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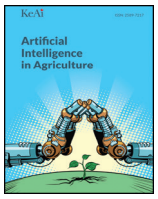

Worldwide trends in the scientific production of literature on traceability in food safety: A bibliometric analysis

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ABSTRACT

Food traceability is an important aspect of the food safety supply chain to ensure efficient tracking of produce to check contamination and other foodborne diseases. The health and nutrition response after the Covid-19 pandemic requires a robust and diverse food supply chain in which traceability could play a major role. Since it is an emerging field of study with growing interest in the technological front, it is important to study the scientific trend and research activities. This study provides an important insight into the food safety value chain response towards modern food safety management systems through scientometric analysis. Scopus database was used to retrieve the documents from the year 1992–2021. The research papers and conference papers were only chosen. Vosviewer software was used to carry out the scientometric analysis. The distribution and growth trend of documents, country-level distribution of publications, the relationship between authors and co-authors, etc., were analyzed. The intensity of publications from different countries and the collaborations was analyzed using bibliometrix R-package. The year-wise research publication showed a rapid increase in the researchers conducted on traceability systems to enhance food safety from 2014 onwards, mainly from the USA and China. However, the research appeared to be in the developing phase compared to other technology implementation and automation advancements.

Contents

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1. Introduction

The importance of food supply chain was largely felt after the declaration of Covid-19 pandemic in March 2020 (WHO, 2020). The food supply chains throughout the world faced intermittent disruption due to the lockdowns and restrictions imposed by the governments (Galanakis, 2020). The United States Centers for Disease Control and Prevention (CDC or U.S. CDC) which acts as the national public health agency of the United States reported over 16,000 Covid-19 cases and 239 deaths among workers of the country in meat processing facilities across 19 states (Dyal et al., 2020). Similarly, China noticed traces of the virus on the beef imports reaching the country from Australia, Brazil, New Zealand, and Bolivia (Singh and Liu, 2020). Similar incidents were also reported from other countries of the world which led to ban on imports and severe measures leading to adverse impact on trade and tariffs.

The food industry is still reliant on a large extent on the physical paper records which mostly remains on the paper and difficult to search and covert into digital form. As such, traceability systems offer the necessary solution leading to risk minimization that is critical to the assurance of food safety in a connected world (Aung and Chang, 2014). The traceability tool is utilized to identify the movement of food from production to distribution along with necessary inspection and certification within the system. The transparency in the chain of events through the traceability systems lead to minimization of possible fraud and cheating (Pearson et al., 2019). Several upcoming researches and development organizations are making use of advanced technologies such as Internet of Things (IoT), distributed ledger and block chain technologies, wireless identification sensor technology, etc., for capture and processing of data leading to the efficiency in management of food systems (Bouzembrak et al., 2019; Iftekhar and Cui, 2021). Blockchain technology has helped the consumers to track the movement of food products which leads to the reduction of counterfeiting, dilution and adulteration of produce (Garaus and Treiblmaier, 2021). The study on consumer benefit through traceability systems have shown an improved access to information for making informed purchase decisions. The retailers also benefit through the access of information related to the origin of the product (Islam and Cullen, 2021). These technological tools are data driven thriving on cloud-based online solutions. The reliability of the data is essential to ensure food safety chains from origin to destination.

The application of traceability on agricultural systems is also useful in the creation of competitive advantage. The addition of value with the integration of the traceability system and supply chain management processes leads to better management of the business process and improvement of performance (Wang and Li, 2006). Traceability systems also leads to profitability and improvement in product quality since it makes easy for the producer to recall the products from the market if a defect is detected due to the efficient tracking of the product. This leads to better profitability for the producer along with ensuring the quality of the product available for the consumers (Bechini et al., 2008; Cui et al., 2019; Germani et al., 2015). Furthermore, the integration of blockchain technologies leads to transparencies for all the participants of the value chain. The storing of data during the process which is irreversible leads to the creation of trust and credibility leading to the sustainable development of the industry along with maintaining a record of clients for further use (Jeppsson and Olsson, 2017; Maity et al., 2021; Malik et al., 2021; Sunny et al., 2020).

The developments in the field traceability related to food safety was observed through bibliometric analysis to measure objectively the impact of the scholarly publications and the influence as a measure of scientific quality (Van Raan, 2003). However, to our best of knowledge, there is no previous study of a global bibliometric analysis on the aspect focusing the future of food safety using traceability-based solutions. The current article explores the application of traceability solutions in the domain of food safety using different technological applications. The major goal of the paper was to offer a comprehensive overview of recent developments in the realm of food safety and traceability. To accomplish our goal, we used the Scopus database to undertake a bibliometric study of documents published in food safety and traceability area. The following were some of the major takeaways from the paper: (1) the distribution and trend of publications over time (2) the distribution of publications from various nations (3) organizations engaged in the area that have published more than two papers (4) relationship between different authors and co-authors (5) authors in the domain who has published more than five documents (6) source and citation relationship of the sources (7) top journals where over ten documents were published (8) top documents which have at least 100 citations, and (8) collaboration between different countries in context of research publication. This paper is structured as follows: In Section 2, we briefly describe the materials and methods adopted for the study. In the third section, we present the findings based on the database and methodology of the study. In Section 4, we conclude the paper in the light of previous literature.

2. Materials and methods

2.1. Study design

The bibliometric analysis was performed using articles published until May 2021 in Scopus indexed journals (https://www.scopus.com/). Out of various document types, only research articles and conference papers were selected for the study because we are interested in checking the research evidence concerning our major keywords, food safety and traceability.

