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A Bibliometric Analysis of Food Fraud

Ade Bastian
Universitas Majalengka and adebastian@unma.ac.id

ABSTRACT

Food fraud threatens consumer health, food integrity, and global food supply systems, making it a global issue. Recently, bibliometric analysis has become a useful method for appraising studies in food science and fraud detection. This systematic review employs bibliometric tools to examine food fraud research trends, notable authors, and significant research issues. This investigation searches different scientific databases for relevant 1931–2023 papers. VOSviewer was used to show co-author networks, keyword co-occurrence, pattern quotations, and other bibliometric indicators. The bibliometric study shows a decade-long growth in food fraud studies. This food fraud detection bibliometric study covers the research landscape. These studies help food fraud researchers, policymakers, and other stakeholders discover research trends, prominent authors, significant work, and collaborative networks. These findings can inform future research, information exchange, and evidence-based food safety and consumer protection decisions.

Keywords: *Food Fraud, Bibliometric Analysis, Research Trend, Collaborative Networks*

1. INTRODUCTION

The problem of fraud has become a global phenomenon that endangers the existence of businesses of all shapes and sizes [1]. Even if the number of studies on food governance has expanded at a rapid rate over the past decade, there is still a lack of a systematic integration of food safety governance in the academic research that is being conducted today [2]. The adulteration or falsification of meat products is by far the most common type of food fraud committed across the world. Over the course of the last decade, there have been several instances of fake food events involving meat products in both China and other countries [3]. It has been demonstrated in a number of studies, for instance in Africa, that the falsification of product labels on fisheries goods is an illegal act of tampering with food items [4]. The decrease in fish catches raises awareness of both the necessity of fish and its long-term viability. In order to ensure the survival of native fish species in Ecuador, environmental forensic DNA (eDNA) metabarcoding is utilized [5]. Nearly all of the respondents confessed that they were looking for direction and advice on how to better manage food safety in relation to food fraud and how to avoid it [6]. Using dynamic approaches that vary the parameters of leaf-based models that are particular to fruit and plant physiological isotope models, it is possible to properly forecast instances of food fraud depending on the geographic origin of the product [7].

Food fraud, which includes economically driven adulteration, should be taken seriously. The food industry and government must prevent food adulteration regardless of the causes. Food adulteration, which endangers public health, can result from food safety, fraud, and defense incidents [8]. Quick tool for egg label controls the construction of a fast and affordable technology to identify egg labeling fraud in compliance with the four EU-permitted farming techniques. Classification algorithms include SVM, LDA, and QDA. Support Vector Machine (SVM). Protein levels were unchanged. Spectral data and color properties varied significantly amongst eggs. QDA and spectral analysis increase calibration set sensitivity beyond 100%. Plasma spectral measurements and a classification algorithm can distinguish the four agricultural systems [9]. In most contexts, the intentional misrepresentation of the nature or composition of a product in the food industry for the

purpose of gaining financial advantage is referred to as "food fraud." Despite its seriousness, Ghana's food safety debate has ignored food fraud. To prevent food fraud, food defense systems like VACCP should be integral to a food safety system. Food fraud should now center on this [10]. Food fraud involves meat adulteration. China and other countries discovered several meat product food frauds in the past decade. Includes processed meats, animals, poultry, and byproducts. The data may be utilized to research meat and food safety, food fraud, rapid detection and screening, counterfeit prevention, and regulation in the meat supply chain market. These are only few uses of the results [11]. Food quality management has routinely employed machine learning to evaluate spectral data. Due to distortion, noise, high dimensionality, and collinearity, tiny spectrometers outside the lab cannot acquire high-quality spectrum data. Miniature spectrometers and machine learning pipelines may accomplish classification jobs as well as non-portable and more costly ones. Food fraud protection begins with consumers [12]. China's sewage oil (GO) food fraud is a growing concern [13]. Food fraud in Australia, including adulteration. “Food hoax,” “food fraud,” and “'food fraud', adulteration, nutrition” were searched. Enter 180 food fraud articles. Only two research (1.1%) focused on food fraud in Australia [14]. Seed oil, which is cheaper than olive oil, is used to fake olive oil. EU food safety rules prevent this. Food processing can benefit from near-infrared spectroscopy (NIRS). PCA was used to compare olive oils to sesame, sunflower, and flax oils. These results suggest the portable prototype may identify food fraud in liquid samples [15].

