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Food Safety and Halal Food in the Supply Chain: Review and Bibliometric Analysis

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Abstract:

Purpose: Researchers have been actively investigating various issues concerning food safety and halal food in the supply chain. The ultimate goal is to provide guarantees for quality and conformance regarding food standards and demanding expectation from the consumers. We review a set of two-decade food safety and halal food in supply chain (SC) literature from 1990 to 2018 (month of February) in order to pinpoint the problems, models, solution approaches and more importantly, the future directions of this field.

Design/methodology/approach: Our method employs the 120 published articles on food safety and halal food in SC research. Various techniques from statistics, bibliometrics, and analytics are systematically deployed to gain insights on how the literature address these two topics.

Findings: The predominant contributing articles, authors, affiliations, and keywords have been reviewed, clustered, and thoroughly analyzed. Through systematic graphical and clustering analyses, four major clusters regarding food safety and two clusters in halal food in SC research have been identified as the most promising and potential future for research opportunities.

Research limitations/implications: This study focuses on articles that discuss food safety and halal.

Practical implications: Our findings provide valuable insights to understand the major clusters of the research endeavour along with the plausible pathways to where they would likely develop in the future. With these insights, researchers and practitioners shall be able to devise initiatives that are of high relevance and significance in the near future.

Social implications: This research provides an understanding to the reader about the relationship between food safety and halal.

Originality/value: This paper provides the first systematic overview of food safety and halal food for supply chain researchers to see the big picture of the field. Serving as the thread connecting research endeavour in these two research areas, our novel work highlights how the work is connected, which research clusters have been the center-of-attention during the last two decades, and consequently, which areas are still lacking an investigation. We believe that people in both academia and industry who are keen to develop a rigorous solution to ensuring food safety and food halal-ness to satisfy global market requirement will be benefitting the most from our analysis.

Keywords: food safety, halal food, supply chain, bibliometric analysis, network analysis, literature review

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1. Introduction

In recent years, food safety and halal food have been part of the actively researched issues in the food quality literature. As related to the quality, the notion of food "halal"-ness is closely associated with the availability of safe and healthy products. In a similar sense, food safety is arguably emphasizing similar goal, especially from the health aspect (Sani & Dahlan, 2015). Furthermore, the issues concerning food safety are one of the most important themes to investigate thoroughly, because the lack of food safety has led to various adversarial incidents. In fact, the demand for ensuring food safety is sharply exponentiating in recent years, because the occurrence of unsafe food consumption linked to deaths have been reported globally. In addition to that, news regarding the food contamination with harmful bacteria, viruses, parasites and chemical substances, responsible for more than 200 diseases, ranging from diarrhoea to cancer, have tremendously affected how consumers globally raise their safety standards towards the food products (WHO, 2016). Facing almost the same pattern of increased demand, halal food market has grown significantly over the last five years, because this type of food has now been consumed by both the Muslim and non-Muslim customers. (Rezai, Mohamed & Nasir-Shamsudin, 2012; Vanany, Maarif & Soon, 2019). Subsequently, halal, as a necessary-and-sufficient condition for food for Muslim consumers, is currently a highly active theme of study for researchers in various part of the world. Reuters and Standards (2016) reported that the halal food sector would grow approximately 18.3% of the global food expenditure to US$ 1,914 billion by 2021.

The previous researchers have studied and reported the recent developments regarding food safety and halal food in the supply chain (SC). Among the topics studied, under food safety literature in SC, are food safety management system for fresh products in the SC (Kirezieva, Luning, Jacxsens, Allende, Johannessen, Tondo, et al., 2015), traceability in the food SC (Aung & Chang, 2014) and multi-player interactions in food safety in an integrated SC (Vitalis, Khaizura & Son, 2016). Meanwhile, under halal SC literature, topics such as halal SC for manufacturing industries (Ngah, Zainuddin & Thurasamy, 2014), analysis of halal logistics (Ab Talib, Abdul Hamid & Zulkafar, 2013), and halal principles in the SC (Tieman, van der Vorst & Ghazali, 2012) have recently been published in various journals. It is disconcerting that these valuable research endeavour, to some extent, are scattered and there has been no effort to provide a systematic review to make them useful for researchers and practitioners in the field.

In this study, we deploy the bibliometric and network analyses to fulfil the needs of such a systematic review. It is widely known that bibliometric and network analyses are among the powerful techniques to identify and cluster the area of research, which can lead to insightful follow-up analysis. Hence, the objective of this paper is to review food safety and halal food discussion in the SC context using these powerful techniques.

The bibliometric analysis is a systematic analytical technique to identify the most influential authors, their affiliations, the keywords they use and more importantly how these attributes link one work to the other. The network analysis, on the other hand, is a rigorous method to determine the cluster of the research areas, thus revealing the directions and gaps in the future research. The systematic guidelines for the bibliometric analysis by Fahimnia, Sarkis and Davarzani (2015) and network analysis using VOSviewer by Cancino, Merigo, Coronado, Dessouky and Dessouky (2017) were adopted in this research. We applied these to the pre-processed 120 published articles on food safety in SC and 33 published articles on halal food in SC from 1990 to 2018. Our goal is that this systematic review will be helpful for researchers, who want to understand the most recent findings and be able to position their line of work. We also believe that this work will be benefitting the practitioners, who need a concise and insightful summary of the literature to understand the state of the research in food safety and halal food in SC systems.

This paper is structured as follows: Section 2 introduces the structured research method, including selection of a bibliometric database, including-and-excluding articles and analysing the articles' attributes. Section 3 reports the statistics of the data and the derived classification analysis. The results and detailed bibliometric and network analyses will be presented in section 4 and section 5, respectively. Finally, section 6 summarizes the discussion and provides conclusions for the opportunity of future research.

2. Research Methods

Our review approach embarks with a preliminary goal of exploring the body of literature, following the related articles and tracing the attributes to attain the big picture of research endeavour in food safety and halal food in context of SC. The procedures are comprehensively performed using iterative cycles of defining relevant and informative keywords, querying the literature database, and performing rigorous analytics (Saunders, Lewis & Thornhill, 2009). We adopted a review of research methods from Fahimnia et al. (2015) and Wamba and Mishra (2017), in which a five-stage research method to achieve similar study objectives are proposed. These five stages are as follows: (1) defining search terms, (2) including-and-excluding articles, (3) selecting the process of articles, (4) performing preliminary data analysis and (5) conducting bibliometric and network analysis. In what follows, we elaborate each of these stages to assure the validity of our findings and to enable the readers to implement this method for systematically performing an analysis-based literature review in their study.