2.2. Source of information

The bibliometric analysis was conducted using publications retrieved from the Scopus database (Elsevier B.V., USA). Scopus database was used since it is the largest abstract and citation database of peer-reviewed literature encompassing science, technology, social sciences, etc. (Ballew, 2009). Also, it includes other relevant information for the study, such as citations per document and country-wise affiliation of all the authors (Agarwal et al., 2016; Hernández-Vásquez et al., 2018).

2.3. Search strategy

The literature search was carried out using the search term in the title and abstract field, as mentioned in Table 1, on a single day, May 27, 2021. The validity of the search strategy was determined by manually reviewing the retrieved documents by two authors. The period restrictions were not applied, resulting in documents published from 1992 to 2021. After removing the duplicates, we were left with 805 documents. The information related to citations, bibliography, abstract and keywords, funding, and others were exported as CSV files for further analysis using bibliometric tools. The Scopus database may involve some errors in bibliometric applications (Falagas et al., 2008), for

Table 1
Combination of keywords used for search on Scopus database.

Major keyword	Operator	Additional keywords	Number of results
Food safety	AND	Traceability	451
Food safety	AND	Radio-Frequency identification OR RFID OR Radio frequency ident*	31
Food safety	AND	Timestrip freshness indicator label* OR "Fresh* Indicator" OR Timestrip	4
Food safety	AND	Bar code	25
Food safety	AND	QR code OR Quick response code	9
Food safety	AND	Digital tag* OR Tag*	77
Food safety	AND	NFC OR Near field communication	5
Food safety	AND	Digital sensing OR Sensing	136
Food safety	AND	IoT OR IOT OR Internet of Thing*	21
Food safety	AND	Wireless identification sensor technology OR Sensor technology OR Identification technology	13
Food safety	AND	Information AND Communication technology OR ICT	14
Food safety	AND	Nanotechnology	81
Food safety	AND	Near infrared spectroscopy	41
Food safety	AND	Blockchain	16

asterisk (*) is a commonly used symbol to broaden a search by finding words that start with the same letters. It is typically used at the end of a root word. Search terms are not case sensitive, so words can be entered in upper case or lower case.

which standardization was necessary for the data. A few documents were detected which were erroneously ascribed to the sphere of author affiliation and country. Thus, a standardization was conducted physically by two authors before conducting the analysis. (See Fig. 1.)

2.4. Data analysis

The current study employs VOSviewer version 1.6.16 software (Derviş, 2019; Van Eck and Waltman, 2013) and open-source bibliometrix R-package (Aria and Cuccurullo, 2017) for conducting bibliometric analysis. VOSviewer software provides maps of various bibliographic data that are easy to interpret. VOSviewer can display maps in different ways along with the functionality of zooming, scrolling, and searching. The popular maps developed using the software are co-authorship, keyword co-occurrence, citation, bibliographic coupling, or co-citation map based on bibliographic data (Van Eck and Waltman, 2010). The maps on VOSviewer are better visualized when the database contains a large number of items (i.e., at least 100 items or more). The other computer programs used in the bibliometric analysis cannot display the maps in such an explicit manner (Pal et al., 2021). The comprehensive science mapping analysis including the worldwide distribution map of publications and collaborations within the countries was conducted through bibliometrix R-package. The tool is programmed in open source platform R which employs specific tools for both bibliometric and scientometric quantitative research. The co-occurrence network

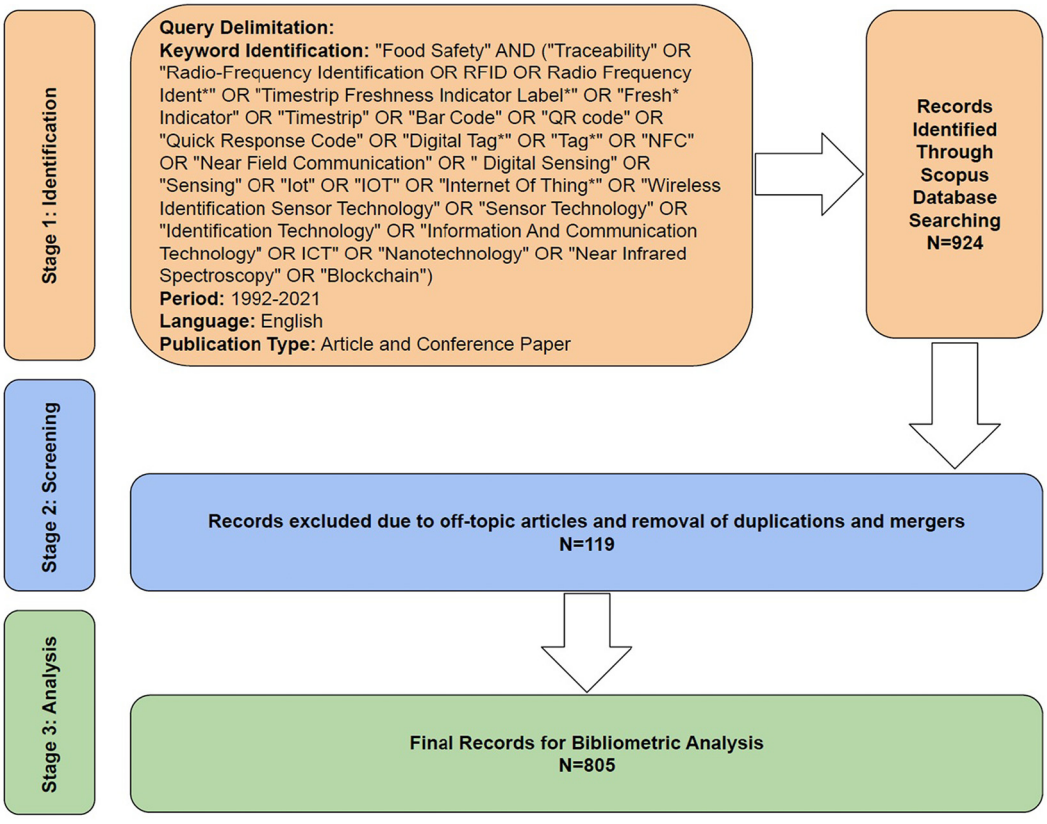

Fig. 1. Outline of search strategy for bibliometric analysis. (Year: 1992–2021).

map and collaboration world maps were prepared using bibliometrix R-package.