A Bayesian network (BN) model to forecast food fraud categories and falsification points. Food category, year, counterfeiting (chemicals, ingredients, non-food, microbiological, physical, and others), reporting nation, point of counterfeiting, and point of detection determine food fraud type. Most fraud cases involve mislabelling (20.7%), artificial augmentation (17.2%), and replacement (16.4%). Drinks (21.4%), milk (14.3%), and meat (14.0%) are highest fraud notification. Food counterfeiting commonly uses chemicals (21.7%) such formaldehyde, methanol, bleach, and cheaper, expired, or damaged products (13.7%). Manufacturing (63.9%), merchants (13.4%), and distribution (9.9%) are the primary counterfeiting points [16]. Data consistency and security are crucial in the livestock-derived food component supply chain. The length of the supply chain and the absence of infrastructure to store and preserve livestock data make data security difficult. Indonesia uses blockchain for livestock, but only in agriculture or a tiny section of the supply chain. Food supply chain blockchain developed. The system protects farm-to-table data [17].

The corona epidemic revealed supply chain weaknesses. Food fraud increases with this life-threatening prospect. Food fraud, often known as economically motivated food adulteration (EMA), occurs when food package labels contradict ingredients [18]. Seafood provides nutrition and vitamins, but legal and illicit fishing activities are depleting fisheries populations. After the supply chain failure there, reinforcing and protection against systemic shocks like COVID-19 and future pandemics acknowledges that food safety has never been more critical. To produce realistic and profitable fisheries solutions for a post-COVID-19 future, these innovations must overcome financial, practical, social, geographic, and regulatory barriers [19].

Bibliometric study on food safety and halal food for researchers in the supply chain who want to have a better understanding of the overall landscape of the area. This article acts as a connecting thread for researchers working in the two research domains by showing how the work is related, which gives a knowledge of the relationship between halal certification and food safety. [20]. The field of study known as chemometrics is described as the study that extracts the most

information possible from chemical data. ln order to give a bibliometric review of the research literature utilizing chemometric approaches in applications related to food science and technology. As a direct consequence of this, China and Brazil have taken the lead amongst nations in the incorporation of chemotherapy into food products [21].

The Internet of Things is a relatively novel method in the field of food safety. The initial pieces were published in 2011, and they have continued to get better since then. The majority of these studies were carried out by academic institutions in China. The primary Internet of Things applications that have been documented are in the food supply chain for the purpose of tracking food goods, followed by the monitoring of food safety and quality [22]. It is essential to measure, assess, classify, and compare the many publications that are already in existence in the subject of food safety as a result of the ever-increasing changes and rising scientific achievements in this area. Globally and across a variety of disciplines, including biotechnology, microbiology, food processing and preservation, consumer research, and policy creation, the state of food safety is undergoing a period of fast change. There is a severe lack of published research publications in the fields of food fraud detection and prevention studies, as well as those dealing with chemical contamination of food caused by pesticides and other chemical residues [23].

Governance of food safety involves several fields of study, including environmental science, food science, economics, and agriculture respectively. The United States of America has the greatest number of papers that are pertinent to the topic at hand, while Wageningen University in the Netherlands is the most prominent scientific research organization. The formulation of distinct standards for the public and private sectors, the joint implementation of these standards, and the joint governance by multiple sectors are the three stages that make up the development of food safety research governance. Specifically, the creation of separate standards for the public and private sectors. Unfortunately, food security is not a primary concern in low- and middle-income nations, which instead place a greater emphasis on food supply and the architecture of food systems. Countries with higher per capita incomes are more concerned about the nutrition and safety of their food [2]. Table 1 shows the state of the art of searching papers with the keyword food fraud.

Table 1. State of the art food fraud

Author(s) & Year	Number of Documents Analyzed	Sources	Findings
[21]	4112	Elsevier	Use chemometric methods to evaluate research papers in agricultural science and technology. Over the past decade, increased funding has made chemometrics a blossoming study topic. Food chemometrics is led by China and Brazil.
[22]	927	Scopus	Chemometrically evaluate research publications in agricultural science and technology. Due to increased funding over the past decade, chemometrics is thriving. China and Brazil lead food chemometrics.