2.1. Selection of Bibliometric Database and Defining Serach Terms

We chose the Scopus database, which is one of the largest bibliometric databases of peer-reviewed articles. It is worth mentioning that this database has been providing an access to high-quality refereed articles, published since 1966 (Burnham, 2006) and has about +22,800 series titles from +5,000 publishers, covering 195 million of reference records (Elsevier, 2017). It is noteworthy that most of the journals in Scopus and Web of Science (WoS) are dual-indexed in both databases, alleviating the need of digging from both sources (Gavel & Iselid, 2008).

We define the search terms or the keywords used for data collection on the food safety in SC research as "Food", "Safety", "Supply Chain", and "Food Safety" or their meaningful combinations; for instance, "Food Safety" AND "Supply Chain" and "Food" AND "Safety" AND "Supply Chain". In context of halal food in SC research, the keywords used are "Halal", "Food", and "Supply Chain". The combinations considered include "Halal Food" AND "Supply Chain" and "Halal" AND "Food" AND "Supply Chain". Using these search terms, we query the database and perform our next stage.

2.2. Including and Excluding Articles

The goal of this including-and-excluding stage is to collect and store the most relevant articles that were extracted from query results of the initial search terms. We considered journal articles excluding several source types (such as conference proceedings and book series) and searching the terms within the "title, abstract, and keywords" fields in Scopus database. Our further exclusion criteria encompass the types of the document. We only considered journal articles written in English and published between 1990 and 2018. We also eliminated conferences paper, editorial, erratum/collection, letter, note, review and short survey to ensure that our analysis will be based only on those peer-reviewed, final version, and widely disseminated work. Our query returned 1,694 articles for food and 53 articles for halal food, all in SC research context. The search results including essential attributes of the articles, such as the name of the author(s), title, year, citation count, affiliations, keywords and references were stored in RIS and CSV format for analytical purposes.

2.3. Selection Process of Articles

By further processing the query results, we removed article duplication using Endnote software. This selection process is conducted so that we only regard published articles restricted in the related subject area (e.g., business, management and accounting, agricultural and biological sciences, computer science, engineering and decision science). For assuring high relevance, we carefully read the abstract of the candidate articles. As a result, we reduced the article numbers from 1,694 to 120 on food safety and from 53 to 33 on halal food in SC.

2.4. Performing Preliminary Data Analyses

At this stage, we obtained some statistics from the data including (1) the annual distribution of the published articles and (2) the article distribution by years and journals. The annual distribution of published articles is used to understand the trend of related articles, while the article distribution data by years and journals are both used to further analyse and determine which journals are publishing the most articles on food safety and halal food issues in SC context. Further, we classified the articles based on two dimensions: (1) the types of food products being addressed and (2) the types of research methods being utilized. We studied the abstract and the related subsections of these papers carefully to identify these dimensions whenever possible. The statistics and output of the classification analysis are presented in section 3.1 and section 3.2 respectively.

2.5. Conducting Bibliometric and Network Analysis

Finally, we conducted the bibliometric analysis using BibExcel and network analysis using VOSviewer. Bibliometric analysis helps us to map the contributing author, affiliation and keywords. In this regard, BibExcel is the preferred tool to utilize because of its high degree of flexibility to deal with large datasets and its compatibility to various network analysis applications, such as Gephi, Pajek and VOSviewer (Persson, Danell & Schneider, 2009). Following that, the network analysis employing VOSviewer is conducted. It is obvious that our choice of BibExcel provides advantages to integrate these two analyses and avoids the errors related to the misinterpretation and disintegrated metrics. It also noteworthy that this tool has the ability to adjust and, in some sense,, 'normalize' the input data obtained from the multi-source databases, including Scopus and Web of Science (Persson et al., 2009). The results of our bibliometric analysis and network analysis are presented in sections 3.3 and 3.4, respectively.

3. Results of Statistical and Classification Analyses

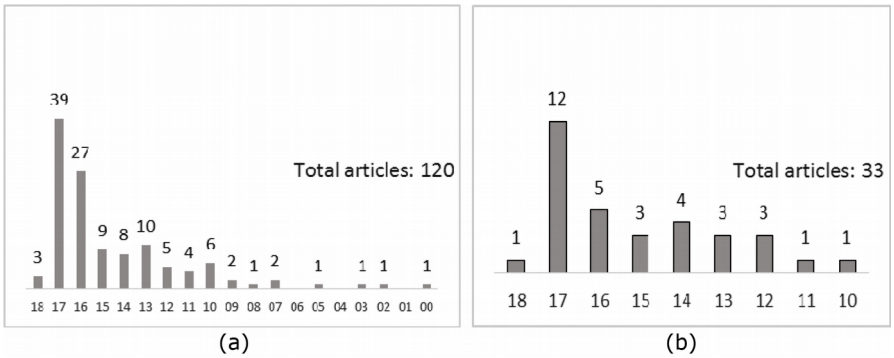
In this section, we will discuss our results from the analytical tools and highlight some interesting insights regarding the nature of the published work in the field of food safety and halal food in SC context.

3.1. Initial Statistical Analysis

The initial statistical analysis is used to describe the annual distribution of the published articles to understand the trend of the quantity over time. The article distribution by years and journals are used to identify the most publishing journals along with the number of articles published each year.

3.1.1. The Annual Distribution of the Published Articles

The annual distribution of the published articles on food safety and halal food in SC context are shown in Figure 1 (a. food safety in SC and b. halal food in SC). The first article addressing the food safety issues was published in 1990, while the first one addressing food safety in SC context was published a decade later, in 2000. Figure 1a shows that there is a significant increase in food safety concerns in SC context, as shown by the trend of publications within the 17-year period. Meanwhile, the first article of halal food research was published in 2008. Two years later, an arguably short period of time, an article discussing halal food issue in SC context was published in 2010.



