was analyzed using VOSviewer, which could calculate co-occurrence of keywords, links, and total link strength. Co-occurrence represents the number of articles where the keyword was found. The Links and Total link strength attributes indicate, respectively, the number of links of an item with other items and the total strength of the links of an item with other items. As shown in Table (2), the keywords with the highest co-occurrence are displayed. Halal, meat, animal, halal food, human, and pig are some of the keywords that appear most often, along with the weight of their occurrence (total link strength) to 123(547), 84(878), 73(858), 56(245), 56(573), and 51(570), respectively.

The occurrence of keywords was also illustrated through network visualization to identify hidden topics from large data sets. As seen in Figure (4), the 161 keywords were able to form 4 clusters: cluster 1 (red), cluster 2 (green), cluster 3 (blue), and cluster 4 (yellow). Then, the keywords in each cluster were examined to determine the main topics brought by each cluster. The size of the circle represented the occurrence of keywords. The larger the circle, the more keywords were selected in the considered documents.

Table 2. Most highly co-occurring keywords

	Keyword	L	T	O
1	Halal	137	547	123
2	Meat	138	878	84
3	Animal	128	858	73
4	Halal Food	107	245	56
	Human	129	573	56
5	Pig	106	570	51
6	Islam	114	399	38
7	Gelatin	88	271	36
	Nonhuman	106	340	36
8	Polymerase Chain Reaction	91	368	34
9	Food Quality	110	311	30
	Malaysia	76	167	30
10	Bovine	99	335	29

L = links; T = total link strength; O = occurrence

Cluster 1. The first cluster was generally associated with efforts to strengthen halal aspects in food industrialization. Halal, halal food, human, Malaysia, and food industry are the keywords with the highest co-occurrence, with scores of 123, 56, 56, 30, and 28, respectively. In other words, for example, a co-occurrence weight of 123 means the keyword "halal" appeared in 123 articles out of 455 articles, or 27% of the total publications in the analysis.

Based on closer network visualization in VOSviewer, halal was more strongly linked with four keywords: animal, human, meat, Islam, and pig. This keyword set can be considered a hot topic in halal research. Individually, these keywords were found in 73, 56, 84, 38, and 51, respectively.

Food industrialization covers providing safe, high-quality, affordable food, from pre-production activities to consumer food consumption. The integration of halal aspects into a food industry can be carried out by running a system that can guarantee safety (purity), quality (goodness), and freedom from negligence (validity) of food in ingredients from all illicit contamination starting from the field to the consumer. This system is often associated with halal certification.

Halal certification officially recognizes an orderly process in preparation, slaughter, cleaning, handling, and other related management practices by an established authorized institution. Around 122 active halal certification bodies in the world apply different halal standards (Halim & Salleh, 2012). For food to be halal-certified, the manufacturer must obtain a halal symbol or qualification as proof that the product is halal according to the Quran. Product halal certification provides strong recognition of the quality of food products.

The key to increasing the integration of halal aspects in the food industry is transparency which allows consumers to make decisions (Alqudsi, 2014). Halal food products require intensive monitoring because consumer quality testing is almost impossible and expensive (Ali et al., 2017). Ideally, the government acts as an accreditation agency that guarantees that

