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## Global Research Hotspots and Trends in Halal Research: A Scientometric Review Based on Descriptive and CiteSpace Analyses

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### ABSTRACT

The halal industry is growing, and there is an increasing recognition of its importance among academics, practitioners, and other industry stakeholders. However, there is limited scientometric research using CiteSpace analysis on halal research. This study is the first to report on scientometric research that used CiteSpace analysis to identify the extent of halal publications. The Web of Science Core Collection databases were queried, and CiteSpace was used for co-citation analysis, while Microsoft Excel was used for descriptive analysis. Our analysis included 1139 publications available in WOSCC between 1987 and 2021. We found a fifteen-fold increase in halal-related publications between 2010 (10) and 2021 (150). Malaysia (37%) and Indonesia (15%) were the top two countries with combined publications more than 50% of published papers. Our literature co-citation cluster analysis identified eleven clusters, with the most prominent being halal tourism, halal certification, pig adulteration, and halal logistics. The major fields with the highest number of halal-related publications were: (i) "Veterinary, Animal Science", (ii) "Psychology, Education, Health"; and (iii) "Economics, Economic, Political". Scientometric analysis of halal research can identify the focal points and frontiers of the field. This study offers valuable theoretical and real-world references, recent developments, and opportunities for collaboration.

## 1. Introduction

Currently, there are 1.7 billion Muslims globally, and by 2050, this number is expected to increase to 2.8 billion, accounting for 26.5% of the world's population [1]. As the Muslim population grows

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rapidly, it is crucial to sustain this growth by addressing various components such as halal food supply, halal tourism, and halal cosmetics and beauty products. Halal refers to something that is permissible or allowed in accordance with Shariah laws, and its popularity has expanded beyond Muslim-majority countries to non-Muslim-majority countries. Among Muslim consumers, one of the most critical components is the availability of halal food. The halal food industry plays a crucial role in ensuring that daily food consumption conforms to Shariah [2]. Muslims are the highest spenders in the food and beverage sector, which the market size was valued at USD 774.93 billion in 2021 and is expected to witness a compound annual growth rate (CAGR) of 3.6% from 2022 to 2030 [3].

The accessibility of halal food in other countries is a crucial factor in expanding the halal tourism industry. Countries with readily available halal food, such as those in East Asia and Southeast Asia, are becoming increasingly popular among Muslim travelers, contributing to the growth of their rural tourism industry [4]. For example, Japan has opened 350 halal restaurants, including those serving traditional Japanese cuisine, to promote their country to Muslim tourists [5]. The expanding Muslim population also drives demand for halal cosmetic and beauty products. The halal beauty products market reached USD 54 billion in 2014 and saw sales of USD 80 billion by 2020. In Europe, the rise in the Muslim population, particularly in France, has led to an increase in demand for halal products. Since 2003, the demand for halal products in the European market has grown by 15% annually [6].

Despite the significant contribution of the halal food industry to the global economy, it faces various challenges, such as issues with halal certification systems, halal authentication in food and non-food products, halal laws, and halal slaughtering [7]. Addressing these challenges requires a collaborative effort from countries, stronger global research intentions, and mutual understanding. Recent years have seen an increase in research into halal to assist the industry, but solutions to the challenges remain elusive. To bridge this gap between research and solutions, bibliometric studies have become a widely used and essential tool for systematically gathering and critically analyzing available data. Several bibliometric studies have synthesized halal-specific topics, including the visualization of knowledge domains in halal food research [8], a structured literature review and research agenda of halal food [9], a bibliometric analysis of halal certification [10], a systematic literature review of qualitative research on halal consumption [11], challenges and strategies in authenticating halal food [12], bibliometrics of kosher meat and production [13], development of halal research [14], and a review and bibliometric analysis of the state of research on halal [15]. Clearly, based on the list of literature review on bibliometric, no publication of bibliometric using CiteSpace is available in the literature.

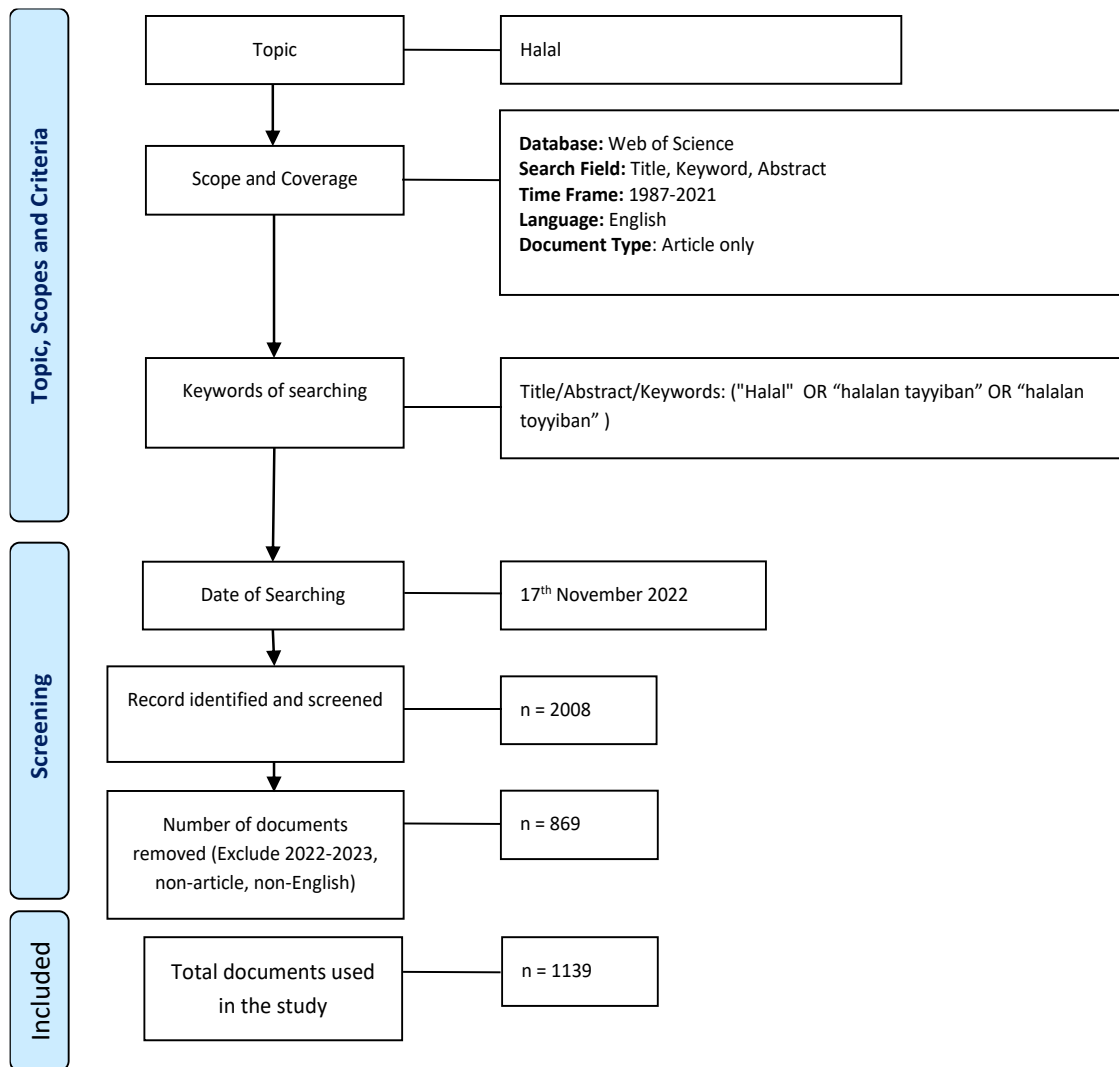
Scientometric analysis can provide insights into the dynamics and connections between journals, authors, and papers in halal research, based on standards such as the growth of knowledge over time, links between subject areas, and intellectual turning points within a subject [16-18]. However, there is a scarcity of scientometric studies on halal research using CiteSpace Analysis, as evidenced by a compilation of literature reviews. Thus, this study aimed to address this gap and achieve two objectives

