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The Food Fraud Landscape: A Brief Review of Food Safety and Authenticity †

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Abstract: Food fraud poses a significant challenge within the global food supply chain, with apprehensions regarding safety, authenticity, and efficiency. This study conducts a brief review of the literature by utilizing the Web of Science database, analyzing 2331 outcomes pertaining to the subject of food fraud. The analysis results demonstrated a noteworthy surge in scientific publications after 2013, which was propelled by events such as the horsemeat scandal and the formation of the European Food Safety Authority. Utilizing Multiple Correspondence Analysis (MCA), the study identified significant clusters pertaining to food transformation, safety, traceability, and distinct meat sources. In addition, trending topics shifted towards a holistic approach to food safety and the implementation of technologies like Blockchain (BC), Internet of Things (IoT), Artificial Intelligence (AI), and Big Data (BD). These technologies offer enhanced traceability, authentication, automation, and decision-making capabilities. The present research offers valuable perspectives on the evolving landscape of food fraud research and the potential of nascent technologies to tackle these issues.

Keywords: food fraud; food safety; food authenticity; food supply chain; review; Industry 4.0; sustainability; blockchain; food traceability; Multiple Correspondence Analysis (MCA)

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1. Introduction

Over the last decade, the Food Supply chain (FSC) has been facing one of the most emerging challenges and issues on a global scale, specifically "Food Fraud". Food fraud is considered an intentional act of misrepresentation of food for economic gain that is intended to remain undetected by the consumer, and often includes food modification or false documentation [1]. Food products are heterogeneous, as they come in various proportions from different geographical sources and comply with different legislation and norms depending on their origin, destination, and manufacturing [2,3]. Thus, food commodities are prone to fraudulent acts. In addition, FSCs have several interconnected and intercorrelated elements and phases that should be considered for assuring elimination of food fraud along the supply chain [4].

2. Materials and Methods

This literature review is mainly focused on the assessment of Web of Science (WoS) database results, regarding the term "food fraud" in abstracts, titles and keywords, leading to the extraction of the factors influencing this specific field. More precisely, partnerships and trending topics were assessed, focusing on the technological, social and economic

dimensions. In this study, 2331 results have been collected through the WoS database, and have been transformed into a unified Bibtex file. Moreover, the Bibliometrix library was used to extract the figures and data presented in the subsequent sections [5].

3. Results and Discussion

The literature review assessment covered the period from 2003 to 2023, coinciding with the establishment of the European Food Safety Authority (EFSA) and extending up to February 2023 (Figure 1). This timeframe reflects the European Union's transition towards producing safer food products for consumers, and it can be divided into three sub-timeframes. From 2003 to 2013 (first time frame), scientific production was limited and low, resulting on the annual production of 25 papers on average for this period regarding food fraud. For the second time frame (2013–2018), the scientific production increased significantly, leading to an annual production of 200 articles in 2018. Post-2018 (third time frame), the annual scientific production had a straight increase reaching up to 400 articles in 2021 on an annual basis. This gap between the different time frames is due to raised awareness regarding food fraud issues. Both the EFSA's report on pesticides and the horsemeat scandal that broke in 2013 indicate that these two incidents were the catalysts for the European strategy to eliminate food fraud [6,7].

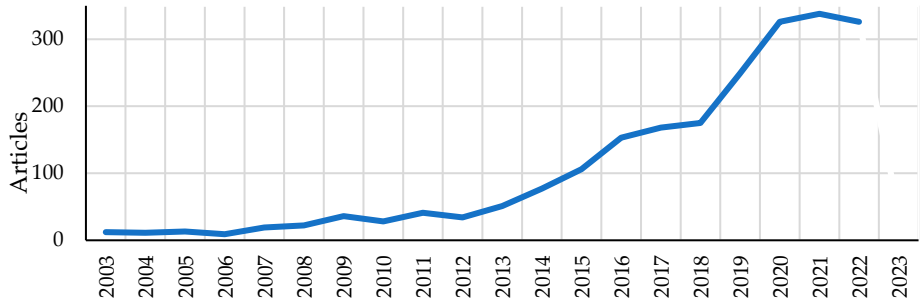

Figure 1. Trend of annual scientific production on food fraud.