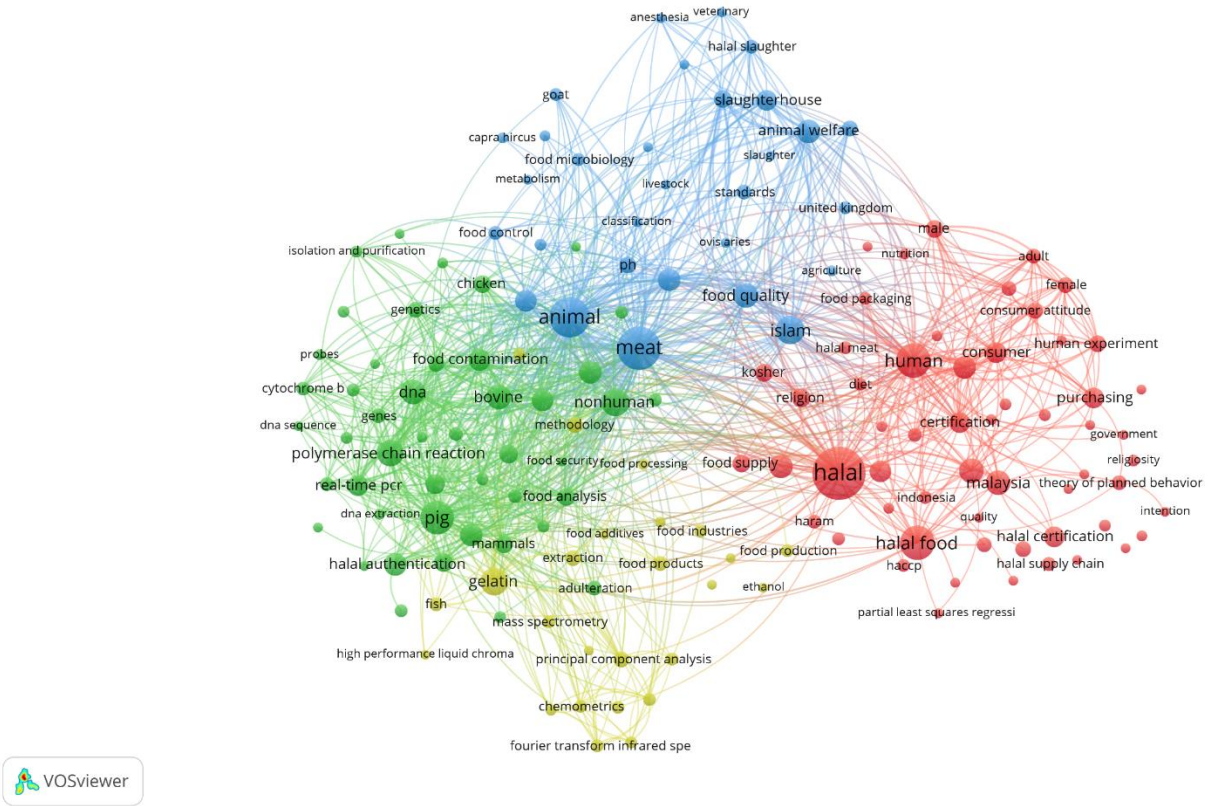

Figure 3. Co-occurrence map of the keywords.

halal companies and certification bodies say what they have done and do what they said.

Cluster 2. The second cluster focused more on efforts to overcome the adulteration of food products. Pig, nonhuman, polymerase chain reaction, DNA, and authentication were the keywords with the highest co-occurrence weights at 51, 36, 34, 28, and 25, respectively. Pig is more related to the keyword animal, meat, gelatin, and polymerase chain reaction, with co-occurrence of 34, 27, 18, and 17, respectively. Thus, it can be explained in these results that the increased interest in pig product research was also closely related to the identification of its presence in food using PCR.

It was found that halal food prices are significantly higher than conventional ones, thereby increasing the risk of counterfeiting, namely illegal mixing with cheaper ingredients. In most countries, food producers choose to use pork derivatives because they are cheap and readily available (Aida et al., 2005).

Detection and quantification of food adulteration were crucial to protect consumers. Authentication verifies food according to the label description (Dennis, 1998). Authentication schemes depend on lipids, proteins, and nucleic acid biomarkers (Rahman et al., 2014). Using protein and fat biomarkers was unsuitable under physicochemical shock conditions and extreme modifications such as heating (Karabasanavar et al., 2014). On the other hand, DNA biomarkers were very stable (Hou et al., 2015). One of the DNA biomarker methods was Multiplex PCR (mPCR) assay.