- i. to determine the landscape of halal research in terms of years, journals, co-cited journals, authors, nations, institutions, keywords, and references.
- ii. to identify the major themes and changes in research priorities over time.

## **2. Methodology**

This study utilized scientometric techniques to examine global halal scientific research networks. Journal articles published between 1987 and 2021 that focused on halal research worldwide were

analyzed using scientometric methods. Scientometric analysis can identify popular research topics, recent trends in chosen research fields, achievements and trends of nations, groups, authors, journals, and other recognized research fields within the given research area [19-22]. Figure 1 illustrates the methodological framework used in this study, which was adapted from Azra *et al.*, [22].



**Fig. 1.** Framework for the current study’s methodologies [22]

### 2.1 Database for Searching

For data mining, the Web of Science (WoS) core collection database from Clarivate Analytics was selected as the data source due to its reliability, extensive coverage of various fields of knowledge, and frequent use as a source for review articles [23]. Furthermore, WoS provides rankings for nations, journals, scientists, works, and organizations by research field. WoS indexed more than 6,650 significant publications from 150 scientific fields, including cited references from those journals [24-25].

## *2.2 Search Strategy*

In conducting the search for the keywords used in this study, we adhered to the Reporting Standards for Systematic Evidence Synthesis (ROSES) [26]. Individual keywords were searched for using the Web of Science Core Collection database, and their search terms were either combined with the "OR" operator or used as a Boolean operator with "\*" symbols for a single character. Only publications between 1987 and 2021 were included in the search, and only original research articles were considered, while editorials, commentaries, brief communications, books and book chapters, protocol papers, theoretical papers, and books were excluded. Non-English language research articles were also excluded. Quantitative, qualitative, and mixed method study designs were all considered. The search was conducted on November 17, 2022.

## *2.3 Article Screening and Study Eligibility Criteria*

Clarivate Analytics collected literature online through the Web of Science Core Collection database, which is one of the most comprehensive databases in the world and covers a wide range of topics [27]. Articles were screened based on three selection criteria: title, abstract, and full text, and the WoS was set to "TS." Only peer-reviewed, English-language publications that were published during the research period and discovered through WoS searches were included in subsequent analyses.

## *2.4 Study Validity Assessment*

The checklist used to assess the validity of this study includes five evaluation criteria, as listed below

- i. The question or objective is adequately described.
- ii. The study design is clear and relevant.
- iii. The sampling strategy is adequately explained, relevant, and supported.
- iv. Data collection techniques are objective and clearly defined.
- v. The data analysis is methodically and fully explained.

None of the articles included in the study met the criteria for exclusion, so none were removed.

## *2.5 Data Extraction and Synthesis*

Data extraction for the halal research was conducted using a Microsoft Excel spreadsheet from Microsoft Office Professional Plus 2019, and displayed in a descriptive format for all term sources, including

- i. The total number of publications.
- ii. Journal names.
- iii. Authors.
- iv. Affiliations.
- v. The nations the authors belonged to and lived in at the time of publication.

CiteSpace version 6.1.4 msi for 64-bit Windows was utilized to visualize knowledge and generate graphics using scientometric research [28].

## *2.6 Descriptive Analysis*

The data were visualized using Microsoft Excel, and simple descriptive analyses were conducted. This included information such as the number of publications per year, the journals in which the articles appeared, the most prolific authors, and the universities/institutions and nations to which the authors were affiliated and where they resided at the time the articles were published.

## *2.7 Scientometric Analysis*

CiteSpace V version 6.1.4 msi for 64-bit Windows was utilized for the knowledge graphic analysis and visualization, as it allows for the creation of numerous bibliometric networks and analysis techniques [29-30]. In this study, the retrieved literature was divided into two categories

- i. Cited journals.
- ii. Citation journals, which were then overlaid on a dual-map to assess cross-domain patterns between specialties related to halal research [30].

CiteSpace was also used to perform keyword analysis to examine instances of two keywords occurring together, and document co-citation analysis (DCA) to evaluate the cluster of co-citation journals. A co-citation occurs when two different sources are cited together in a publication [27,29-30]. The strength of the connections between these elements was assessed using CiteSpace.