Author(s) & Year	Number of Documents Analyzed	Sources	Findings
[24]	4375	Elsevier	iRASFF, EMA, HorizonScan, AAC-FF, MedISys-FF, and others identify counterfeit items early, although only MedISys-FF is publically available. MedISys-FF food fraud cases from 2015 to 2020. Network analysis indicates food fraud publications. MedISys-FF can detect food fraud trends early and assure safe, healthy, and authentic food.
[23]	6500	WoS	Biotechnology, microbiology, food processing, preservation, consumer studies, and policy development are growing food safety research globally. Pesticide contamination research is limited.
[25]	270	WoS	Agri-food is using blockchain technology (BCT). China, US, and India lead BCT research and publishing, although India has limited research collaborations. Keyword analysis shows BCT preserves critical members' personal data for supply chain transparency. BCT can improve food safety, traceability, payment, recordkeeping, supply chain management, credit, and insurance in agri-food systems.

There does not appear to be any bibliometrics food fraud issue analysis, as far as we are aware. The purpose of this paper is to answer the following questions:

1. How are food fraud articles classified?
2. What is the trend of food fraud analysis research?
3. Which research topics are the subject of more publications?
4. What are future food fraud analysis topics that provide for further research?

The preparation of this article begins with a literature evaluation of the concept of food fraud based on the findings of prior investigations. Beside In Section 1, you will also find a presentation of the research goals. In Section 2, we will discuss the definition of food fraud as well as the current examination of the term food fraud. Methodology that was utilized in order to carry out a bibliometric study methodology stages associated with the utilization of the database from three different journals presented in Section 3. In Section 4, the results are shown with the help of VOSviewer. Section 5 contains the research ideas, conclusions, and limits.

2. METHODS

The objective of this study is to investigate the many categories that a publication on food fraud might fall under. The next step is to evaluate the topic of future food fraud, which provides opportunities for more study, after determining the social trends related to food fraud research, which is the subject of the research that is the subject of more publications.

2.1 Search of specific Terms Food fraud

The practice of using bibliometric analysis as a tool for investigating and evaluating huge amounts of data is becoming increasingly common and respected. This makes it possible for us to dissect the subtle morphological changes that have occurred over the course of a given field's history while also describing what new areas are developing within that field. Techniques for bibliometric analysis may be broken down into two distinct categories: (1) performance analysis, and (2) scientific mapping. The most important difference between performance analysis and mapping science is that the former takes into consideration the contributions made by research constituents, while the latter concentrates on the links that exist between research constituents [26]. The work begins by searching the Google database associated with the terms which specifically addresses the topic of food fraud with Harzing's Publish or Perish.

2.2 Terms Metrics Information

The objective of this study is to investigate the many categories that a publication on food fraud might fall under. The next step is to find out what the current societal trends are about food fraud research, which is the topic of study that is the topic of more publications, and to evaluate the topic of future food fraud, which provides opportunities for more inquiry. Table 2 shows the metric information of terms.

Table 2. Metrics information of Terms

Metrics data	Food Fraud
Publication's years	1931-2023
Citation years	92 (1931-2023)
Papers	1000
Citations	18672
Cites/year	202.96
Cites/paper	18.67
Authors/paper	2.30
h-index	65
g-index	125
hI,norm	43
hI,annual	0.47
hA-index	26

2.3 Reference Management

After all, papers have been retrieved from the websites of two different journals. The next action involves cleaning up references by utilizing the Mendeley tool. It is necessary to have a

reference in order to guarantee that the article's metadata, which may include information about the author, keywords, an abstract, and other information, are all present.

2.4 Bibliometric Analysis

After all article info is confirmed After finishing everything, the following step is to conduct a bibliometric examination. VosViewer was one of the applications that was utilized in the process of bibliometric analysis for this work.

3. RESULTS AND DISCUSSION

To accomplish the first goal of this study, which was to determine how to categorize articles on social entrepreneurship, the author used the VosViewer program to create a map based on text data by making use of the titles and abstract fields. Using the binary counting approach, the author discovered a total of 4007 keywords. There are 91 thresholds discovered when the minimum number of occurrences of the word is set to 10. On the other hand, a relevance score will be determined for each of the 55 phrases individually. On the basis of this score, the most pertinent keywords will be chosen automatically by default until they reach 60% of the Template: Anonymous Document, at which point we will have 55 words that are the most appropriate. However, the verification procedure must still be carried out by hand, and it requires the elimination of terms that are not pertinent to the topic at hand. These words may include editorials, examples, abstracts, and so on. Therefore, the maximum number of words that may be incorporated into the creation of a map is 55 words.