The reliability of mPCR has been proven by Ali et al. (2015) , who identified the presence of 5 species of haram meats in meatballs, both raw and cooked. This is possible because mPCR utilizes short nucleic acid targets, which are very stable under processing conditions, and mitochondrial genes which can be found in various cell copies (Zhang, 2013).

Cluster 3. The top 5 keywords were meat, animal, Islam, food quality, and animal welfare with co-occurrence frequencies of 84, 73, 38, 30, and 27, respectively. By examining the keywords associated with this cluster, it can be seen that the topic concentration lies in halalness and quality of meat / meat alternatives related to animal welfare.

Religion is one of the main factors determining food avoidance, taboos, and special regulations, especially for meat. In Islam, animal welfare must be maintained so that the halal status of meat can be fulfilled. At all times during the slaughter process, animals must be treated humanely, e.g., animals must be well fed, rested, and not stressed before slaughter. Slaughter was done while the animal was still alive using a sharp

knife and mentioning the name of Allah during the slaughter so that the animal died from bleeding and not from stunning (Bonne & Verbeke, 2008a).

Although meat is rich in nutrients, excessive intake of meat products is not recommended for specific population groups because of their significant fat content (Cengiz & Gokoglu, 2005). Therefore, protein of vegetable origin is an alternative to animal protein for food applications due to the wide variety of sources, such as legumes, oilseeds, cereals, and mushrooms. An important reason for the increasing acceptance of vegetable proteins, such as textured soy protein (TSP), is their low cost (Singh et al., 2008).

Using soybeans in various food applications is very important to the food industry. However, the undesired taste is the main problem limiting the incorporation of textured soy protein into alternative meat products. Katayama and Wilson (2008) successfully utilized soy components by developing chicken-flavored soy protein acceptable to consumers.

Cluster 4. The fourth cluster focused on procuring alternative halal gelatine and food analysis for identification. Gelatine, bovine, cattle, and food analysis were the keywords with the highest co-occurrence weights at 36, 29, 22, and 16, respectively. Gelatine more with keyword pig, bovine, animal, and halal indicates that these keywords often appear together.

Gelatin is a product obtained by partial hydrolysis of collagen derived from animal skins, white connective tissue, and bones (Morrison et al., 1999). Overall functional uses include as a stabilizer, thickener, and texturizer. So far, the primary commercial sources of gelatin have been limited to pork skins or bovine hides and bones, possibly because of the relatively low cost of the final gelatin product. Production of gelatin from pig skins is unacceptable in Islam, and gelatin from cows is only acceptable if it has been prepared according to religious requirements (Karim & Bhat, 2008). As a result, academia and industry have tried for many years to develop alternatives to gelatin that share most or all of the unique functional properties of mammalian gelatin.

Fish gelatin is acceptable to Islam as something halal. In addition, fish skin is a significant by-product of the fish processing industry, causing waste and pollution, and can be a valuable source of gelatin (Badii & Howell, 2006). Although fish gelatin was considered an attractive alternative to mammalian gelatin, commercial interest in exploiting fish gelatin has been relatively low. Fish gelatin (especially from cold-water fish) does not gel at room temperature. The gelling temperature of fish gelatin is usually below 8-10°C, depending on the gelatin concentration, average molecular weight,

ionic strength, pH, cooling rate and determination method (Cheow et al., 2007).

Gómez-Guillén et al. (2001) reported that adding microbial TGase to fish gelatin increased the melting point, gel strength, and viscosity at 60°C, depending on the enzyme concentration and incubation time. Haug et al. (2004) reported that hybrid gelatin-k-carrageenan gel systems could be carefully formulated, leading to systems with increased gel strength, gelling, and melting temperature.

