**Food supply chain and Blockchain**

**Introduction**

In recent years, several research studies have investigated the potential of blockchain technology in food supply chain management (Chiaraluce et al., 2014; Mohammed et al., 2023). Food supply chain comprises a sequence of participants, processes, and operational activities that convert food from raw materials into a finished products to satisfy customer demands (Burgess et al., 2024; Terziyska et al., 2024). Food supply chain encompasses all activities and processes that occur before food from a farm reaches our tables (Vern, et al, 2024). The design and management of the food supply chain focus on quality, safety, sustainability, and logistical efficiency, from farm to fork (Su, et al, 2024). Food supply chain management involves interrelated processes like raw material production, processing, distribution, consumption, and disposal, with disruptions triggering a cascade of events affecting product delivery to consumers (Ellahi, et al, 2024). In comparison to other industries, food production occurs within more susceptible value chains, necessitating heightened scrutiny of handling activities, including manufacturing and storage. Moreover, food inherently undergoes continuous changes in quality, posing a barrier to the assurance of food safety and quality (Duan et al., 2020). The food supply chain is affected by several unique elements such as regulations, law, and food safety (Terziyska, et al, 2024).

The food supply chain is a complex system involving various stakeholders, including customers, farmers, manufacturers, distributors, retailers, and the government, responsible for the distribution of food items (Etemadi et al., 2020; Mohammed et al., 2023). Therefore, effective management of food supply chains is complex (Katsikouli et al., 2020; Kamilaris et al., 2019). This complexity often leads to food quality and safety concerns, such as contamination, spoilage, and waste (Vern, et al, 2024). The need for transparency in the food supply chain is increasing as stakeholders from production to consumption seek enhanced sustainability, food quality, and food safety (Burgess, et al, 2024). Consumers are increasingly prioritizing food quality, safety, and nutrition above mere quantity (Duan et al., 2020). In this regard, blockchain technology provides advantages in the management of the food supply chain by facilitating rapid and reliable traceability (Cruzalegui et al., 2023). Additionally, blockchain technology can enhance the food industry’s supply chain via increased transparency, security, and efficiency (Terziyska, et al, 2024).

Blockchain technology has the potential to be applied across various sectors and industries (Malisic, et al, 2023). Blockchain technology was established in 2008 by Satoshi Nakamoto to develop Bitcoin. Since then, blockchain applications have expanded significantly beyond cryptocurrencies to include food traceability, ballot tracking, identity verification, real estate processing, and supply chain management, among others (Sharma et al., 2023; Mohammed et al., 2023; Sundarakani and Ghouse, 2024). Blockchain has been effectively used in financial sectors, such as Bitcoin, and currently generates significant attention in several domains, including the food supply chain (Duan et al., 2020). Blockchain technology is a decentralized ledger that significantly enhances data transparency, trust, immutability, integrity, and traceability for all participants in the food supply chain (Etemadi et al., 2020; Mohammed et al., 2023). This has led to significant interest from the food industry (Vu, et al, 2023).

In recent years, blockchain has been positively embraced in the supply chain sector because to its provision of assured transparency and traceability (Sakib, 2021). Traceability is a crucial instrument in the food supply. It acquires, saves and tracks food supply chain information at every level to ensure the maintenance of quality, safety, and traceability along the food supply chain (Sharma et al., 2023). Traceability is seen as an effective strategy for monitoring food safety throughout the food supply chain (Yadav and Singh, 2019). Historically, the traceability system mostly depended on paper-based methods or internal computer systems, which were laborious and prone to inaccuracies. Blockchain offers a viable solution to these challenges, improving transparency and traceability in food supply chains (Duan et al., 2020). Blockchain has been recognized as a viable technology for improving transparency and traceability in food supply chains (Malisic, et al, 2023). Blockchain can guarantee product authenticity, mitigate fraud, and boost customer confidence (Hasan, et al, 2023).