Note: x-axis = amount of articles and y-axis = year

Figure 1. Annual distribution of articles on (a) food safety in SC (b) halal food in SC

Figure 1a shows the number of published articles on food safety in SC by years. In this figure, it is obvious that the number of published articles increased during the period of 2000–2017. It can be observed that the last two years, 2016 (27 articles (22.50%)) and 2017 (39 articles (32.50%)), are both representing big jumps in terms of number of published articles, indicating that the food safety in SC research has recently attracted significant attention from many researchers and would very likely continue to do so, if not amplify, in the near future. In Figure 1b, the number of articles on halal food in SC also increased from 2011 to 2017, with the most publication in 2017 (12 articles (36.36%)). These findings align with Reuters and Standards (2016) prediction that the demand concerning food safety and halal food, especially that applied in the whole chain, will continue to exponentiate in the foreseeable future.

3.1.2. Article Distribution by Journals and Years

Our review of 120 articles on food safety in SC from 84 journals and 33 articles on halal food in SC topic from 24 journals, reveals that over thirty-three percent of the articles in food safety in SC have been published in ten flagship journals (see Table 1). It is interesting to note that the issues of food safety in SC are highlighted, addressed and published in journals from various fields, such as agricultural and biological sciences, business, management, accounting, decision science and computer science, indicating the multi-disciplinary nature of the problems. It can be noted that The Food Control (17 articles (14.17%)) and British Food Journal (5 articles (4.17%)) both published more articles in this regard than other journals in consideration. The annual distribution of the published articles on food safety in SC by various journals is shown in detail in Table 1.

No	Name of Journal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
1	Food Control								1					1	1	1	2	5	6		17
2	British Food Journal*				1										1		1	1	1		5
3	Food Research International											1		1						1	3
4	Trends in Food Science and Technology *																	1	1	1	3
5	Journal of Marketing Channels																		2		2
6	Meat Science *								1										1		2
7	Sustainability (Switzerland)																	1	1		2
8	Critical Reviews in Food Science and Nutrition																	1	1		2
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81	China Economic Review		1																		1
82	Journal of Agricultural Economics										1										1
83	Asian- Australasian Journal of Animal Science																		1		1
84	Journal of Industrial Engineering and Management																		1		1
Total		1	0	1	1	0	1	0	2	1	3	5	4	5	9	8	9	27	39	3	120

Table 1. Distribution of food safety in supply chain articles by years and journals

Table 2 shows the distribution of articles on halal food in SC by different years and journals from a total of 24 journals. The five most publishing journal is the Journal of Islamic Marketing (6 articles (18.18%)), British Food Journal (6.06%), Industrial Management and Data System (6.06.1%), International Business Management (2 articles (6.06%)) and International Journal of Supply Chain Management (6.06%). This indicates that research related to halal food in SC is also an active and multi-disciplinary area spanning from business, management, and accounting, agricultural and biological sciences, computer science, to decision sciences.

No	Name of Journal	Publication Year									Amount
		'10	'11	'12	'13	'14	'15	'16	'17	'18	
1	Journal of Islamic Marketing		1	1			1		2	1	6
2	International Journal of Food Properties								1		1
3	Food Policy								1		1
4	International Journal of Supply Chain Management								2		2
5	British Food Journal								2		2
6	Industrial Management and Data Systems								2		2
7	Social Science Pakistan							1			1
8	Supply Chain Management								1		1
9	Journal of Macro-Marketing							1			1
10	Meat Science							1			1
11	Jurnal Pengurusan							1			1
12	International Business Management			1				1			2
13	Asian Pasific Journal of Marketing and Logistic						1				1
14	Journal fo Food Product Marketing					1					1
15	Journal of Internastional Food and Agribusiness Marketing					1					1
16	Industrial Engineerin and Management System					1					1
17	Sustainabilty (Switzerland)					1					1
18	American Journal of Enviromental Science				1						1
19	International Journal of Lean Six SIgma				1						1
20	Advance in Natural and Applied Science			1							1
21	Advance Science Letters								1		1
22	Enviromental Law and Management	1									1
23	Food Additive and Contaminants Part A Chemistry, Analysis Control, Exposure and Risk Management						1				1
24	Recents Patents on Food Nutrition and Agriculture				1						1
	Total	1	1	3	2	5	3	5	12	1	33

Table 2. Distribution articles of halal food in supply chain by journals and years

There are 7 journals that published articles about the food safety and halal food in SC, namely: (1) Journal of Islamic Marketing, (2) British Food Journal, (3) Industrial Management and Data Systems, (4) Food Additives and Contaminants Part A Chemistry Analysis Control Exposure And Risk Assessment, (5) Food Policy, (6) Meat Science and (7) Sustainability Switzerland. These results align with the commonly acknowledged idea that there is indeed a close relationship between food safety and halal food issues in SC and integratedly addressing both issues simultaneously would lead to highly effective and robust SC strategy.

3.2. Classification Analysis

3.2.1. Types of Research Methods

According to Chen, Zhao, Tang, Price, Zhang and Zhu (2017), the various research methods used by the researchers on food safety and halal food in SC context can generally be divided into four classes: survey, case study, concept development and modelling. In this context, a survey is a research method that is useful to investigate characteristics of the population under study. A case study is highly effective to understand various real-life phenomena. The concept development describes the methodological approach developed to further advance science and human understanding. Finally, the modelling is an approach that simplifies a problem in the form of mathematical models that are tractable to solve in a closed-form or, at the very least, yield to a numerically attainable solution. Overall, the distribution of the methods used is shown in Figure 2. As shown, nearly 40 percent (47 articles (39%)), i.e. almost half of the food safety in SC articles, were using the survey method, which is well aligned with our findings in the case of halal food in SC with 14 articles (46%).