3. Results and discussion

3.1. The distribution and growth trend of publications yearly

The increase in the number of publications in a certain discipline is a fair indication of the research trend in that field. The study of the rising trend in the number of publications can offer answers to a variety of new concerns and the future of the discipline.

A plot of the number of publications and cumulative publications on a year-to-year basis was plotted to analyze the research trend in connection to the growing scenario linked to traceability relevant to food safety paradigms (Fig. 2). Traceability about food safety is a relatively recent field, with the first papers dating back to 1992. However, it wasn't until 2008 that researchers began to show a significant increase in this field of study. Every year since 2009, at least 30 papers have been published. This year alone (2021), 48 articles have been published thus far. Furthermore, the cumulative publication graph shows that, since 2003, academics all over the world have been paying close attention to the subject of traceability in the context of food safety. The number of cumulative articles has increased exponentially since 2003, with an R^2 value close to 0.85 ($p < 0.0001$).

3.2. Publication distribution on a country-by-country basis

The 805 articles came from 85 different nations. China had the most publications (199 articles, or 18.49% of all papers), followed by the United States of America with 185 articles (17.19%) (USA). Italy was on the third position with 77 articles (7.16%) followed by Spain with 49 articles (4.55%). Canada occupied the sixth rank with 34 articles (3.16%). Germany and the Netherlands tied for seventh place, both producing 28 articles (2.60%). Following that, five countries (South Korea, Australia, India, France, and Ireland) produced 20–24 articles. Furthermore, eight countries published articles in the range of ten to nineteen. The remaining 129 countries published less than ten articles on the aspect of traceability linked to food safety. When each country's contributions are added together, the total number of publications is 1076, which is greater than 805. This is evidenced by the fact that there has been a great deal of cross-national collaboration. In total, twenty nations published more than ten publications in the field of food safety connected to traceability. Table 2 shows the data for the various nations.

Table 2 shows that 13 of the top 20 nations have a nominal GDP of less than $15,000. This shows that economically developed nations have recognized the benefits of traceability solutions in food safety and are investigating their viability in order to ensure that the country's food is safe. The United States of America has received the most citations out of the 185 papers that have been published in the country. In terms of the number of documents published in the domain, China, the United States of America, and Italy are the top three nations. However, it is worth noting that China ranks fifteenth (15.99), the United States of America tenth (27.04), and Italy thirteenth (20.47) in terms of average citations per document. The European nations of Ireland (86.10), Belgium (46.21), and Spain (46.21) are in top place in terms of average citations per document (37.67).

The Total Link Strength (TLS) is a measurement of a country's collaborative research with another (Table 2). TLS study revealed that the United States, with a TLS of 98, was by far the most superior country in terms of collaborative research. The US has collaborated on papers with China, the UK, Germany, Italy, the Netherlands, Spain, Ireland, Canada, France, Japan, Belgium, South Korea, India, Norway, Taiwan, Thailand, Kenya, Denmark, Turkey, Chile, and Columbia (Fig. 3). China was in second place, with a TLS of 85. The United States, Italy, the United Kingdom, Canada, Spain, Germany, Ireland, New Zealand, France, Sweden, Columbia, the Netherlands, Japan, Thailand, South Korea, Taiwan, Indonesia, Romania, Singapore, and Hong Kong have all published research documents with China.

The United Kingdom occupied the third position in joint research with a TLS score of 57. Researchers from the United Kingdom, the United States, China, Italy, Canada, Spain, Germany, New Zealand, Ireland, Belgium, France, the Netherlands, Japan, Sweden, Kenya, Finland, and Hungary collaborated on papers. The TLS score and the Country Cooperation Network Map reveal that most nations have a strong research connection with the United States, the United Kingdom, and China. Fig. 3 shows the country collaboration network.

Furthermore, the top organizations that published more than two publications in the same field of research were selected (Table 3). According to the bibliometric analysis, eight organizations generated at least three papers during the years. Six of the eight organizations that released more than two publications in the study domain are from China, which is noteworthy.