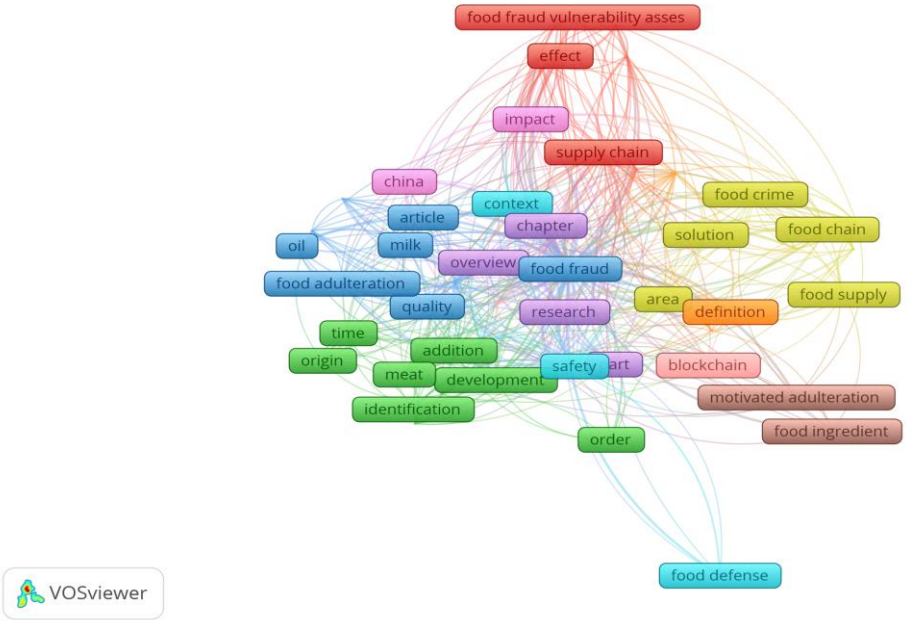

Figure 1. Network visualization map of keywords

According to Figure 1, there are various clusters that have been designated with different colors, including blue, purple, yellow, red, and green. According to the overall number of articles, numerous of the cluster's terms are used most frequently. This cluster provides evidence that, as of

this writing, there are nine different categories for articles. Table 3 has more information that may be viewed.

Table 3. Clusters and keyword therein

Cluster	Total items	Most frequest keywords (occurences)	Keywords
1	9	supply chain (83), effect (26), food fraud database (21)	covid, effect, food fraud database, food fraud risk, food fraud vulnerability assessment, fraud vulnerability, supply chain, vulnerability
2	9	meat (33), idenfication (28), development (24)	addition, development, fish, idenfication, meat, meat product, order, origin, time
3	9	food fraud (1306), oil (37), food adulteration (29)	article, food adulteration, food fraud, form, milk, oil, perception, quality, technique
4	8	chain (34), integrity (27), fighting food fraud (21)	area, coffee, fighting food fraud, food chain, food crime, food supply, integrity, solution
5	7	application (47), food fraud prevention (46), research (36)	application, chapter, focus, food fraud prevention, overview, part, research

Then, in order to address questions regarding societal trends regarding food fraud study, we may look to the cluster itself to see the answer. Figure 2 is a graphic representation of the number of papers that have been published. The term that appears most frequently is located in Cluster 1, which includes the words resource and service.