3.1. Conceptual Structure Map

For a deeper understanding of the dynamics of the terms used in the scientific production, a conceptual structure map was obtained through the Multiple Correspondence Analysis (MCA) method. Two main groups were recognized, as shown in Figure 2. The first group, which is highlighted in red, contains the majority of the keywords regarding food transformation and science, as well as safety and traceability. Meanwhile, the second group contains seafood and substitution. Two subgroups can be identified within the red group. The first one refers to the applied methodologies (e.g., chemometrics, metabolomics and markers), and the second one refers to the different meat sources (e.g., meat, beef, pork). An important finding is that fish meat is an independent cluster, meaning that there is a special treatment towards this sensitive product. Overall, the MCA model can explain 69.3% of the involved keyword variability, which is considered representative of the whole sample of 2331 papers being incorporated into this literature review.

3.2. Trend Topic

Over the last decade, trend topics have been changing, leading to the creation of new directions of the scientific orientation regarding food fraud and its assessment in the FSC. Figure 3 presents the food fraud trend topics over the years. Up until 2017, the terms *quality, authenticity, food safety*, and *supply chain monitoring* were absent. Prior to 2017, almost all keywords and trend topics were focused more on the food science and biochemistry domains, rather than ensuring the quality and the elimination of food fraud in the FSC. It was no later than 2019 that there was a shift towards a holistic approach for increasing food safety standards and providing more insights about the implementation of new technologies for monitoring.

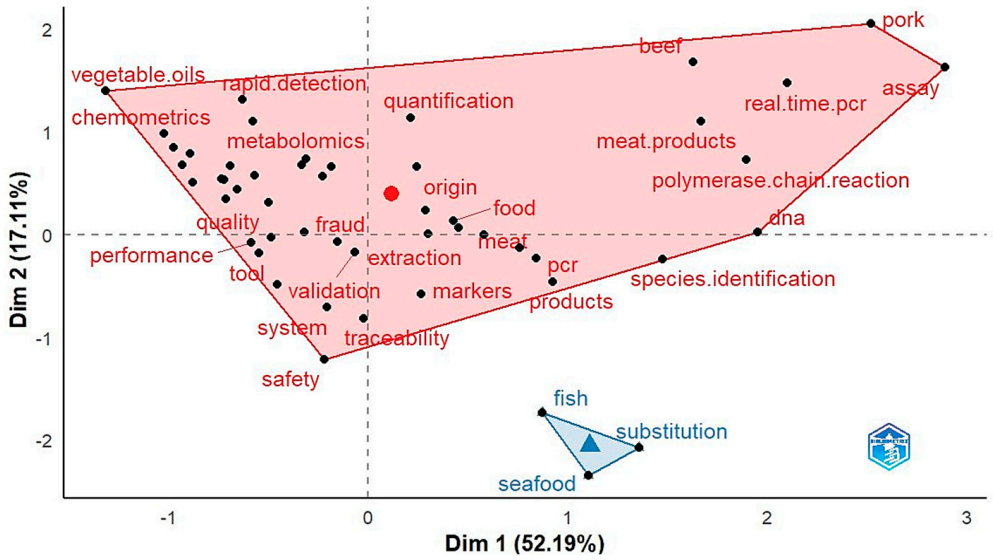

Figure 2. Analysis of food fraud most relevant keywords. Conceptual structure map using MCA.