It was found that the School of Food and Biological Engineering, Jiangsu University, China, had published five documents that received 154 citations. The average citation per document was found to be 30.80. It was followed by the Food Science and Technology Programme, C/o Department of Chemistry, National University of Singapore, Singapore and National University of Singapore (Suzhou) Research Institute, Suzhou, Jiangsu, China, with four publications and an equal number of average citations per document (34.50). The average citation per document of China Agricultural University, Beijing was the highest

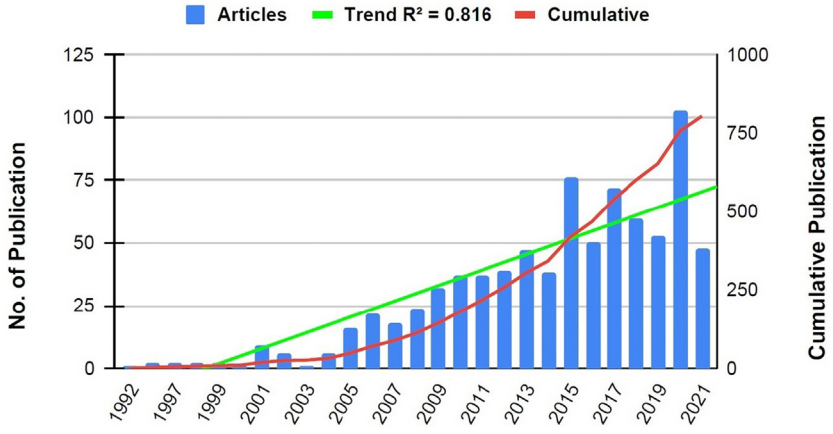

Fig. 2. Year-over-year changes in the number of publications and the total number of publications. (Year: 1992–2021).

Table 2
Countries with over ten publications. Nominal GDP rank as per the International Monitory Fund.

S·No.	Country	No. of documents	% Documents	No. of citations	Avg. citation per document	Total link strength	Nominal GDP Rank*
1	China	199	18.49	3182	15.99	85	2
2	United States	185	17.19	5002	27.04	98	1
3	Italy	77	7.16	1576	20.47	41	8
4	Spain	49	4.55	1846	37.67	33	14
5	United Kingdom	41	3.81	1244	30.34	57	5
6	Canada	34	3.16	1190	35.00	29	9
7	Germany	28	2.60	761	27.18	51	4
8	Netherlands	28	2.60	924	33.00	36	17
9	South Korea	24	2.23	365	15.21	15	10
10	Australia	23	2.14	672	29.22	20	12
11	India	22	2.04	435	19.77	9	6
12	France	21	1.95	734	34.95	25	7
13	Ireland	20	1.86	1722	86.10	30	29
14	Taiwan	18	1.67	233	12.94	6	21
15	Brazil	17	1.58	154	9.06	2	13
16	Japan	16	1.49	116	7.25	23	3
17	Portugal	16	1.49	403	25.19	13	49
18	Belgium	14	1.30	647	46.21	22	25
19	New Zealand	12	1.12	250	20.83	11	50
20	Thailand	11	1.02	147	13.36	10	26
21	Other 65 countries	221	20.53	3480	15.75	–	–

* Nominal GDP rank as per the International (2021 estimates), World Economic Outlook Database, April 2021.

(50.67) though it produced only three documents with 138 citations. The remaining four universities received less than 20 average citations per document and produced three documents in the research area. From the analysis, it can be concluded that the School of Food and Biological Engineering, Jiangsu University, Zhenjiang, China and China Agricultural University, Beijing, China, plays a significant role in the field of research.

3.3. Authors and co-authors relationship

The number of published papers and citation metrics obtained by the authors was used to identify the most active researchers in the area (Table 4). Wang J. has the highest number of publications (16) followed by Li, J. (13). Liu, Y and Wang, S. had equal number of (12). However, in relation to the citations; Hobbs, J.E. had the maximum number of citations (454), followed by Wu, L. (415) and Kim, M.S. (355). This suggested that these three researchers are the most active researchers in the study area Fig. 4.

The average number of citations per document, on the other hand, provides information about the most influential scholars. In other words, a high-quality article will have more citations, which may be determined by computing the average number of citations per document. It can be observed that Hobbs, J.E. (documents: 6, citations: 149), followed by Kim, M.S. (documents: 6, citations: 355) and Wu, L. (documents: 9, citations: 415), had the highest average citations per document. This is suggestive that the documents of Hobbs, J.E., Kim, M.S.