Research Trend Evolution

Overlay visualizations were used to show the changing patterns of terms over time (Figure 4). Such visualizations were vital for studying the evolutionary trend, trajectory, and research in front of a given field. Since early 2019, several new keywords related to the halal food industry have begun to emerge. The top three keywords were Muslim, halal supply chain, and limit of detection, with occurrences of 24, 10, and 9, respectively. The emergence of these keywords shows the challenges currently being faced and wished to be resolved by researchers recently. These challenges include strengthening the halal supply chain, developing the latest authentication methods to overcome the detection limits of existing methods, and analyzing halal consumer behavior concerning nutritional and food hygiene aspects. These challenges are related to the realization of halal traceability, which according to Ma'rifat et al. (2017), is essential to make it easier for customers to check a product's halal status and track its quality.

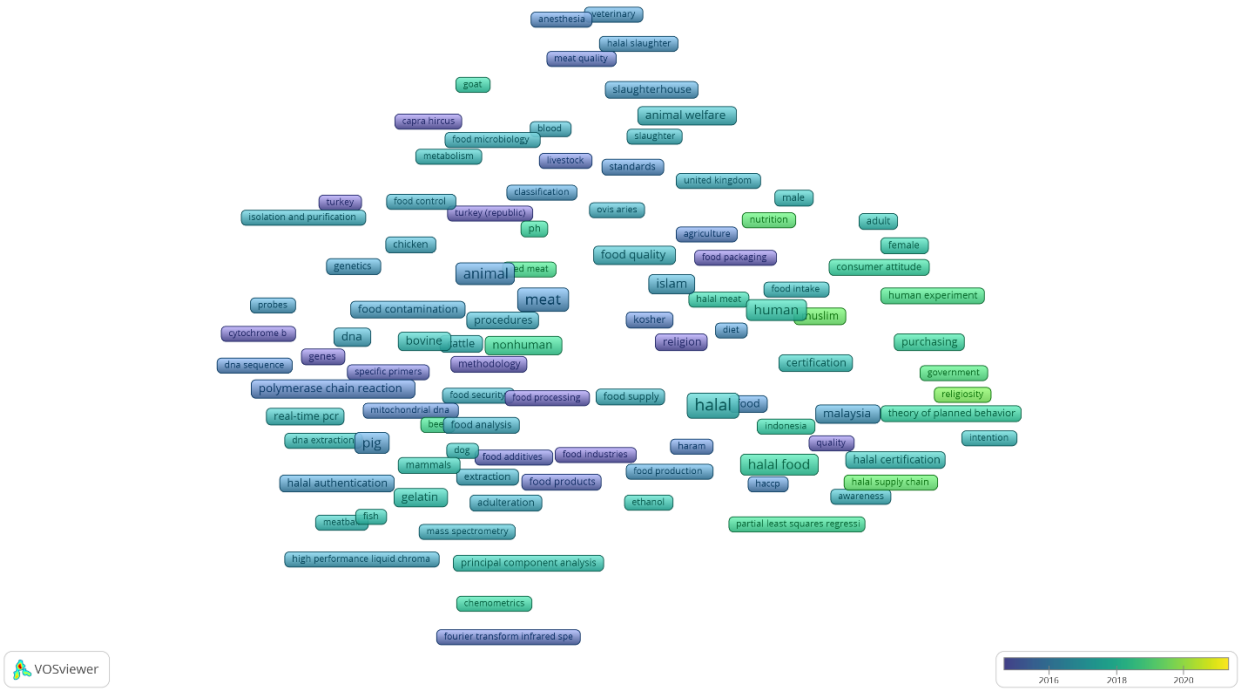

Figure 4. Overlay visualizations of keywords evolution.