Investigating the practice of the utilized methods deeper, we found that the surveys were mostly conducted through questionnaires or interviews using the structured questions. In food safety SC research, such as the study by Cavaliere, Aiello, Perri, Amico, Martial, Thibaut et al. (2016), researchers analysed the characteristics of organic supply chain relationships focusing on processing and retail sectors. In halal SC research, Ali, Kader, Yunus, Mohezar & Nazri (2017b) used a cross-sectional approach in their survey. Meanwhile, the concept development in food safety SC and halal SC leads to the integration with other variables, such as quality (Zhang, Fu, Wang, Tang, Zhao & Zhang, 2017), global trends and developments (King, Cole, Farber, Eisenbrand, Zabaras, Fox et al., 2017), and certification (Ab Talib, 2017; White & Samuel, 2016). Case studies are used to investigate the growth of various types of bacteria, that degrade the quality of food products in manufacturing or distribution systems (Pang, 2017; Ssemanda, Reij, Bagabe, Muvunyi, Joosten & Zwietering, 2017) concerning the food safety issues. On halal SC, case studies are found closely related to risk management (Ali, Tan, Pawar & Makhbul, 2014) because of the various processes involved in SC and the implementation of halal behaviour in certain regions or countries (Heiman, Gordon, & Zilberman, 2017). Finally, in terms of modelling method, mathematical equations are used to describe the behaviour of the bacterial growth or some measure of risks to be mitigated (Mohammed, Wang & Li, 2017; Nascimento, Carminati, Silva, Silva, Bernardi & Copetti, 2018).

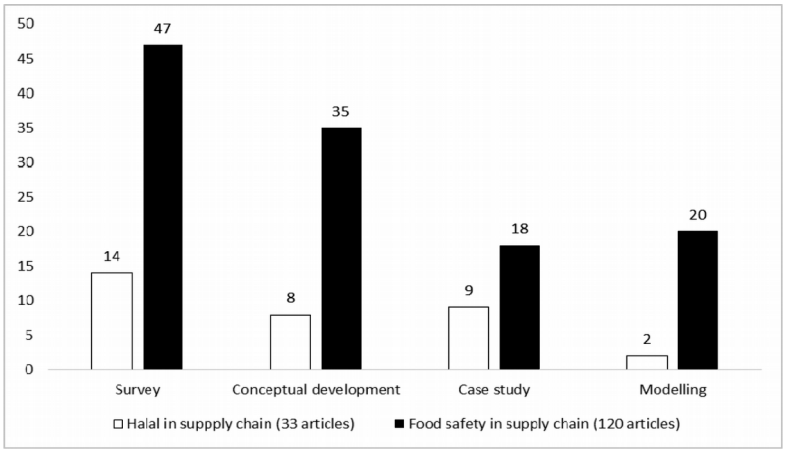


Figure 2. Types of research methods

3.2.2. Type of Food Products

The articles on food safety and halal food in SC appear to extend to several product types. The types of food product shown in Figure 3 are general terms, and therefore not included in the analysis. The most common application has been for meat products (10 articles), which are inherently and widely understood, where issues concerning food safety and halal food in SC have frequently been raised. In the articles related to food safety in SC, Telligman, Worosz and Bratcher (2017) conducted research to explore the consumers' top-of-mind food safety belief about the local beef, using the survey method. They found that the consumers tend to be more confident on the local beef or those sourced from close proximity, which, in turn, leads to the higher food safety confidence compared to those sourced from unknown places.

In the articles about halal food in SC, most of the applications have also been around meat products. Mohammed et al. (2017) developed a framework using RFID-enabled monitoring system and applied it in context of halal meat products. In their subsequent research, they investigated the economic feasibility of a three-echelon halal meat product in SC (Mohammed et al., 2017). Farouk, Pufpaff and Amir (2016) discussed why poor practices and animal welfare abuse are still occurring during the halal meat production and how to reduce such undesired practices through some initiatives, including staff training and CCTV installation, among many others.

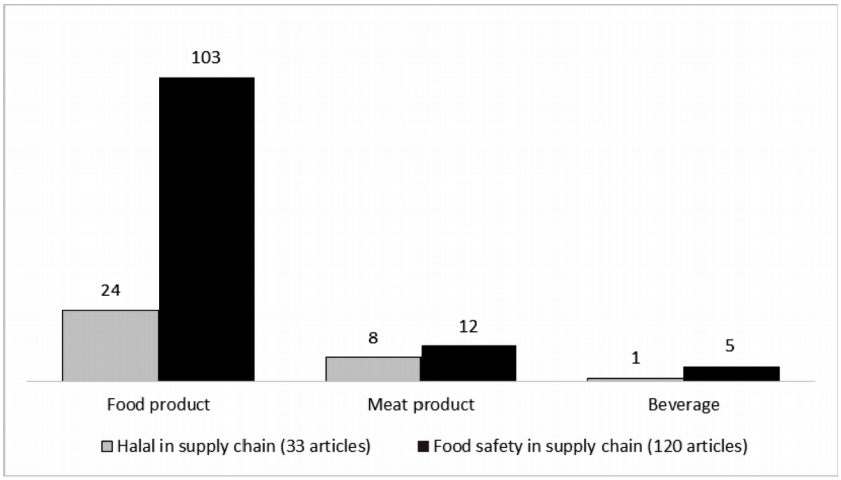


Figure 3. Type of food product

4. Bibliometric Analysis

In this section, we conducted the bibliometric analysis using BibExcel. Leveraging on the ability to provide comprehensive network analysis tools, such as Gephi, Pajek and VOSviewer, our analysis is cognizantly adopted and comprehensively performed using various inbuilt features of BibExcel. We refer readers to the study of Persson et al (2009) for more details. The pre-processed input data, containing various attributes of the articles from the previous stages, are in the form of RIS format from Scopus, which are compatible to be fetched directly into BibExcel. We focused on analysing a set of information, such as author(s), year, document title, journal, affiliation, keywords, citation count and references. In what follows, we discuss our findings regarding the influence of the authors, the citation of the articles and the statistics of the keyword based on BibExcel and Excel analytics.

4.1. Influence of Authors

We analysed the influence of authors by extracting the field "author" from the data file and recorded the number of publications from each author. Table 3 shows the list of top ten contributing authors and the number of publications they have authored or co-authored. In research related to the food safety in SC, Jacxsens, L. is the highest contributing authors with 8 publications, followed by Uyttendaele M. with 7 publications. In Halal food in SC, Ali and Tan are at the top with 5 publications each, followed by Manzouri and Tieman with 4 publications each. Please see Table 3 for more details.