As mentioned earlier, the input data for CiteSpace was retrieved from WoS, and a threshold setting was necessary to enable item selection and construct a unique network. In this study, the threshold was set to g-index per slice, allowing for the selection of the most cited items from each slice to create a network based on an input value of 25 and various node types. CiteSpace also displayed and ranked the top 50 most-cited pages accordingly. The years per slice were set to 1 year, and time slicing was set from 1987 to 2021. The network was cleaned up using the pruning parameter. For term sources, the title, abstract, author keywords, and keywords plus were all selected in Web of Science.

Multidimensional clustering was utilized to identify research clusters in priority areas, with the log-likelihood ratio (LLR) providing the best results in terms of uniqueness and coverage, leading to its use in automatically extracting the cluster label. Document co-citation (DCA) was used to visualize the network's shape and form, with both the timeline view and cluster view utilized. The timeline view depicted a vertical range of chronological time periods from left to right, while the cluster view generated a color-coded spatial network of plots that were automatically labeled in landscape orientation.

## *2.8 Quality Control and Impact*

The accuracy and consistency of the studies and the identified clusters were evaluated using the modularity Q index, average silhouette metric, and centrality metric [16-17,31]. A higher index value indicates greater reliability, with a range of 0 to 1 for the modularity Q index. Values greater than 0 indicate greater consistency. The typical silhouette metric ranges from -1 to 1, with higher values indicating greater consistency. Publications that connect more journals or publications and therefore

have more information and pathways through them have a greater impact on the network, as measured by the centrality metric.

Temporal metrics, such as Sigma and Citation Burstness, were used to identify the most important articles and keywords. A red ring appears around the node to indicate a sudden increase in citations for a particular article or an abrupt rise in citation frequencies over a specific period of time [16-17, 31]. Sigma is the result of combining centrality and burstness scores, with a score ranging from 0 to 1. It was calculated as  $(\text{centrality} + 1)^{\text{burstness}}$ , with the highest-quality research having the highest value. Sigma is a tool for identifying and evaluating innovative concepts in scientific literature. [16-17,28,31].

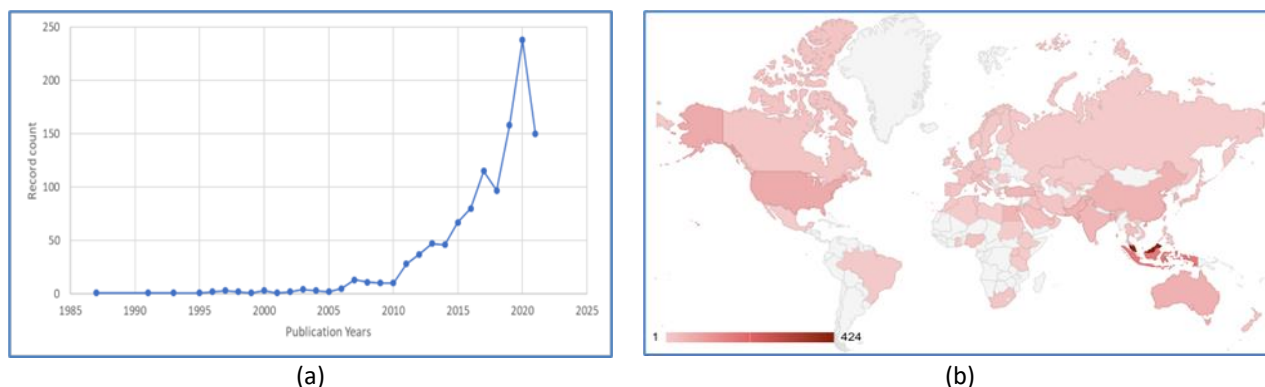
### 3. Results and Discussion

#### 3.1 Descriptive Analyses

This section presents the findings of descriptive analyses, including publication trends and regional distribution, open access status, affiliations of the most productive authors, productive journals, and frequently cited publication journals.

##### 3.1.1 Publication trends and regional distribution

Between 1987 and 2021, a total of 1139 articles on halal research were published in the Web of Science Core Collection (WOSCC) (Figure 2a). The number of publications has been rapidly increasing since 2013 and reached its peak in 2020. These increasing trends in research are likely driven by the growing demand for halal business [32]. In terms of regional distribution, 76 countries or states were found to be active in this area (Figure 2b). Malaysia had the highest contribution to publications with 37.226%, followed by Indonesia in second place with 15.013%, and England in third place with 8.341%.

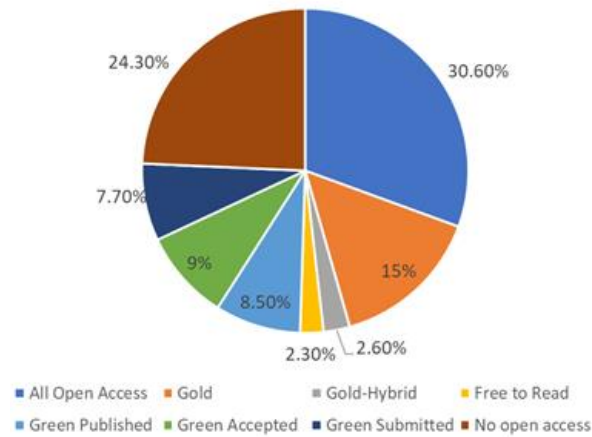


**Fig. 2.** The number of articles published in halal research increased significantly between 2013 and 2020, according to the following publication trends: (a) global distribution of halal research by state and region, with dark magenta representing the highest total number of publications and lighter shades denoting fewer publications

##### 3.1.2 Open access status

According to the WOSCC database (Figure 3), 75.7% of all publications had the Open Access option, while only 24.3% did not. Of the Open Access publications, 30.6% were classified as "All Open Access," 15% as "Gold Access," 2.6% as "Gold-Hybrid," 2.3% as "Free to read," 8.5% as "Green

Published," 9% as "Green Accepted," and 7.7% as "Green Submitted." The remaining 24.3% of publications had no open access status.



**Fig. 3.** Degree of Open Access of the generated halal research literature based on the Web of Science Core Collection database between 1987 to 2021

### 3.1.3 Affiliations and most productive authors

Malaysia stands out as the most significant country in halal research, owing to its numerous universities that concentrate on this field. Table 1 highlights the top eight affiliations in Malaysia that are actively involved in halal research, which are Universiti Putra Malaysia, Universiti Malaya, International Islamic University Malaysia, Universiti Kebangsaan Malaysia, Universiti Teknologi MARA, Universiti Sains Malaysia, Universiti Teknologi Malaysia, and Universiti Sains Islam Malaysia. Additionally, two other affiliations outside Malaysia, namely Egyptian Knowledge Bank EKB, Egypt and Universitas Gadjah Mada University from Indonesia, also made significant contributions in this area.