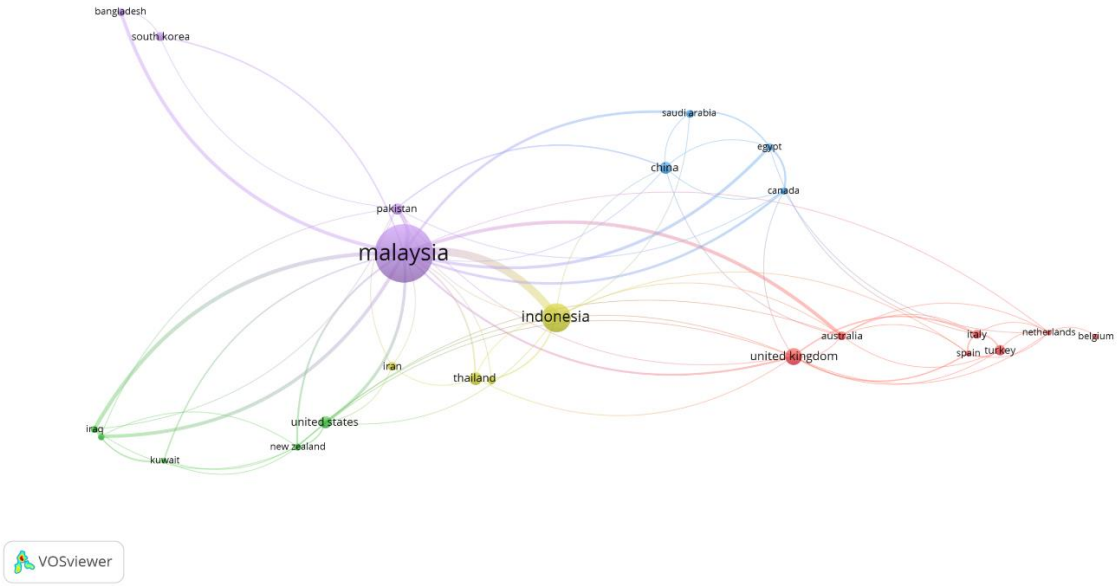

Figure 5. Geographical distribution map.

Geographical Distribution

A total of 455 articles were drawn on the halal food industry obtained from over 24 contributing countries. Table (3) presents the top 10 countries receiving 77.5% of the total citations. As of 2021, Malaysia published the most articles, followed by Indonesia, the United Kingdom (UK), and Thailand.

Malaysia is one of the countries in the world whose government provides full support in promoting the halal certification process for products and services. In 2022, Malaysia has succeeded in occupying the Top Halal tourist destination based on the Global Muslim Travel Index and becoming the Top Muslim-Friendly Destination of the Year. More importantly, Malaysia also dominates the impact of its scientific output on the halal food industry, with a total of 4495 citations or 41.8% of the total citations, followed by the UK, Indonesia, and China.

Table 3. Top-ten countries with the highest number of publications.

	Country	Documents	Citations
1	Malaysia	241	4495
2	Indonesia	72	770
3	United Kingdom	30	792
4	Thailand	19	112
5	United States	18	319
6	China	17	412
7	Pakistan	15	302
8	Turkey	13	297
9	Australia	11	185
	Italy	11	211
10	Iran	10	318
	South Korea	10	118

Halal research trends are also emerging in countries with minority Muslim populations, such as the United Kingdom. In the case of the UK, consumption of halal food reached 8% even though the Muslim population was only 5%. The concept of halal is an absolute key for Muslim consumption. However, the concept of halal is receiving

growing attention among non-Muslim consumers for several reasons, such as how food was prepared in a hygienic and safe environment (Aziz & Chok, 2013).

Furthermore, the co-authorship between countries was illustrated in Figure (5). Malaysia was more collaborative with researchers from Indonesia, Pakistan, and Iraq, whereas the United Kingdom has more collaborations with Malaysia and Italy. Regarding research collaboration between researchers from the top 5 countries, Indonesia still needed to have a halal research collaboration with the United Kingdom. Collaboration in the future is likely to strengthen halal literacy globally.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Increasing the integrity of the halal food industry has been pursued through research on providing alternative halal raw materials, implementing technology to authenticate halal products (raw/processed), and identifying consumer behavior. Furthermore, recent research has started to study a lot about the halal supply chain, efforts to overcome the detection limit on existing halal product authentication methods, and the relationship between nutrition and food hygiene on the consumption of halal food for Muslims.

Recommendations

Further research needs to be conducted to answer the challenges of the halal food industry sector, which has been summarized in this paper with the collaboration of all stakeholders.

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