Food Safety in Supply Chain		Halal Food in Supply Chain	
Author	Number of publications	Author	Number of publications
1. Jacxsens, L.	8	1. Ali, M.H.	5
2. Uyttendaele, M.	7	2. Tan, K.H.	5
3. Luning, P.A.	4	3. Manzouri, M.	4
4. Raspor, P.	2	4. Tieman, M.	4
5. Manning, L.	2	5. Ab-Rahman, M.N.	3
6. Kirezieva, K.	2	6. Li, X.	2
7. Hammoudi, A.	1	7. Makhbul, Z.M.	2
8. Zheng, L.	1	8. Mohammed, A.	2
9. Desmarchelier, P.	1	9. Othman, S.N.	2
10. Monaghan	1	10. Wang, Q.	2

Table 3. Top 10 contributing authors by number of publications related to food safety and halal food in the SC

4.1. Affiliation of the Authors

The affiliation of the authors is analysed by extracting the field "author's affiliation" from the data file and the number of articles is recorded. For each affiliation, the country where the organization is located was identified. Table 4 shows the list of the top ten affiliations based on the number of paper published by the affiliating authors. In research related to food safety in SC, the three top contributing organizations are from the United States. This may be because the researchers in several US universities tend to be more aware towards the societies' demand for food safety, and thus have spent more effort in investigating this issues using SC perspectives. In case of halal food in SC, the top ten organizations are from Malaysia, such as Universiti Kebangsaan Malaysia and from the United Kingdom, such as the University of Nottingham. These institutions are frequently represented by more prolific authors, including Ali, Mohd Helmi, and Tan, Kimhua.

Food Safety in Supply Chain		Halal Food in Supply Chain	
The affiliation of author - Country	Frequency	The affiliation of author- Country	Frequency
1. Food and Drug Administration - United States	7	1. Universiti Kebangsaan Malaysia - Malaysia	9
2. Michigan State University - United States	5	2. University of Nottingham - United Kingdom	5
3. University of California - United States	4	3. Universiti Putra Malaysia - Malaysia	4
4. University of Tasmania - Australia	2	4. University of Malaya - Malaysia	4
5. Institute of Food Technologists –Canada	2	5. Universiti Teknologi MARA - Malaysia	3
6. Cranfield University - United Kingdom	1	6. University Utara Malaysia - Malaysia	2
7. China Agricultural University - China	1	7. University of Portsmouth - United Kingdom	2
8. Chinese Academy of Agricultural Sciences - China	1	8. Universiti Tun Abdul Razak - Malaysia	1
9. University of Queensland - United Kingdom	1	9. Politeknik Sultan Haji Ahmad Shah - Malaysia	1
10. University of Saskatchewan - Canada	1	10. National Coordinator Malaysia - Malaysia	1
…	…	…	…
80. University of Ljubljana - Slovenia	1	29. Universitas Islam Indonesia - Indonesia	1
Total	94	Total	51

Table 4. The 10 most frequent affiliations of the authors (by country)

4.2. Keyword Used by the Authors

The keyword is an important information provided by the authors to help readers to find the relevant papers. The authors' keywords were extracted from Scopus data file using BibExcel and were summarised using Excel spreadsheet. The 20 most frequent keywords are presented in Table 5. This list is derived from a collection of 561 keywords from 120 papers related to the food safety in SC research and 160 keywords from 33 papers about the halal food in SC research. In food safety, it is not surprising that "food safety" and "supply chain" are among the most popular keywords. This demonstrates that the most popular keywords are actually the initial search terms of this study. In halal food, the four most popular keywords were also identified.

Food Safety in Supply Chain		Halal Food in Supply Chain	
Keyword	Frequency	Keyword	Frequency
1. Food safety	75	1. Halal	15
2. Supply chain	24	2. supply chains	8
3. Microorganism	22	3. Halal supply chain management	5
4. Risk	21	4. Supply chain management	4
5. Food supply chain	19	5. Malaysia	4
6. Hazard	16	6. halal logistics	4
7. Vegetables	12	7. RFID	3
8. Country	11	8. Food integrity	3
9. Agricultural	6	9. Halal food	3
10. Meat	5	10. Halal supply chain	3
11. Foodborne disease	5	11. Islam	3
12. Food industry	4	12. Supply chain integration	3
13. Halal	3	13. Barriers	2
14. Contamination	3	14. Challenges	2
15. Certification	2	15. Food industry	2
16. Economic impact	2	16. Food supply chain integrity	2
17. Aflatoxins	2	17. Halal food supply chain	2
18. Food defence	2	18. Halal Malaysia	2
19. Food chain	2	19. Illegal food supply	2
20. Traceability	2	20. Lean practices	2
…	…	…	…
Total	561	Total	159

Table 5. The 20 most frequent keywords by the authors

5. Network Analysis

The tools or software needed to conduct the network analysis include those that provide graphical and clustering ability, such as HistCite Graph Maker, Pajek, VOSviewer and Gephi. VOSViewer is used in this paper to analyse the citation of articles based on global citation and total link strength. Besides, it also provides both graphical and clustering analyses. As such, we utilize VOSviewer to provide general graphs in terms of bibliographical coupling, co-citation, co-authorship, citation and co-occurrence of keywords (Eck & Waltman, 2010).

5.1. Citation of Articles

The number of citations reflects the importance of particular articles in that area of research (Garfield, 1972). The importance of an article can be measured by the number of citations it receives. It should be noticed that such citation analysis has been criticized. However, for practical reasons, MacRoberts and MacRoberts (2010) believe that citation analysis is still one of the most commonly used techniques to analyse the importance of an article in the literature. To analyse the contribution of papers that are accepted by other authors, we used the VOSviewer to determine the most cited articles. The total link strength (TLS) was also recorded to indicate the connections with other articles.