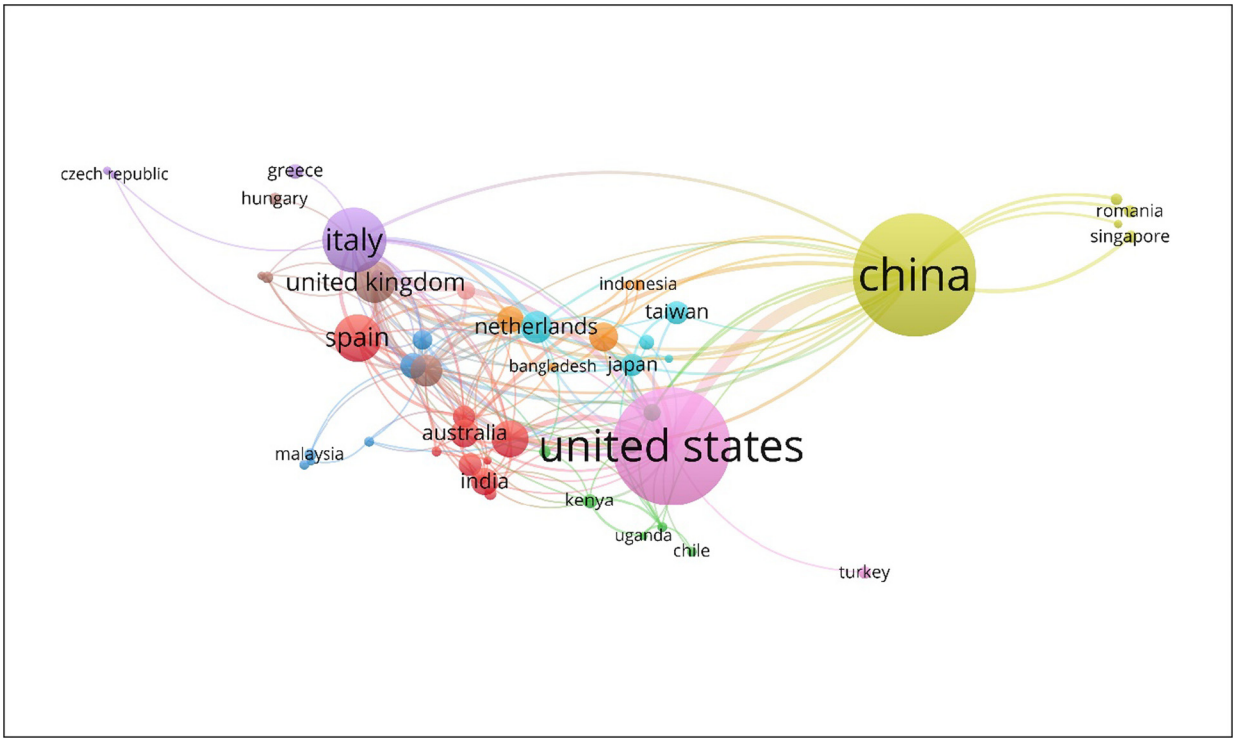

Fig. 3. A network of country collaborations based on the use of traceability in food safety research. (Note: Countries with at least three documents published were considered for the collaboration network).

Table 3
Leading organizations with over two publications.

S·No.	Organization	Country	Documents	Citations	Avg citation per document
1	School of Food and Biological Engineering, Jiangsu University, Zhenjiang	China	5	154	30.80
2	Food Science and Technology Programme, C/o Department of Chemistry, National University of Singapore	Singapore	4	138	34.50
3	National University of Singapore (Suzhou) Research Institute, Suzhou, Jiangsu	China	4	138	34.50
4	China Agricultural University, Beijing	China	3	152	50.67
5	State Key Laboratory of Food Science and Technology, School of Food Science and Technology, Jiangnan University	China	3	54	18.00
6	National Isotope Centre, GNS Science, 30 Gracefield Road, Lower Hutt	New Zealand	3	26	8.67
7	School of Public Health, Jilin University, Changchun	China	3	20	6.67
8	College of Biosystems Engineering and Food Science, Zhejiang University, Hangzhou	China	3	1	0.33

and Wu, L. were more impactful than the others. The average citation per document of Thakur, M. was 31.00 (fourth position) and Zhang, J. was in the fifth position with an average citation score of 27.30. Interestingly, Wang, J. was at the first position with 16 documents in the research area, indicating that even though Wang, J. is a prolific researcher with strong networking and collaboration skills, his research findings are rarely recognized.

3.4. Distribution and co-citation relationship

The relationship between sources and citations indicates which prominent publications the authors choose to publish their findings (Fig. 5). Table 5 shows the major publications/ journals that have published research articles on traceability in the context of food safety. The most preferred journal for publishing the study on traceability in food safety problems was the Food Control journal. So far, seventy-eight papers have been published in the journal. The journal received 1901 citations as a result of these papers. The Food Chemistry journal came in second, with forty-eight papers published and 870 citations. With twenty-seven publications, the Journal of Agricultural and Food Chemistry came in third. These research papers got 575 citations in the journal. The average number of citations per document indicates the importance of publications published in journals. Food Policy, Journal of Food Engineering, and British Food Journal were the top three journals in terms of average citations per document. This is due to the fact that high-quality research was published in Food Policy, Journal of Food Engineering, and British Food Journal. This is supported by the fact that these journals have an impact factor exceeding 2.30. Except for Acta horticulturae, Advance journal of food science and technology, and Journal of Food Science and Food Technology, the rest of the journals had an impact factor of over 2.30. It is also worth noting that journals with a higher total link strength had a higher average citation per document than those with a lower average citation per document. This points to the fact that these journals were highly cited by papers published in other journals, as seen by the source-citation relationship map (Fig. 6).

Table 4
Leading authors with over five publications.

S·No	Author	No. of Documents	Citations	Average citation	Total link strength
1	Wang J.	16	238	14.88	22
2	Li J.	13	111	8.54	34
3	Liu Y.	12	214	17.83	23
4	Wang S.	12	242	20.17	23
5	Zhang X.	11	271	24.64	25
6	Zhang J.	10	273	27.30	19
7	Zhang Y.	10	115	11.50	15
8	Li Y.	9	92	10.22	18
9	Liu X.	9	67	7.44	16
10	Wu L.	9	415	46.11	19
11	Bhatt T.	8	55	6.88	8
12	Yang H.	8	166	20.75	13
13	Wang X.	7	65	9.29	18
14	Xu L.	7	146	20.86	16
15	Xu Y.	7	46	6.57	15
16	Hobbs J.E.	6	454	75.67	2
17	Kim M.S.	6	355	59.17	6
18	Li M.	6	45	7.50	10
19	Thakur M.	6	186	31.00	4
20	Wang H.	6	97	16.17	9
21	Wang H.	6	97	16.17	9

3.5. Documents and citation relationships

The relationship between the published documents and citations received is important to understand the quality of the publication. The higher citation count is representative of superior quality of the publication resulting in a greater number of citations by other researchers in the same field. In our study, the articles which have been cited for over 100 times were only selected. This narrowed down the number of articles to 36 (Table 6). The article which was cited the greatest number of times was authored by Gowen et al. (2007), which highlighted hyperspectral imaging as an emerging process for food quality and safety control. Consumer preferences in terms of food safety, country-of-origin labelling, and traceability were reported in the second most referenced paper. The hyperspectral reflectance and fluorescence imaging system for food quality and safety was highlighted in the third most referenced document. The paper by (Loureiro and Umberger, 2007) has been cited the most (23 times) by the selected set of 36 articles among these three top-cited pieces. Bertolini et al. (2006) and Angulo and Gil (2007) articles were referenced 10 times by the chosen group. This indicates that more high-quality publications in the subject of food safety and traceability follow these two texts.