**Table 1**

Top ten institutional that have written in-depth articles about halal research

Affiliations	Country	Record Count	% of 1,139
Universiti Putra Malaysia	Malaysia	102	8.955
Universiti Malaya	Malaysia	84	7.375
International Islamic University Malaysia	Malaysia	58	5.092
Universiti Kebangsaan Malaysia	Malaysia	52	4.565
Universiti Teknologi Mara	Malaysia	48	4.214
Egyptian Knowledge Bank	Egypt	45	3.951
Universiti Sains Malaysia	Malaysia	43	3.775
Universitas Gadjah Mada	Indonesia	33	2.897
Universiti Teknologi Malaysia	Malaysia	33	2.897
Universiti Sains Islam Malaysia	Malaysia	24	2.107

The academic articles that scholars actively cite delineate the boundaries of a field's research. Table 2 presents a summary of the most highly cited publications in halal research. The authors with the greatest impact are Abdul Rohman from Universitas Gadjah Mada in Indonesia with 26 articles, followed by Awis Qurni Sazili from Universiti Putra Malaysia with 23 articles, and in third place is Shuhaimi Mustafa, also from Universiti Putra Malaysia, with 20 articles. Of the top ten authors, 70%

were affiliated with institutions in Malaysia, while the remaining 30% were from Indonesia (10%), Nigeria (10%), and Saudi Arabia (10%).

**Table 2**

Affiliation of published articles based on the Web of Science Core Collection database between 1987 to 2021

Authors	Record Count	Affiliation	No of publication in WoS	h-index WoS
Abdul Rohman	26	Universitas Gadjah Mada, Indonesia	163	24
Awis Qurni Sazili	23	Universiti Putra Malaysia, Malaysia	152	26
Shuhaimi Mustafa	20	Universiti Putra Malaysia, Malaysia	157	35
Md. Eaqub Ali	20	Universiti Malaya, Malaysia	118	31
Yong Meng Goh	14	Universiti Putra Malaysia, Malaysia	194	27
Yaakob bin Che Man	14	Universiti Putra Malaysia, Malaysia	233	52
Suhaiza Zailani	14	Universiti Malaya, Malaysia	123	36
Zulkifli Idrus	13	Universiti Putra Malaysia, Malaysia	90	25
Kazeem D. Adeyemi	12	University of Ilorin, Nigeria	51	15
Mohd Imran Khan	12	King Abdulaziz University, Saudi Arabia	45	17

### 3.1.4 Productive journal

Out of the 1139 publications in the WOSCC database between 1987 and 2021, Table 3 presents the top ten journals based on the number of publications. The leading journal with the highest number of total articles is the Journal of Islamic Marketing with 18.613%, followed by the British Food Journal with 2.897% and Meat Science with 2.897%. It is evident from Table 3 that research on halal topics can be published in both Q1 and Q4 journals. The highest Impact Factor (IF) for publications in Q1 journals for halal research was Food Chemistry (IF = 9.231), followed by Meat Science (IF = 7.077) and lastly, Food Control (IF = 6.652). In general, the citation trends for halal research are increasing.

**Table 3**

Number of publications from the top ten journals published between 1987 and 2021

Publication Title	% out of 1139	Quartile JIF	JIF 2021	JIF 5 years	Quartile JCI	JCI 2021
Journal of Islamic Marketing	18.613	-	-	-	Q3	0.61
British Food Journal	2.897	Q2	3.224	3.475	Q2	0.95
Meat Science	2.897	Q1	7.077	6.632	Q1	1.46
International Food Research Journal	2.195	Q4	1.169	1.401	Q4	0.23
Pertanika Journal of Social Science and Humanities	1.844	-	-	-	Q3	0.13
Food Chemistry	1.317	Q1	9.231	8.795	Q1	1.89
Food Control	1.229	Q1	6.652	6.498	Q1	1.51
International Journal of Business and Society	1.144	-	-	-	Q4	0.16
Sustainability	1.141	Q2-Q3	3.889	4.089	Q2-Q3	0.65
Food Analytical Methods	1.054	Q2	3.498	3.226	Q2	0.78

Note: Journal Impact Factor (JIF) and Journal Citation Indicator (JCI)

### 3.1.5 Highly cited publication journal

Table 4 presents the 20 most highly cited articles out of 1139 publications retrieved from the WOSCC database between 1987 and 2021. The article "Gelatin alternatives for the food industry: recent developments, challenges and prospects" by Karim, AA *et al.*, in Trends in Food Science and Technology received the highest number of citations (238), followed by Choi, SS *et al.*, in the Journal



of Food Science with 234 citations, and Asgar *et al.*, in Comprehensive Reviews in Food Science and Food Safety with 210 citations.

The top five most cited articles all relate to the field of food science and address topics such as gelatin, meat, non-meat, halal meat, and adulterated pork. Among these topics, halal meat is the most fundamental issue, as according to Sharia law, Muslims are only allowed to consume halal meat. The importance of consuming halal food is emphasized in several verses in the Al-Quran. The term "halal" refers to things or actions that are permissible under Islamic law, and when it comes to food and drink, it includes the concept of Halalan tayyiban [33]. In addition, disciplines such as halal tourism, halal hospitality, and customer behaviour have received high recognition following the fields of veterinary science, animal science, and food science.