Food Safety in Supply Chain			Halal Food in Supply Chain		
Author(s) - Year	Global citation	Total Link Strength (TLS)	Author(s) - Year	Global citation	Total Link Strength (TLS)
1. Marucheck, Greis, Mena and Cai (2011)	118	218	1. Tieman (2011)	62	52
2. Van Boxstael, Habib, Jacxsens, De Vocht, Baert, Van De Perre et al. (2013)	75	110	2. Tieman et al. (2012)	44	105
3. Borchers, Teuber, Keen & Gershwin (2010)	59	18	3. Tieman (2015)	15	62
4. Jacxsens et al. (2010)	56	97	4. Manzouri, Ab-Rahman, Saibani and Mohd-Zain (2013)	12	30
5. Kleter and Marvin (2009)	45	18	5. Ali et al. (2014)	10	90
6. Amaya-González, Santos-Álvarez, Miranda-Ordieres and Lobo-Castañón (2013)	42	18	6. Tieman and Van Nistelrooy (2014)	10	112
7. Stringer, Sang and Croppenstedt (2009)	22	54	7. Ali, Tan & Ismail (2017a)	7	8
8. Tonsor, Schroeder and Pennings (2009)	22	38	8. Razzak et al. (2015)	7	17
9. Wang et al. (2012)	20	48	9. Farouk et al. (2016)	5	4
10. Mahian and Arianfar (2016)	0	51	10. Soon, Chandia and Regenstein (2017)	4	46
…	…	…	…	…	...
120. Raspor and Jevšnik (2016)	0	0	33. Pocklington (2010)	0	0
Total	847	5144	Total	205	1666

Table 6. The 10 most cited articles

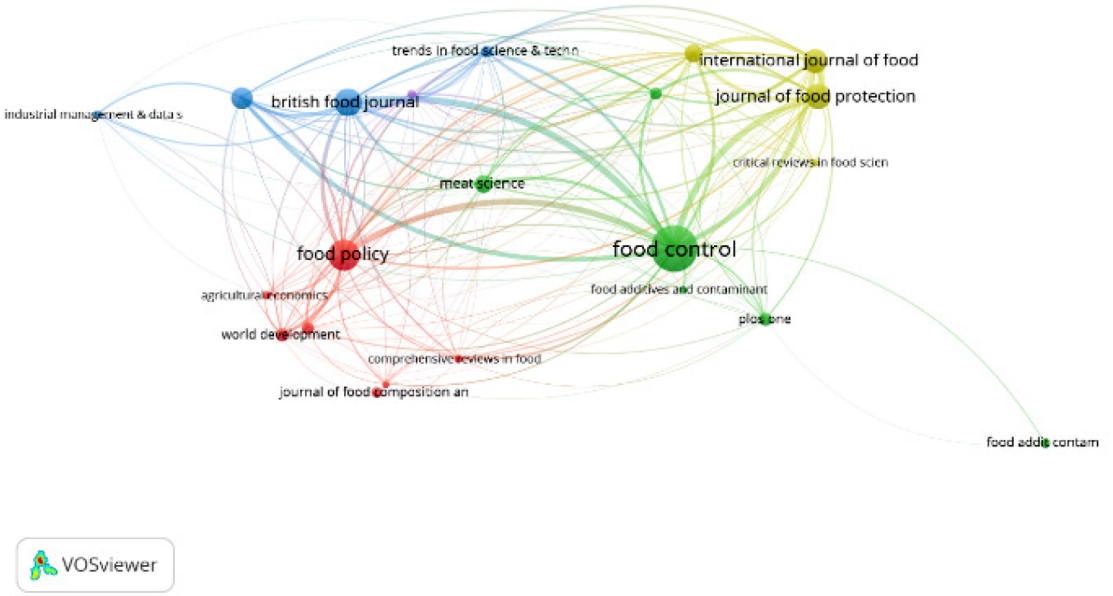
Table 6 presents a list of the top ten most frequently cited paper. It is noteworthy that the most cited paper is by Marucheck et al. (2011) with 118 citations, followed by the paper by Van Boxtael et al. (2013) with 75 citations, in research about food safety in SC. Marucheck et al. (2011) investigated how the field of operation management can provide a new perspective on the challenges regarding product safety and security, throughout the whole supply chain. Another important work was made by Van Boxtael et al. (2013), which represented food safety issues in fresh product from the perspectives of food safety experts.

In the research related to halal food in SC a paper by Tieman (2011) is the most frequently cited article with 62 citations, followed by a paper by Tieman et al. (2012) with 44 citations. Tieman (2011) investigated the basic requirements for halal supply chains to ensure the integrity of halal food. Tieman with Van der Vorst and Ghazali,

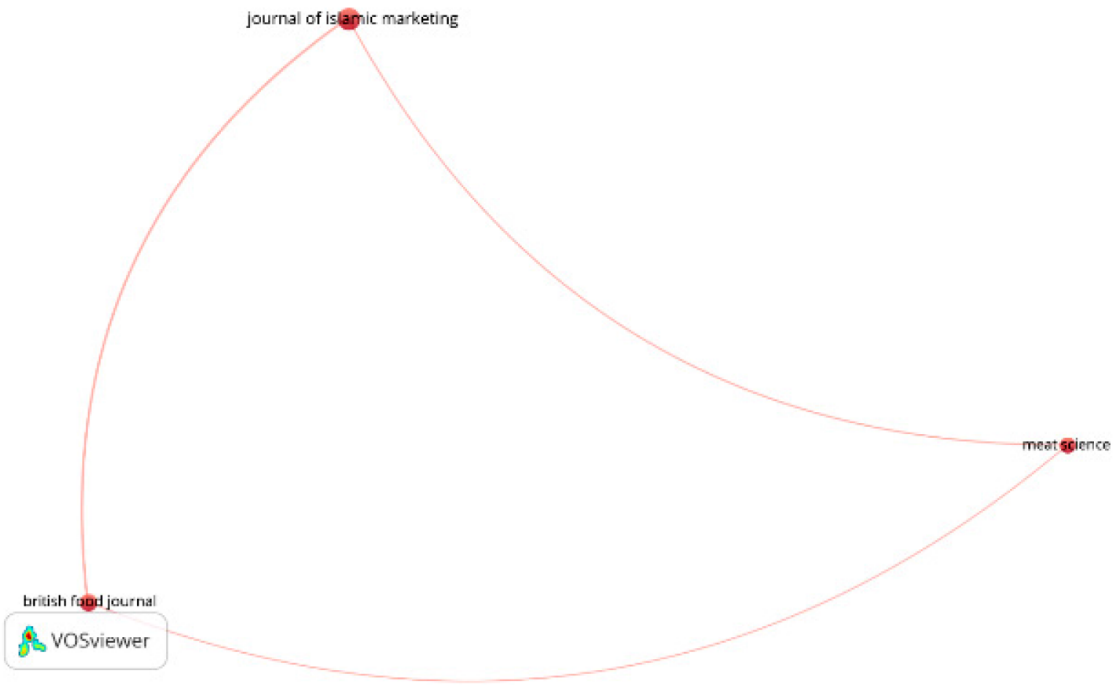
in 2012, also introduced a new framework (halal supply chain model) to optimize the design of halal food supply chains, providing more prescriptive analysis to the problems.