Effective management of food distribution along the supply chain is essential to prevent food waste and loss during manufacturing, procurement, storage, and distribution stages. The efficient design and management of the food supply chain enhance food availability, accessibility, and security. Innovative technologies like blockchain are characterized by their uniqueness, disruptive potential, and ability to effect significant transformations in our perceptions of trust, security, and transparency in the digital era (Sundarakani and Ghouse, 2024). Blockchain is acknowledged as a promising advanced technology; yet, substantial research gaps exist owing to insufficient studies on its development and deployment within the food supply chain (Astuti and Hidayati, 2023). It is a relatively new concept and actual case studies are absent in the literature (Sharma et al., 2023). This systematic literature review seeks to address this gap by collecting and evaluating existing research to provide a comprehensive understanding of the integration of Blockchain in the food supply chain. This comprehensive literature review presents results and offers scholars recommendations for potential future study topics.

**Methodology**

Systematic reviews and meta-analyses are essential methodologies for synthesizing scientific literature using predetermined criteria and follow a specified methodological framework to address a particular research inquiry (Moher et al., 2015; Arya et al., 2021). Systematic reviews and meta-analyses can summarize large bodies of relevant original studies and then synthesize independent findings (Zhang et al., 2020). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement is a guideline designed to improve the transparency of systematic reviews and meta-analyses (Page and Moher, 2017). The PRISMA assists authors in effectively reporting their systematic reviews and meta-analyses (Peters et al., 2015). PRISMA is a guideline designed to improve the quality of systematic review reporting and ensure transparency in article selection. It assists authors in preparing protocols for systematic reviews and meta-analyses, requiring minimal components for inclusion in the protocol (Knobloch et al., 2011; Hutton et al., 2015; Moher et al., 2015; O'Dea et al., 2022).

PRISMA was released in 2009 to provide criteria for the reporting of systematic reviews and meta-analyses (Moher et al., 2009; Panic et al., 2013; O'Dea et al., 2021; Parums, 2021). It has been established and used by academic institutions and publications globally to enhance the reporting quality of systematic reviews and meta-analyses (Wang et al., 2019). It has received extensive citations and endorsement from prominent publications (O'Dea, et al., 2021).

The PRISMA guidelines delineated eight principal considerations for authors prior to conducting a systematic review and meta-analysis: define the review question; compose and publish or register the study protocol; execute an objective and comprehensive systematic review of the literature; identify included studies by screening results against selection criteria; assess the quality of the studies; synthesize the evidence through meta-analysis; and prepare a manuscript for publication in accordance with reporting guidelines. Revise the systematic review and meta-analysis when new data becomes available (Parums, 2021).

***Search process and Data Source***

Considering the integration of blockchain in the food supply chain in recent years, along with the changes it has introduced and the challenges encountered in the use of such technologies, it is important to identify and summarize the state of the literature on the relationship between blockchain and the food supply chain. This study undertakes a comprehensive systematic literature review to identify research trends and gaps in the field. A systematic literature review summarizes existing studies, identifies research gaps, and suggests directions for future research (Petticrew and Roberts, 2006; Lame, 2019; Bhimania, et al, 2019). Therefore, by reviewing the relevant literature, the depth and scope of existing studies can be assessed (Xiao and Watson, 2017). In light of this, we believe that the systematic literature review is the best approach for achieving our research goal, which is to present a thorough and excellent analysis of the substantial body of recent research in blockchain-based food supply chains.

The databases considered for this study were Scopus, which were used by multiple researches in the literature. Scopus database, is widely used in academic and research fields. Scopus offers advanced smart tools to scan, assess and visualize research (Bhimani et al, 2019).

To address the current scientific gap of blockchain adoption in the food supply chain, this study aims to o assess the current situation of blockchain implementation in this sector. To support the research aim, clear objectives were set to enable a comprehensive and systematic search of relevant studies. As the research topic is new, the search string was kept broad to ensure comprehensive coverage of related studies. Hence a combination of terms related to both areas (i.e. blockchain and food supply chain) were used to identify the related studies. To capture the most recent studies on blockchain adoption in food supply chains, the publication period was set as 2016 to 2024. Following established guidelines for high-quality literature reviews, only specific document types were considered, such as articles, conference papers, reviews, and conference reviews. Additionally, studies were only considered if they were available in English language. Likewise, to allow for appropriate review and analysis, studies were considered only if there are open access. Documents meeting these criteria were selected and exported in CSV format for detailed review. At the end of this process, 628 studies were obtained.