**Table 4**

Top twenty articles published between 1987 and 2021 with more than 100 citations

Name of authors	Name of journal	Citation counts*	Journal IF**
Karim <i>et al.</i> , [34]	Trends in Food Science and Technology	238	16.002
Choi <i>et al.</i> , [35]	Journal of Food Science	234	3.693
Asgar <i>et al.</i> , [36]	Comprehensive Reviews in Food Science and Food Safety	210	15.786
Bonne <i>et al.</i> , [37]	British Food Journal	207	3.224
Rohman <i>et al.</i> , [38]	Meat Science	203	7.077
Battour and Ismail [39]	Tourism Management Perspective	167	7.608
Nakyinsige <i>et al.</i> , [40]	Meat Science	166	7.077
Olya and Al-Ansi [41]	Tourism Management	144	12.879
Bonne and Verbeke [42]	Agriculture and Human Values	141	4.908
Ali <i>et al.</i> , [43]	Food Chemistry	132	9.231
Stephenson [44]	Tourism Management	131	12.879
Nurjuliana <i>et al.</i> , [45]	Meat Science	123	7.077
Von Bargaen <i>et al.</i> , [46]	Journal of Agricultural and Food Chemistry	121	5.895
Chriki and Hocquette [47]	Frontiers in Nutrition	120	6.59
Battour <i>et al.</i> , [48]	International Journal of Tourism Research	120	4.737
Doosti <i>et al.</i> , [49]	Journal of Food Science and Technology-MYSORE	115	3.117
El-Gohary [50]	Tourism Management Perspective	113	7.608
Han <i>et al.</i> , [51]	Tourism Management	110	12.879
Jamal and Sharifuddin [52]	Journal of Business Research	107	10.969
Lever and Miele [53]	Journal of Rural Studies	106	5.157

Note: \* Citation count in all databases (WoS, Scopus and others); \*\* Journal Impact Factor for 2021

## 3.2 Scientometric Analysis

### 3.2.1 Author's co-citation analysis

Co-citation is the frequency with which two documents are jointly referred to by other documents. If at least one other document cites two documents together, they are said to be jointly-cited. The more co-citations two documents receive, the higher their co-citation strength, indicating that they are more likely to be semantically related. Co-citation analysis is a quantitative method for mapping scientific knowledge that can identify and locate research related to hot topics, research centres, and research linkages. It is a vital tool for analysing the trend of knowledge base and progress in a certain topic.

Using the Web of Science Core Collection database and only including authors with centrality scores greater than or equal to 0.1, Figure 4 displays the co-citation analysis for halal research authors. Six authors and their articles were found to be significant for halal research based on their centrality values. These authors are

- i. Man YBC from Universiti Putra Malaysia
- ii. Aida AA from Universiti Putra Malaysia
- iii. Velarde, A. from Institute of Agrifood Research and Technology, Spain
- iv. Riaz Mian N from Texas A & M University, USA
- v. Samori Z from UiTM Shah Alam, Malaysia
- vi. Nakyinsige K from Salahaddin University, Iraq

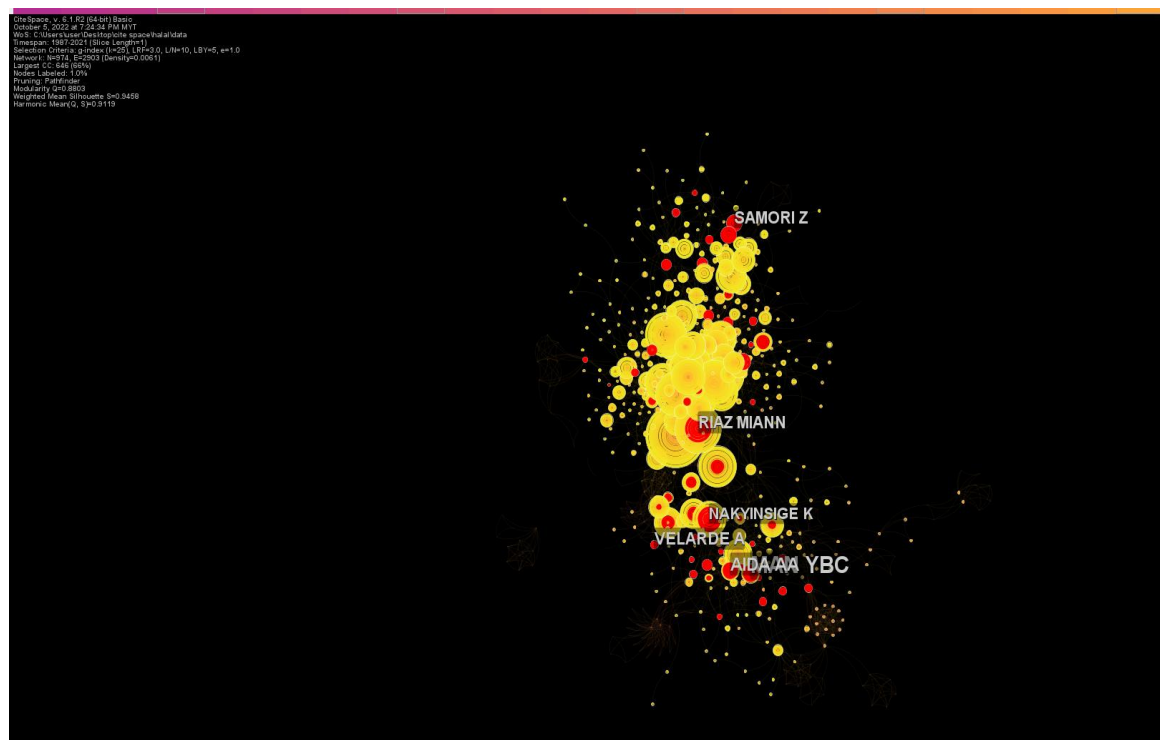


Fig. 4. Author co-citation analysis

### 3.2.2 Co-citation network analysis

The identification of distinct communities based on associations in the scientific community, on the World Wide Web, and in scientific publications has gained more attention in recent times [54-55]. One reason for this interest is the resurgence of social network analysis, which has been inspired by the rapid advancements in complex network analysis. Most community detection techniques rely on Freeman's betweenness centrality metric. CiteSpace, which has been used to determine the centrality of nodes across nations, organizations, journals, cited articles, and clusters, has recently been applied in this regard [56]. A node's betweenness centrality indicates the likelihood that it will be directly on any graph's shortest path. In CiteSpace, the betweenness centrality of nodes is used to identify connections between different theme clusters. In other words, the betweenness centrality of pivots is instrumental in the development of scientific networks.