It can be seen in Fig. 6 that there were two separate and closely linked clusters. The document by Hobbs et al. (2005) received the most citations in the first category. The materials from Gowen et al. (2007) were among the most referenced articles in the second group. To sum up, the documents by Loureiro and Umberger (2007), Hobbs et al. (2005), and Gowen et al. (2007) were the most important publications that had a major influence on the concerned research domain.

4. Conclusion

The results presented in our study showed an increasing trend particularly from the year 2014. The majority of publications and collaborations were from countries like the China, US and countries of the European Union. The sources analysis indicated that the organizations publishing more than two documents in the area were mostly from China, Singapore and New Zealand. The findings support the efforts of the developed countries in prioritizing traceability of agricultural

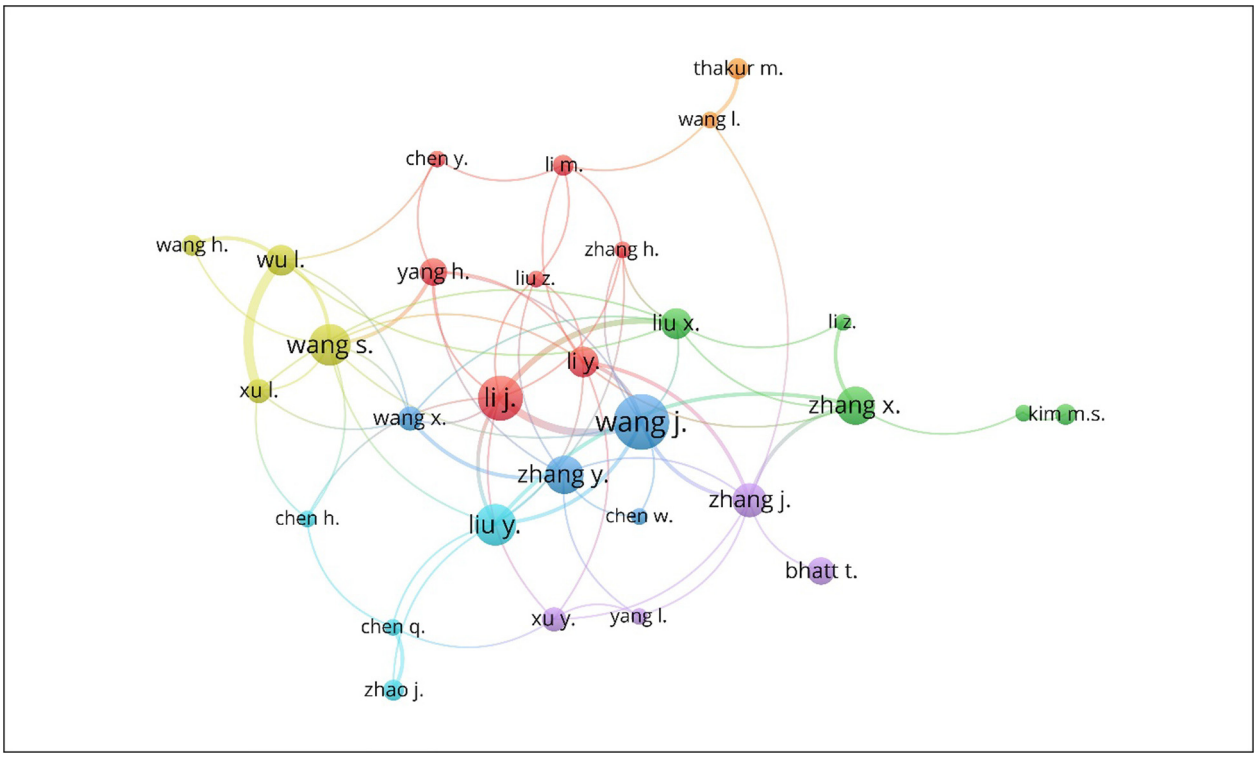

Fig. 4. The relationship between authors and co-authors working in the field of traceability and food safety research. (Note: Authors with more than five publications were considered).