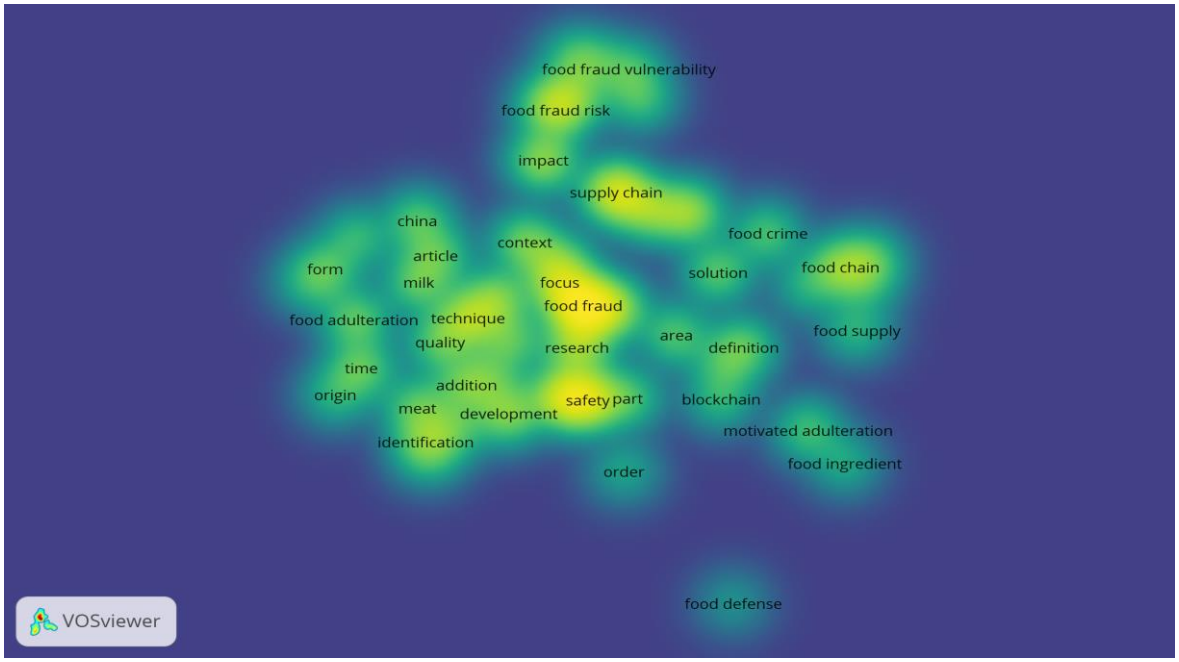

Figure 2. Density Visualization Map of Keywords

The findings of this mapping show that there are clusters that occur on at least some of the keyword clusters 8, 9, and 10. This cluster includes discussions on issues such as the conflict, food

components, motivated adulteration, China, influence, blockchain, and aceability. In addition, there are a few terms that only appear seldom among the keywords for each cluster. Some examples of these words are food fraud, food adulteration, battling food fraud, food defense, and food quality. That is to say, there are still research gaps that are quite likely to arise as a trend in the future, which of course is fitted to the conditions of both the world we live in now and the world that will come after us. According to the findings of the study, there are additional nine distinct clusters, which are depicted in figure 3.

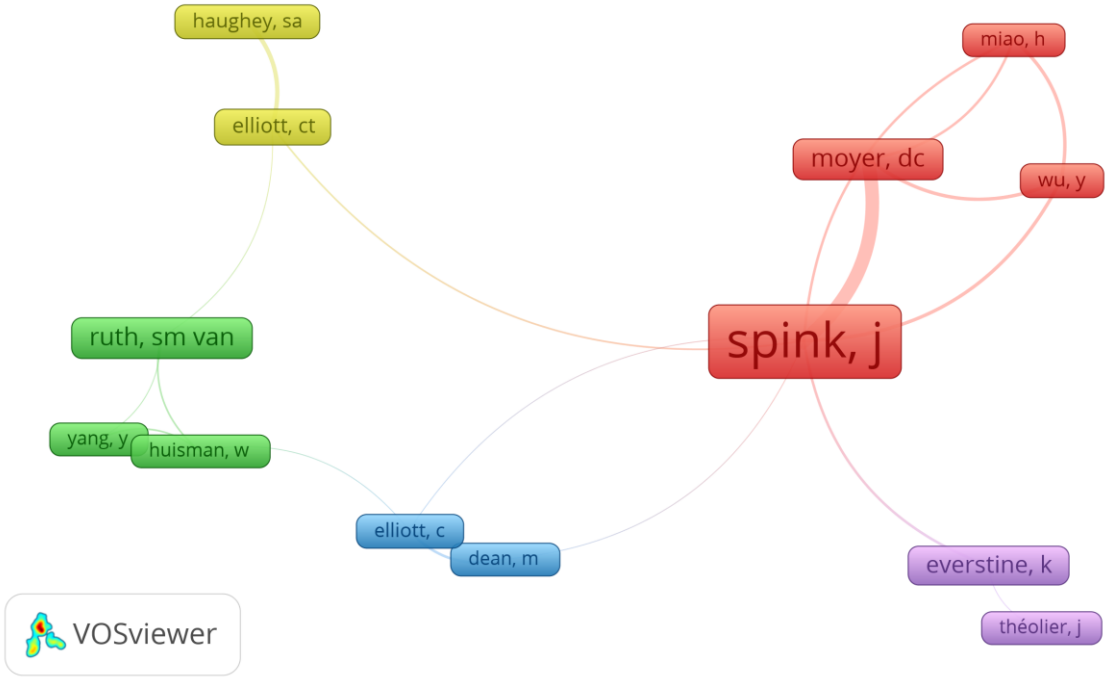

Figure 3. Network visualization map of authors

It is clear from looking at Figure 3 that there are a top five names that come from each designated cluster that has a significant number of points in each cluster. Only the writers who are affiliated with their articles are shown in the photo. Imagine, nevertheless, that the credibility of authorship was taken away. In this particular instance, the author with the most significant points is John Spink, who has a total of sixty documents. Saskia M. van Ruth and Douglas C. Moyer each have a total of seventeen papers and sixteen articles respectively. It is known that the calculations for Table 4 will take place on May 18, 2020, and they will include papers from the two journals with the highest citations, along with additional specific features.