Table 5 illustrates that Malaysia has the highest centrality score (0.49), indicating that it is the hub for key players in advancing halal research. This means that Malaysia has the most significant impact in halal research. With 379 published papers out of a total of 1139 publications, Malaysia also has the highest publishing frequency. According to the cited half-life, which is 13.5, the median age of a journal article in the JCT year was 13.5 years ago. England has the second-highest centrality, with a score of 0.26 and contributions to 89 publications with a cited half-life of 20.5. Indonesia, on the other hand, has the second-highest publication frequency (total = 139) but a low centrality score of

0.06. It is understood that only centrality scores above 0.1 had the greatest impact on the co-citation network. Besides Malaysia and England, the United States of America, Egypt, and the United Arab Emirates are other countries with centrality scores above 0.1.

In addition to centrality, burstness is also an important indicator. A burst refers to a sudden increase in the frequency of a specific type of event. CiteSpace can detect bursts on various types of events, such as phrases of one or more words from the title, abstract, or other parts of a publication, the number of citations of cited references over time, the frequency of occurrence of keywords over time, and the number of publications by an author, institution, or country [57]. According to Table 5, Nigeria shows the highest burstness with a score of 6.04, followed by Australia with 5.09, Iraq with 4.99, and the United States of America with 3.6.

**Table 5**  
 Top Ten co-citation network analysis between countries

Countries of authors	Frequency	Burst	Degree	Centrality	Sigma	Half-life
Malaysia	379	-	33	0.49	1.00	13.5
Indonesia	139	-	9	0.06	1.00	17.5
England	89	-	21	0.26	1.00	20.5
USA	64	3.6	19	0.24	2.14	16.5
Australia	46	5.09	11	0.09	1.55	13.5
Turkey	40	-	15	0.06	1.00	14.5
Egypt	39	-	13	0.16	1.0	19.5
United Arab Emirates	20	-	17	0.10	1.00	8.5
Nigeria	19	6.04	5	0.01	1.03	0.5
Iraq	16	4.66	4	0.00	1.00	1.5

Figure 5 displays the document co-citation analysis which is dominated by publications from Malaysia, Indonesia, and England. A total of 76 countries contributed to the publications in this area, with Malaysia having the highest share of publications at 37.23%. Indonesia is the second-highest contributor with 15.01% of the total publications. The figure also presents a network of co-authors based on countries to provide a more comprehensive view of country collaboration in Halal research. The yellow line indicates the cooperation among the countries, with each node representing a nation. Only the countries with a centrality score greater than 0.1 are displayed with the size of the nodes indicating the country's centrality score.



**Fig. 5.** Document co-citation analysis

Together with the document co-citation analysis shown in Figure 6, these analyses demonstrate that the interaction between different authors and articles has an impact on Halal research. The element ranked first by centrality is Tieman M [58] in cluster #3 (halal logistics) with a centrality score of 0.12. The second is Nakyinsige K [40] in cluster #3 (halal logistics) with a centrality of 0.12. The third is Van Derspiegel m [59] in cluster #2 (pork adulteration) with a centrality of 0.10. Fourth place is Bonne K [37] in cluster #5 (Halal Meat Status) with a centrality score of 0.09. Fifth is Alam SS [60] in cluster #4 (Halal food purchases) with a centrality of 0.08. Sixth is Ahmed A [61] in cluster #15 (halal) with a centrality of 0.08. Seventh is Zulfakar MH [62] in cluster #1 (Halal certification) with a centrality score of 0.08. Eighth is Nakyinsige K [63] in cluster #8 (oxidative stability) with a centrality of 0.08. Ninth is Aziz YA [64] in cluster #3 (halal logistics) with a centrality score of 0.06. Tenth is Rohman A [38] in cluster #2 (pork adulteration) with a centrality of 0.06.

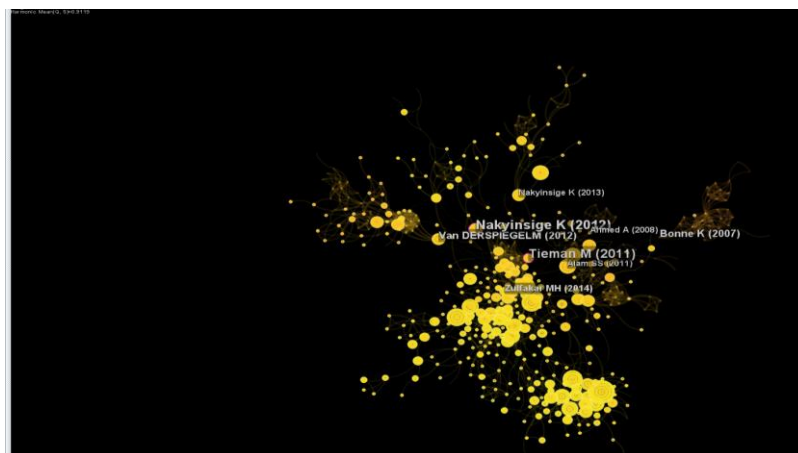


Fig. 6. Document co-citation analysis

### 3.2.3 Document cluster analysis network

The cluster analysis shown in Figure 7 indicates that halal tourism, halal certification, pork adulteration, halal logistics, and purchasing halal food products are among the top five clusters that are significant in halal research over time.

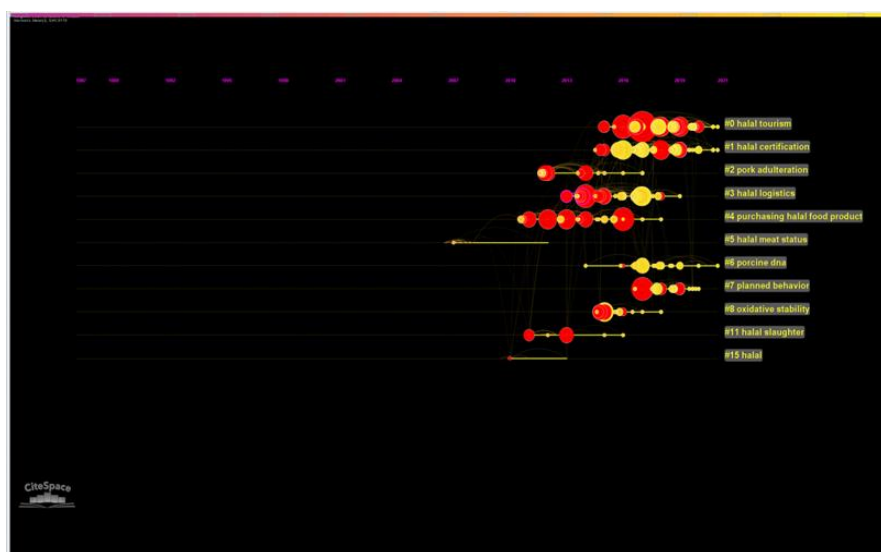


Fig. 7. Timeline view of document co-citation networks

The frontier of Halal research was developed using CiteSpace, with the knot visualization process applied to cited references from 1987 to 2021. The slice length was set to 1, and the selection criteria were g-index with LBY = 5 (tracing period of 5 years) and pruning with Pathfinder. The modularity Q index and average silhouette metric for the document co-citation network were 0.8803 and 0.9458, respectively, indicating a high level of reliability and homogeneity. The analysis resulted in 11 co-citation clusters, as summarized in Table 6.