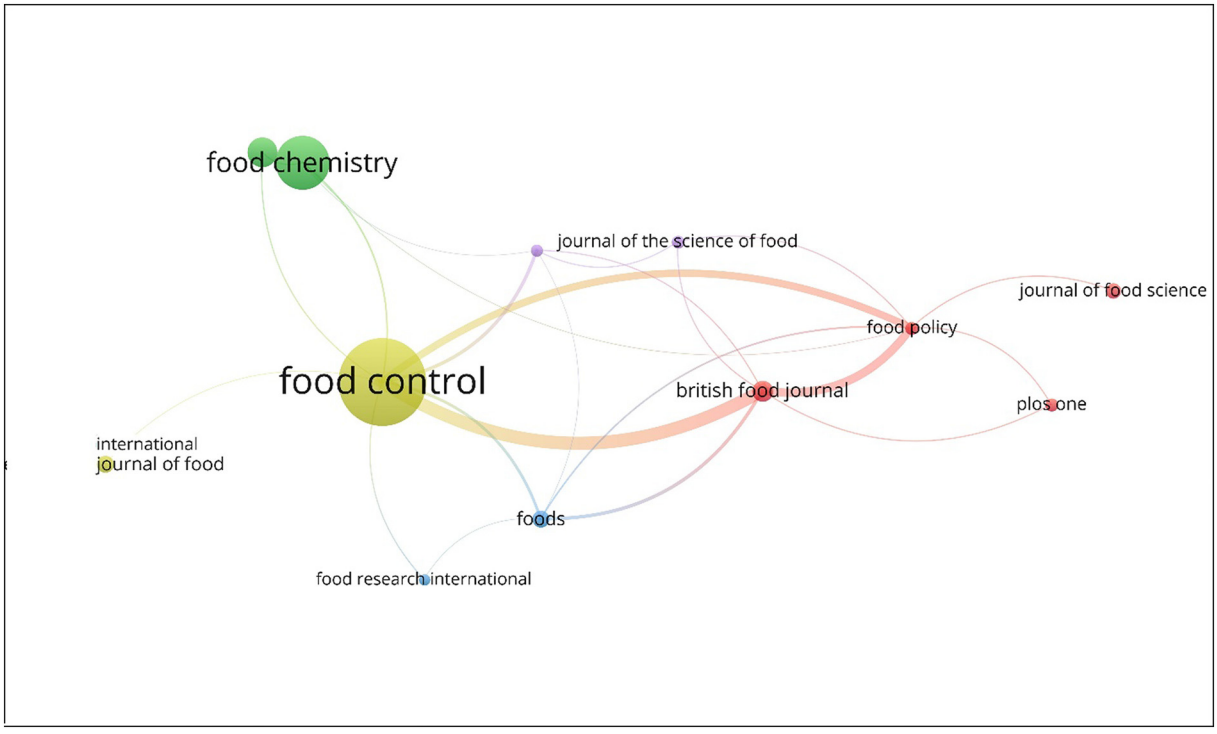

Fig. 5. Relationship between source and citations on published documents of traceability and food safety research. (Note: Only sources with at least 10 documents published were evaluated).

Table 5
Top journals where more than ten documents were published.

S.No	Source	No. of documents	Citations	Avg citation per document	Total link strength
1	Food Control	78	1901	24.37	102
2	Food Chemistry	48	870	18.13	8
3	Journal of Agricultural and Food Chemistry	27	575	21.30	6
4	Acta Horticulture	23	64	2.78	0
5	British Food Journal	19	739	38.89	105
6	Food Technology	15	53	3.53	0
7	Foods	15	53	3.53	23
8	International Journal of Food Microbiology	15	474	31.60	3
9	Advance Journal of Food Science and Technology	14	20	1.43	0
10	Food and Chemical Toxicology	14	196	14.00	0
11	Journal of Food Science	14	98	7.00	6
12	Food Policy	12	1074	89.50	71
13	Journal of the Science of Food and Agriculture	12	116	9.67	13
14	PlosOne	12	229	19.08	8
15	Journal of Food Engineering	11	609	55.36	24

products to ensure food safety and security (Caporale et al., 2001; Salina et al., 2021). The most active author in the domain was (Wang and Li, 2006) with 16 publications and a citation count of 238. The average citation received by the author was 14.88. The publications in the domain were not dominated by any particular journal. The journal 'Food Control' contributed maximum articles in the domain with 78 documents and 1901 citations followed by the journal 'Food Chemistry' (48 documents and 870 citations) and 'Journal of Agricultural and Food Chemistry' (27 documents and 575 citations). The articles with over 100 citations narrowed down the total number of articles to 36. The article with greatest number of citations was authored by (Gowen et al., 2007), which provided an insight the role of hyperspectral imaging for ensuring food quality and safety control. The collaboration map between the authors of different countries in the research domain showed that the prominent countries in article publication in this domain were USA, China, Australia, India, Brazil, New Zealand and European countries. Also, the highest collaboration in publications were observed between USA and China. The results are in consistence with the international collaboration publication output of China and USA which has showed exponential growth in the past two decades. The growth of science in China during the period has led to major collaboration with G7 countries at the research field (He, 2009; Verbeek et al., 2002). The major limitation of the study could be the reliance on the Scopus database which is subject to continuous change and updating in the number of indexed journals (Durieux and Gevenois, 2010; Uthman, 2008). This implies that a bibliometric analysis after an interval of few years may provide substantial variations in the results since the researches in the area is continuously growing with the emergence of several novel technologies. There could be a possibility to combine different databases for better depiction of content in the research area. However, the results obtained in the study can help the researchers to dive deeper into the research area and investigate possible research gaps for future study.