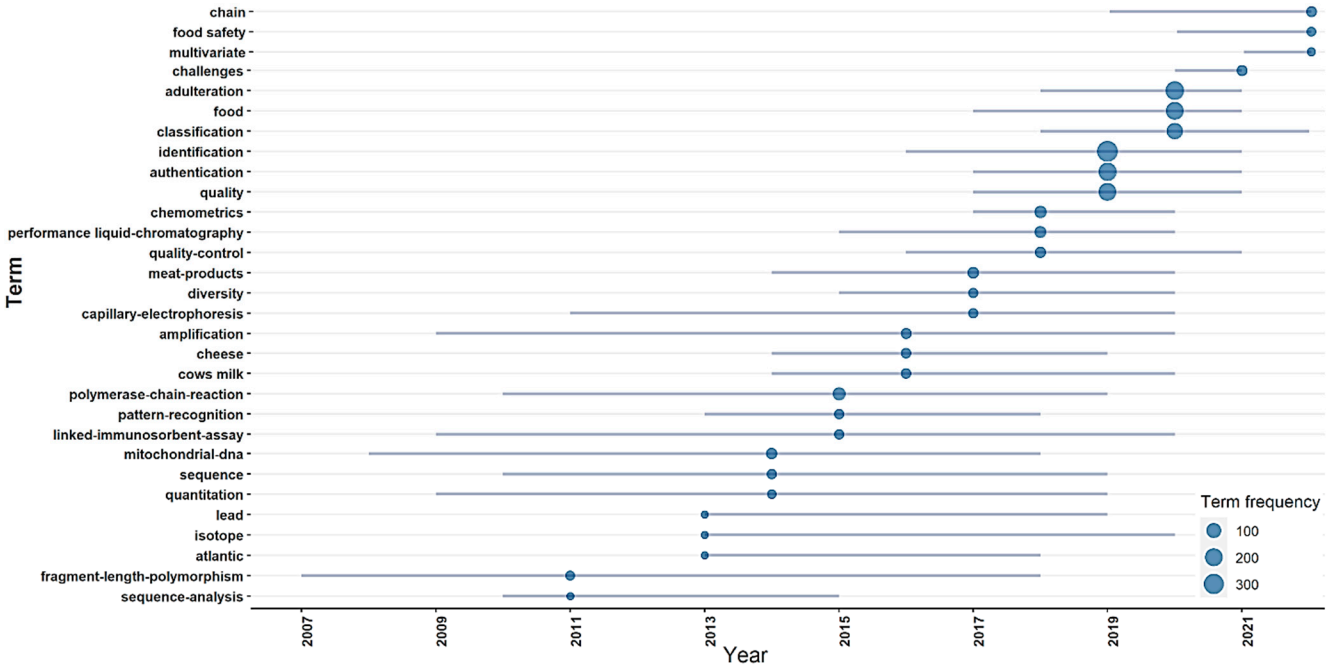

Figure 3. Representation of food fraud trend topics over the years.

Furthermore, a subsequent review was conducted regarding trending technologies on FSC for food safety and authenticity. The dominant technology is Blockchain (BC), followed by IoT, Artificial Intelligence (AI) and Big Data (BD). BC and IoT provide reliable traceability systems, and offer the assurance of food authenticity and safety, given the input of the data is reliable. AI, on the other hand, enhances automation and digitalization, and can provide predictions for food fraud, while Big Data supports the prementioned technologies while improving decision-making [8]. Table 1 quotes selected publications classified based on these technologies.

Table 1. Selected publications classified based on these technologies.

Source	Category	AI	BC	BD	IoT
2019 [9]	Food quality and Authenticity	•			
2022 [10]	Food Safety		•		
2017 [11]	Food Safety			•	
2022 [12]	Food Authenticity		•		
2019 [13]	Food Fraud Detection	•	•		
2020 [14]	Food Provenance and Authenticity	•	•	•	•
2018 [15]	Food Quality & Safety				•
2021 [16]	Food Authenticity		•		

4. Conclusions

The issue of food fraud poses a continuous and dynamic challenges in FSC. The literature review of this study highlighted the growing recognition and scholarly inquiry into comprehending and addressing the issue of food fraud. The identification of pivotal clusters pertaining to safety, authenticity, and meat origins yields valuable insights into the research's focal points. The shift towards a holistic approach and the adoption of technologies like Blockchain, IoT, AI, and Big Data demonstrate promising solutions for ensuring food authenticity and safety. However, further research and collaboration are required to bridge gaps and inconsistencies in FSC, ultimately safeguarding consumers and upholding the integrity of the industry. The mitigation of food fraud necessitates an ongoing level of vigilance, advancements in the field of technology, and comprehensive strategies focused on enhancing the transparency and efficacy of the FSC.

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