Text mining and keyword analysis techniques in the CiteSpace programme were used to produce the cluster labels. Four techniques; Latent Semantic Indexing (LSI), Term Frequency\*Inverted Document Frequency (TF\*IDF), Loglikelihood Ratio (LLR), and Mutual Information; were used to name these clusters (MI). This study reports the cluster based on loglikelihood ratio (LLR) as the other outputs from LLR were not always reliable [65].

**Table 6**  
 Top 11 cluster within the halal research area

Cluster ID	Size	Silhouette	Mean year	Label (LLR) – Cluster label	Label (MI)	Average Year
0	85	0.954	2019	halal tourism (608.17, 1.0E-4)	social capital capabilities (1.47)	2019
1	78	0.879	2018	halal certification (155.53, 1.0E-4)	halal executive’s consultant (1.19)	2018
2	61	0.994	2013	pork adulteration (156.54, 1.0E-4)	beef jerky (0.26)	2013
3	60	0.909	2015	halal logistics (220.67, 1.0E-4)	beef jerky (1.46)	2015
4	54	0.927	2013	purchasing halal food product (105.68, 1.0E-4)	boycotting foreign product (0.69)	2013
5	34	0.992	2007	halal meat status (49.76, 1.0E-4)	halal tourism (0.02)	2007
6	34	0.962	2018	porcine DNA (117.31, 1.0E-4)	beef jerky (0.31)	2018
7	32	0.94	2018	planned behavior (169.5, 1.0E-4)	Islamic purchasing behavior (0.53)	2018
8	32	0.993	2016	oxidative stability (260.89, 1.0E-4)	physio-chemical characteristics (0.13)	2016
11	18	0.999	2013	halal slaughter (75.09, 1.0E-4)	beef jerky (0.06)	2013
15	10	0.987	2010	halal (28.81, 1.0E-4)	halal tourism (0.02)	2010

The largest cluster (#0) comprises 85 members and has a silhouette value of 0.954. It is labelled as Halal Tourism by both LLR and LSI, and Social Capital Capabilities by MI (1.47). The most relevant article cited in this cluster is Papastathopoulos, A. [66]. The second largest cluster (#1) consists of 78 members and has a silhouette value of 0.879. It is labelled as Halal Certification by both LLR and LSI, and Halal Executive Consultant (1.19) by MI. The most relevant cited article in this cluster is Khan, S. [67]. The third largest cluster (#2) comprises 61 members and has a silhouette value of 0.994. It is labeled as Pork Adulteration by both LLR and LSI, and Beef Jerky (0.26) by MI. The most relevant cited article in this cluster is Ali [68].

### 3.3 Research Hotspots and Trends

#### 3.3.1 Co-occurrence keywords

Keywords serve as a summary of research topics and the main content of literature. By analysing keywords, we can identify the hotspots in the field. In the CiteSpace software interface, Keywords were used as nodes, Years Per Slice was set to 1, g-index was set to 25, and 523 keywords were identified. The top three keywords are "polymerase chain reaction", which had a burst from 2011 to 2017 and is often used for studies related to Halal authentication with molecular techniques. The keyword has a strong burst score of 6.27. The second keyword is "halal slaughter", with a burst power of 5.93 and is one of the most important disciplines in Halal research. The keyword's burst began in 2014 and ended in 2017. The third important keyword is "meat quality" with a burst power of 5.76. Research into meat quality is critical in the field of food and veterinary science. The burstness started in 2013 and ended in 2018.

**Table 7**

Top 10 keywords with the strongest citation burst (Red bars indicate keywords cited frequently; blue bars indicate keyword cited infrequently)

Keywords	Year	Strength	Begin	End	1987 - 2021
polymerase chain reaction	1987	6.27	2011	2017	
halal slaughter	1987	5.93	2014	2017	
meat quality	1987	5.76	2013	2018	
identification	1987	5.31	2012	2015	
beef	1987	4.57	2009	2014	
tourism	1987	4.01	2019	2021	
image	1987	4.01	2019	2021	
raw	1987	3.90	2012	2014	
calve	1987	3.86	2004	2012	
innovation	1987	3.62	2015	2016	

#### 3.3.2 Burstness analysis

The top-ranked element by bursts is Wilson JAJ [69] in cluster #4 (purchasing halal food products), with bursts of 13.16. The second is Battour M [39] in cluster #0 (halal tourism), with bursts of 11.57. The third is Mukhtar A [70] in cluster #3 (halal logistics), with bursts of 11.11. The fourth is Han H [51] in cluster #0 (halal tourism), with bursts of 11.08. The fifth is Wilson JAJ [71] in cluster #4 (purchasing halal food products), with bursts of 10.85. The sixth is Alam SS [60] in cluster #4 (purchasing halal food products), with bursts of 10.41. The seventh is Lever J [53] in cluster #11 (halal slaughter), with bursts of 8.47. The eighth is Wilson JA [72] in cluster #4 (purchasing halal food products), with bursts of 8.13. The ninth is Aziz YA [64] in cluster #3 (halal logistics), with bursts of 8.02. The tenth is Van Der Spiegel [59] in cluster #2 (pork adulteration), with bursts of 7.84.