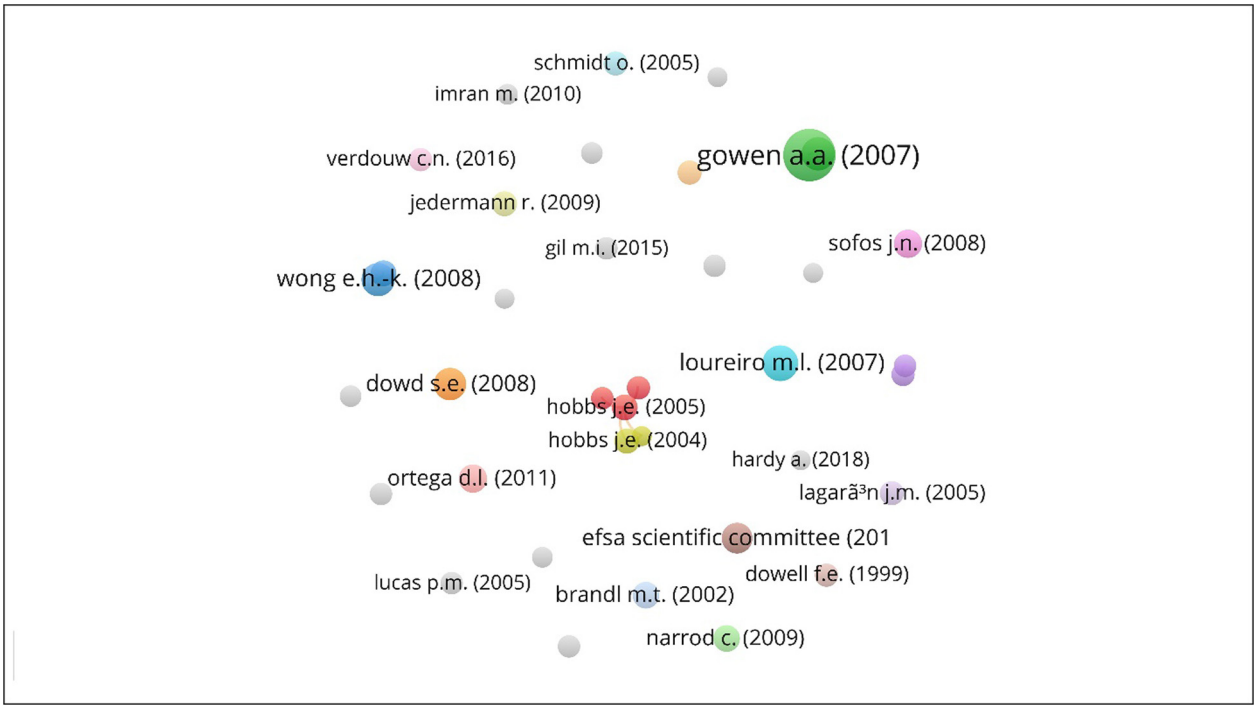

Fig. 6. Relationship between documents and citations for publications that have been cited at least 100 times.

Table 6
Leading documents with at least 100 citations. (Year: 1992–2021).

S.No	Document	Citations	Links	References
1	Gowen A.A. (2007)	859	1	(Gowen et al., 2007)
2	Loureiro M.L. (2007)	381	23	(Loureiro and Umberger, 2007)
3	Kim M.S. (2001)	328	2	(Kim et al., 2001)
4	Wong E.H.-K. (2008)	317	3	(Wong and Hanner, 2008)
5	Dowd S.E. (2008)	295	0	(Dowd et al., 2008)
6	Sofos J.N. (2008)	227	0	(Sofos, 2008)
7	Ortega D.L. (2011)	226	17	(Ortega et al., 2011)
8	Narrod C. (2009)	196	1	(Narrod et al., 2009)
9	Brandl M.T. (2002)	194	0	(Brandl and Mandrell, 2002)
10	Barbuto M. (2010)	185	4	(Barbuto et al., 2010)
11	Hobbs J.E. (2005)	183	31	(Hobbs et al., 2005)
12	Hobbs J.E. (2004)	168	17	(Hobbs, 2004)
13	Jedermann R. (2009)	167	1	(Jedermann et al., 2009)
14	Lagarón J.M. (2005)	164	0	(Lagaron et al., 2005)
15	Schmidt O. (2005)	162	0	(Schmidt et al., 2005)
16	Feng Y.-Z. (2013)	157	0	(Feng et al., 2013)
17	Becker T. (2000)	149	5	(Becker, 2000)
18	Dowell F.E. (1999)	149	0	(Dowell et al., 1999)
19	Van Rijswijk W. (2008)	145	7	(Van Rijswijk and Frewer, 2008)
20	Verdurme et al. (2001)	142	1	(Verdurme et al., 2001)
21	Bertolini M. (2006)	140	10	(Bertolini et al., 2006)
22	Busolo M.A. (2010)	140	0	(Busolo et al., 2010)
23	Lucas P.M. (2005)	137	0	(Lucas et al., 2005)
24	Gil M.I. (2015)	136	0	(Gil et al., 2015)
25	Angulo A.M. (2007)	135	10	(Angulo and Gil, 2007)
26	Chen J. (2012)	134	0	(Chen et al., 2012)
27	Van Rijswijk W. (2008)	133	17	(Van Rijswijk and Frewer, 2008)
28	Smith G.C. (2005)	125	8	(Smith et al., 2005)
29	Souza V.G.L. (2016)	121	0	(Souza and Fernando, 2016)
30	Potyrailo R.A. (2012)	118	0	(Potyrailo et al., 2012)
31	Imran M. (2010)	111	0	(Imran et al., 2010)
32	Garcia-Alonso M. (2006)	109	0	(Garcia-Alonso et al., 2006)
33	Golberg D. (2011)	108	0	(Golberg et al., 2011)
34	Dupuy C. (2005)	106	7	(Dupuy et al., 2005)
34	Hardy A. (2018)	106	0	(EFSA Scientific Committee et al., 2018)
36	Pouliot S. (2008)	104	5	(Pouliot and Sumner, 2008)

Author's contribution

AS was responsible for conceptualization, drafting the manuscript, reviewing and editing. PP assisted in data analysis and visualization. MS contributed in supervision and validation of results, DD assisted in reviewing and editing. The authors discussed the results and implications of the manuscript at all stages.

Availability of data and material

All relevant data and material are presented in the main paper.

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Not applicable.

Declaration of Competing Interest

There is no conflict of interest whatsoever between the co-author and me. Any cooperation or institution did not fund this research.

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