5.2. Graphical and Clustering Analysis

We used VOSviewer software to provide the graphical analysis for the research related to food safety and halal food in SC based on the bibliometric data, with which we visualized the co-citation of journals and co-occurrence of keywords. The graph of journal co-citation is used to visualize the most cited journals and the network links to indicate those journals that are highly co-cited. Figure 4 presents the results of journal co-citation visual for the research about food safety and halal food in SC.



(a)

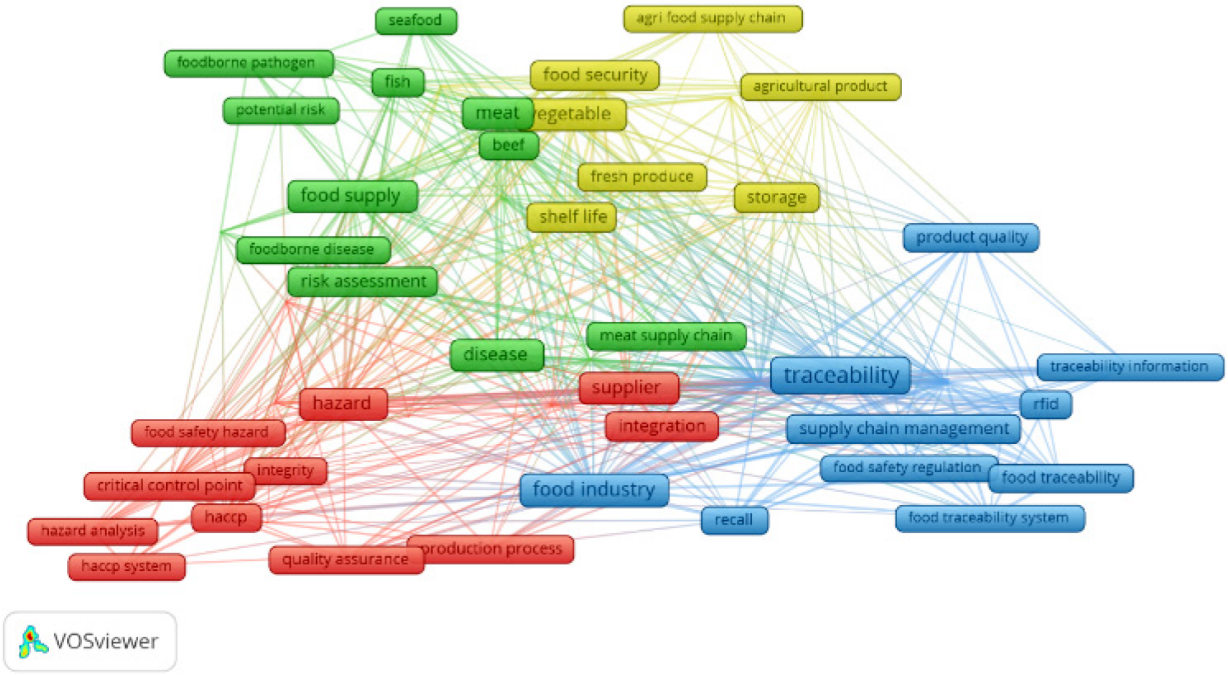


(b)

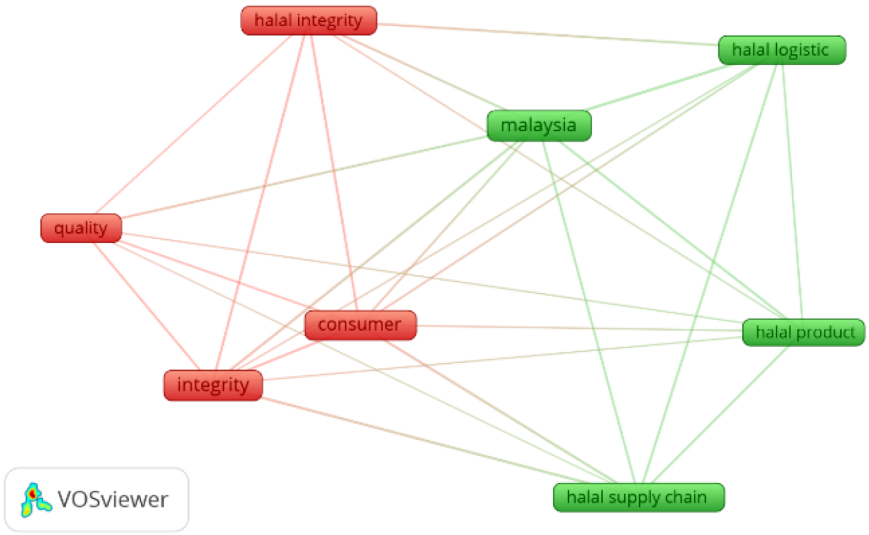
Figure 4. Co-citation of journals cited in the research about (a) food safety in SC and (b) halal food in SC

In case of food safety in SC, Food Control is the most cited journal and has the largest network. British Food Journal, Journal of Food Protection, International Journal of Food Microbiology and Food Policy are also highly cited. This is in-line with the number of distribution of articles by journals and years. In halal food in SC, Journal of Islamic Marketing is the most cited journal followed by British Food Journal and Meat Science.

In clustering analysis, a graph of the keyword co-occurrence is used to present the major cluster of research and the network connections based on the abstracts of articles. Using VOSviewer software, we identified five major clusters for research related to food safety in SC and two clusters for halal food in SC (see Figure 5).