**Table 7**

Top 10 keywords with the strongest citation burst (Red bars indicate keywords cited frequently; blue bars indicate keyword cited infrequently)

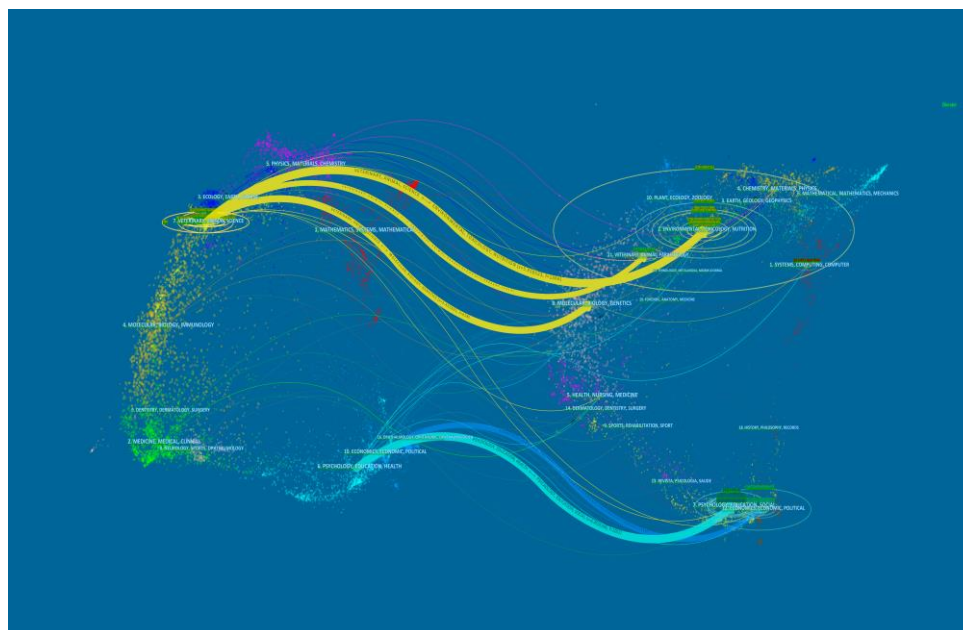
References	Burst Strength	Duration	Cluster ID	1987 – 2021
Wilson JAJ	13.16	2011-2015	4	
Battour M	11.57	2019-2022	0	
Mukhtar A	11.11	2015-2017	3	
Han H	11.08	2020-2022	0	
Wilson JAJ	10.85	2013-2016	4	
Alam SS	10.41	2013-2016	4	
Lever J	8.47	2015-2017	11	
Wilson JA	8.13	2017-2019	4	
Aziz YA	8.02	2014-2018	3	
Van Derspiegel	7.84	2014-2017	2	

### 3.3.3 Dual map overlay

The dual-map overlay in Figure 8 depicts the landscape of halal research articles from 1987 to 2021. This tool helps to identify the disciplines leading the foundational research in the field and those that are most active in referencing halal research. The nodes on the left represent articles citing other articles, while the nodes on the right represent the disciplines and referenced articles relevant to halal research. The thickness of the curves between any two nodes represents the strength of their relationship, based on the number of citations in the dual map overlay graphic. The ovals in the map indicate the presence of clusters actively citing and being cited by journals in the field.

The disciplines with the most papers related to halal research are "Veterinary, Animal Science", "Psychology, Education, Health", and "Economics, Economic, Political". Among these, publications in the "Veterinary, Animal Science" discipline are the most frequently cited in "Environmental, Toxicological, Nutrition" with a z-score of 5.91 and f-value of 1366, followed by "Molecular Biology, Genetics" with a z-score of 2.43 and f-value of 618, and "Veterinary, Animal Parasitology" with a z-score of 1.95 and f-value of 514. All three disciplines are considered the intellectual basis for scientific and technical research.

Interestingly, publications in non-science technology areas such as "Psychology, Education, Health" and "Economics, Economic, Political" are also prominent in halal research. Research from the "Psychology, Education, Social" discipline with a z-score of 4.45 and f-value of 1052 cites publications in "Psychology, Education, Health". Similarly, research from the same discipline is cited by publications in the field of "Economics, Economic, Political" with a z-score of 2.15 and an f-value of 558. This suggests that the study of halal research has an interdisciplinary character, as evidenced by the numerous interactions between different disciplines and research centres represented on the map.



**Fig. 8.** Dual-map overlay on Halal research

### 3.4 Limitation of Study

Despite shedding light on the halal research network and its scientific foundation, this study has certain limitations. Firstly, it only focused on scholarly articles on Halal research available in the WoS (core collection only) and excluded other important databases like Scopus and PubMed. Previous research has shown that different databases, such as Scopus versus WoS, have their own biases in source selection and entry updates [73]. Secondly, all articles analyzed in this study were written in English. Lastly, while CiteSpace software was used to identify datasets, it may not be as comprehensive as a more thorough systematic assessment that involves manual selection.

When compared to other public datasets, WOS's database is more extensive and focused on both physical and social sciences, making it ideal for research [24-25]. However, there are still limitations to this study. Utilizing CiteSpace to mine the data is another restriction, as the software automatically gathers the dataset, and it is possible that some unrelated topics were included, which could distort the findings. It can be difficult to strike a balance between using stringent standards and excessively eliminating particular studies.

Additionally, in this study's co-citation analyses, only the names of the primary (first) authors were used, and databases of referenced publications downloaded from WOS did not contain the identities of additional authors who contributed to the work. The co-citation study could produce different findings if these databases had provided more author names. Lastly, all the articles analyzed in this study were in English, which may limit the generalizability of the findings to non-English-speaking countries or regions.

## 4. Conclusions

This study was aimed to determine the landscape of halal research in terms of years, journals, co-cited journals, authors, nations, institutions, keywords, and references; and to identify the major themes and changes in research priorities over time. In summary, this study used scientometric analysis using CiteSpace to examine the landscape of halal research and identified major themes and changes in research priorities over time. The study revealed eleven major clusters in halal research,



with the most prominent being halal tourism, halal certification, pig adulteration, and halal logistics. This study has provided important insights into the halal research landscape and can serve as a useful reference for researchers, policymakers, and industry practitioners. However, it is important to acknowledge the limitations of the study, including the use of a single database and the potential biases introduced by using automated tools for data analysis. Overall, the study highlights the need for continued research in halal-related topics and interdisciplinary collaboration in the field of halal research to address its complex challenges and opportunities while meeting the needs of various stakeholders.

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