Table 4. The Top Ten Cited Documents in Food Fraud

Citations	Authors and year	Title
771	JC Moore, J Spink, M Lipp 2012	Development and application of a database of food ingredient fraud and economically motivated adulteration from 1980 to 2010
768	J Spink, DC Moyer 2011	Defining the public health of food fraud

Citations	Authors and year	Title
653	JF Galvez, JC Mejuto, J Simal-Gandara, 2018	Future challenges on the use of blockchain for food traceability analysis
492	GP Danezis, AS Tsgkaris, F Carmin, V Brusic, 1992	Food authentication techniques, trends & emerging approaches
393	M Woolfe, S Primrose 2004	Food forensics: using DNA technology to combat misdescription and fraud
365	D Bumblauskas, A Mann, B Dugan, J RIttmer, 2020	A blockchain use case in food distribution: Do you know where your food has been?
331	K Everstine, J Spink, S Kennedy, 2013	Economically motivated adulteration (EMA) of food: common characterictics of EMA incidents
330	R Johnson, 2014	Food fraud and economically motivated adulteration of food and food ingredients
303	E Cubero-Leon, R Penalver, A Maquet, 2014	Review on metabolomics for food autehtication
248	F Antonucci, S Figorilli, C Costa, 2019	A review on blockchain applications in the agri-food sector

From 1931 until 2023, the majority of food fraud documentation included direct quotations. Only if the author has done extensive background research will you find numerous citations in the most recent materials. Then, let's look at Table 5 to discover which areas of study have generated the most scholarly articles.

Table 5. The 15 Most and Fewer Occurences Terms in Food Fraud

Most Occurences		**Fewer Occurences**	
Occurences	Term	Occurences	Term
1306	Food fraud	16	Food fraud vulnerability
83	Supply chain	16	Perception
75	Safety	16	Meat
47	Application	15	Food fraud risk
46	Food fraud prevention	15	Area
43	Strategy	15	Time
37	Oil	14	Food quality
36	Research	14	Blockchain
35	Impact	13	Solution
34	Food chain	13	Fish
33	Meat product	13	Coffee
31	Overview	12	Covid
29	Food adulteration	12	Order
29	China	12	Food defence
28	Technique	12	Food supply

Table 5 not only explains the themes that are discussed the most frequently in published works, but it also highlights the overarching purpose of this piece of writing, which is to determine

which potential future food fraud issues present prospects for more study. Concerning matters like the prevention of food fraud, its application, and safety, quite a lot of new information has been acquired. The same can be said about issues concerning the adulteration of food, such as their supply networks and the methods they use, both of which are mentioned quite a bit in the paragraphs that came before.

Problems that have the potential to become possibilities for future research of more detailed aspects and lead to food supply, food defense, and blockchain technology. Not a lot of study has been done on a lot of different topics, including finding food fraud.

4. CONCLUSION

The current study conducted an analysis of one thousand different articles on a topic that was related to food fraud. There are five distinct categories for the articles about food fraud. Research on food fraud is focusing increasingly on prevention, application, and safety as recent trends indicate. Publications cover a variety of issues on a regular basis, including the prevention of food fraud and food adulteration as well as food chain and strategy. Food supply, food defense, and blockchain are three topics that are discussed infrequently. One limitation of the current research is that it is based on metric terminology. This is a limitation of the current study. In spite of the fact that this research utilized standard techniques (such as PoP software, VOSviewer, and Mendeley), the authors did engage in subjective assessment, which raises the possibility that errors were identified. In further studies, it would be beneficial to make use of a bigger sample size by include more articles that are not indexed in Scopus. In addition, it is proposed that additional bibliometric analysis tools, such as BibExcel and HistCite, be used to compare and contrast the conclusions of the analytical work.

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BIOGRAPHY OF AUTHOR

Ade Bastian Bachelor of Informatics Engineering at Universitas Majalengka, Master of Information Systems at STMIK LIKMI Bandung. Research focus on Multimedia, Computer Graphics, and Computer Vision Vision. adebastian@unma.ac.id