***Inclusion and Exclusion Criteria***

The purpose of implementing inclusion and exclusion criteria is to ensure that all studies selected in the systematic literature review are pertinent and directly related to the study. The inclusion and exclusion criteria that were established in this study were summarized Table 1.

Table 1 Inclusion and exclusion criteria

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| --- | --- |
| Inclusion criteria | Studies indexed in Scopus and written in English.  Open access studies.  Studies published in the period 2016-2024. |
| Exclusion criteria | Studies not indexed in Scopus and written in languages other than English.  Subscription studies.  Chapters from books, and books. |

The authors were initially screened 628 studies. 26 articles were excluded due to duplication and missing author information. The remaining 602 studies were subjected to title review; studies without the keywords “blockchain” and “food supply chain” in their titles were excluded. Subsequently, during the screening phase 336 abstracts were removed. 259 articles were excluded after a comprehensive assessment of their content. Ultimately, 7 studies were deemed suitable for further analysis. Figure 1 summarizes the selection and exclusion procedure for the chosen article.

Identification of studies via Scopus database.

Records identified from via Scopus database (n=628).

Identification

Records removed before screening: Duplicate records and those with missing authors (n=26).

Total abstract screened (n=602)

Screening

Rejected at abstract (n=336).

Full text assessed for eligibility (n=266).

Rejected at abstract (n=255).

Full text assessed for eligibility (n=11).

Rejected based on eligibility criteria (n=4).

Included

Studies included in review (n=7).

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| **Author** | **Purpose** | **Methodology** | **Key findings** |
| Ellahi et al. (2024) | This study explores the application of Blockchain technology in food supply chains, identifying areas where its potential is not fully utilized. | Systematic review | The research emphasizes the significance of Blockchain technology in enhancing food traceability, streamlining supply chain stages, reducing waste, and ensuring surplus food distribution. |
| Chopra and Pathrotkar (2024) | The study aims to introduce a new Food Traceability System (FTS) called FTS-IoT-BT, which integrates IoT and Blockchain Technology to improve security protocols in the Food Supply Chain. | Literature review | The study showcases the FTS-IoT-BT system's superior performance, achieving 96.7% efficiency with ten IoT devices, enhancing security, traceability, and data reliability in the Food Supply Chain. |
| Chunduri et al. (2024) | The study aims to improve the PBFT algorithm through empirical analysis, enhancing its reliability, performance, and transparency in a food traceability system. | Experimental research design | The t-PBFT approach outperforms the PBFT algorithm in terms of throughput, request delay, and information overhead, according to experimental evidence. |
| Burgess et al. (2024) | This study aims to identify, categorize, and prioritize information needs in alternative food supply chains. | Mixed-methods | The study emphasizes the importance of product quality, production processes, and sustainability in alternative food supply chains. It suggests that blockchain can increase transparency and dynamically address these needs. |
| Hao et al. (2024) | This study aims to explore the integration of blockchain technology into the food supply chain within the restaurant industry. | Experiments | The study found that blockchain adoption enhances traceability, trust, and customer satisfaction in the food supply chain, with its impact varying depending on restaurant type and location. |
| Vern et al. (2024) | The main objective of the study is to identify factors influencing trust in blockchain-supported traceability systems for processed food products, focusing on increasing consumer trust and revealing their underlying mechanisms. | Quantitative research approach | Blockchain-supported systems enhance transparency, authenticity, consumer confidence, and product quality by providing traceability information to consumers, thereby enhancing the quality of processed food products. |
| Chiaraluce et al. (2024) | This study evaluates blockchain adoption in the agri-food sector, focusing on high-value supply chains like wine and olive oil, to assess its current status. | Systematic Review | The study reveals blockchain's potential in addressing fraud and food safety issues in the agri-food sector, particularly in wine production, but not yet fully applicable to olive oil production. |

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