(a)



(b)

Figure 5. Co-occurrence of keywords in research related to (a) food safety in SC and (b) halal food in SC

The links (edges) indicate the number of links between an item (node) with the other items. The TLS indicate the total strength of the link between an item with the other items (Eck & Waltman, 2010). The TLS values are recorded to highlight the strength of the relationships between keywords (items/nodes) and the links' strength (edges weight) of the keyword. In Table 7, the top 10 keywords from each cluster based on their TLS values were recorded.

We analysed and evaluated the objectives of the papers identified with the same keywords to determine the research focus for each cluster. In the research about food safety in SC, the main research issue in cluster 1 is on managing the hazard as the danger of risks in food (including HACCP (Hazard Analysis and Critical Control Points) because of its popularity) in supply chain context. This approach has been applied to chemical, microbiological, physical hazards (Van Asselt, Van Der Fels-Klerx, Marvin, Van De Veen & Groot, 2017), and emerging hazards (Kleter & Marvin, 2009), Manning and Soon (2013) reviewed the methods for assessing food safety risk as a key element for HACCP approach.

Food safety suplly chain cluster			
Keyword	TLS	Keyword	TLS
Cluster 1		Cluster 2	
Hazard	174	Traceability	282
HACCP	111	Technology	280
Supplier	103	Food industry	202
Critical control point	88	Traceability system	196
Hazard analysis	73	Supply chain management	92
Food sector	71	Integration	86
Quality assurance	58	RFID	86
Certification	58	Food traceability	71
Production process	57	Recall	63
Contaminant	44	Traceability information	52
Cluster 3		Cluster 4	
Contamination	194	Vegetable	139
Food supply	136	Fruit	110
Disease	123	Storage	102
Risk assessment	116	Shelf life	76
Plant	83	Fresh produce	71
Probability	57	Transportation	61
Meat product	47	Food security	58
Meat supply chain	45	Dairy product	34
Livestock	43	Food waste	33
Foodborne disease	42	Agricultural product	31
Foodborne pathogen	36	Food safety standard	30
Food safety concern	28	Microbiological safety	22
Potential risk	23	Agricultural food supply chain	16

Halal supply chain cluster	
Keyword	TLS
Cluster 1	
Integrity	92
Consumer	78
Halal integrity	68
Quality	38
Cluster 2	
Malaysia	106
Halal supply chain	77
Halal logistic	71
Halal product	42

Table 7. The 10 most used keywords in each cluster (TLS co-occurrence indicator)

Cluster 2 mainly concentrates on developing traceability system, as technology information tools, for food safety to avoid food contamination incidents in a supply chain. The study by Marucheck et al. (2011) is often cited, because it provides four areas of the operations management, including traceability system as innovative solutions for food product safety. Wang, Yue and Zhou (2017) proposed a better food traceability system to evaluate the food safety in the supply chain and provided this evaluation information to customers.

Cluster 3 mainly focuses on reducing and avoiding contamination and diseases for food safety. For contamination issues, developing and applying Aptamers (Amaya-González et al., 2013), analysing the security of the commodities and imported food supplements (Zach, Doyle, Bier & Czuprynski, 2012) and various decontamination technologies (Khan, Miskeen, Khalil, Phull, Kim & Oh, 2016) were conducted. For disease, analysing, practical application of ALOP (Appropriate Level of Protection) and FSO (Food Safety Objective) in case of Salmonella in chicken meat (Gkogka, Reij, Gorris & Zwietering, 2013) and various microbial pathogens in salads (Mir, Shah, Mir, Dar, Greiner & Roohinejad, 2018), are the topics actively discussed by the researchers.

Cluster 4 mainly concentrates on managing vegetables and fruit for food safety using technology, such as irradiation (Shahbaz, Akram, Ahn & Kwon, 2016) and post-harvest technology (Mahajan, Caleb, Gil, Izumi, Colelli, Watkins et al., 2017). The investigation and review of food safety for vegetable and fruits, for problems related to the international food supply chain context (Ait-Hou, Grazia & Malorgio, 2015), customer behaviours (Cheng, Jiang, Zhang, You, Zhang, Zhou et al., 2016), microbial testing integration (Duvenage & Korsten, 2017), micro-organisms indication (Ssemanda et al., 2017) were elaborated and discussed.

In research related to halal food in SC, the main research issues in cluster 1 mainly focuses on halal food integrity. The halal food integrity is mainly conducted to maintain good quality to satisfy the customers' expectation. Ali et al. (2017a) developed a framework for achieving and maintaining food supply chain integrity in context of halal food. Ali et al. (2017b) investigated the relationships between supply chain integration and halal food supply chain integrity and the impact of halal food supply integrity on the firm's performance. Tan, Ali, Makhbul and Ismail (2017) studied the impact of external integration on compliance with halal standards, as an example of product integrity, within the food industries. Ali et al. (2017a) and Ali et al. (2017b) highlighted the fully-integrated supply chain investigation in halal food integrity for future research. In cluster 2, Malaysia is a popular research object about halal food in SC to investigate several issues related to the halal supply chain (Tieman, 2011; Tieman et al., 2012), and lean in halal supply chain (Manzouri et al., 2013; Manzouri, Ab-Rahman & Mohd-Zain, 2014).

6. Discussion and Conclusions

This paper presented an overview of the distribution of literature on food safety and halal food in SC by bibliometric and network analyses. A set of 120 papers published on food safety and 33 papers published on halal food in SC research were collected by querying Scopus database using predefined keywords. The pre-processing by analysing the title of the papers and their abstracts, and by removing those that are irrelevant to the topic, is also conducted to ensure the validity of the analysis.

The prevalent contributing authors, affiliation and keywords have been extracted to allow for an analytical approach. With network analyses, major research areas—four on food safety and two on halal food in SC research have been identified. These results yield to some clusters of influential keywords found in the literature, which could be utilized as a guide for young researchers to gain further insights regarding the emerging areas of research in context of food safety and halal food in SC.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Our findings may help researchers to understand the current research overview and the status of their work. In addition to that, our findings also can help the practitioners to understand the practical challenges about food safety and halal food that span along the supply chain system.

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