IJARBM – International Journal of Applied Research in Business and Management
Vol. 05 / Issue 02, July 2024
ISSN: 2700-8983 | an Open Access Journal by Wohllebe & Ross Publishing

This paper is available online at
www.ijarbm.org

Blockchain Applications in the Food Industry: A Systematic Literature Review

Juan C. Montenegro Hernandez
Montenegro.Hernandez.Juan.Carlos@phd.uni-mate.hu
Hungarian University of Agriculture and Life Sciences, Kaposvár, Hungary

https://doi.org/10.51137/ijarbm.2024.5.2.23

Abstract – This paper presents the findings from a systematic literature review that explores the applications of blockchain technology within the food industry. The review is based on an analysis of 83 selected publications which have been sourced from ScienceDirect and Web of Science databases. The findings show promising and multifaceted ways of blockchain technology in the supply chain. By enabling secure and traceable data management, blockchain contributes to more safety and reliability of information hereby contributing to auditing functions as well as enabling sustainability-oriented business and reporting practices. The impact of blockchain technology is affecting various stakeholders in the supply chain. For example, consumers benefit from improved access to trustworthy food-related information, which in turn can shape purchasing decisions. Businesses, on the other hand, face the imperative of assessing the potential implications of blockchain technology on their existing strategies. Despite the evident progress and the promise of numerous advantages, it is apparent that blockchain technology in the food industry remains at an early stage of development with much work ahead with respect to academic contributions and practical implications. It is essential to tailor the implementation of blockchain technology to the specific conditions of individual supply chains, particularly regarding different types of food products. This applies equally to the bakery industry, where academic research is still missing so far. Therefore, insights from other sectors within the food industry are informative as to their applicability in the bakery industry as well if they are indirectly applied.

Keywords – Blockchain, Smart Contracts, Supply Chain, Food Industry, Bakery, Sustainability

Submitted: 2024-08-27. Revised: 2024-09-11. Accepted: 2024-09-18.

1 Introduction

Blockchains are examples of a distributed ledger technology where all members within a network engage into mutual information sharing. Therefore, a blockchain is virtually a distributed database that contains a continuously growing list of data. By design, the data records are secured against falsifications alterations even if such revisions are attempted by the operator of the network (Yoo, 2017). Blockchain technology is considered as having the potential of creating new systems of collaboration and communication in a large variety of sectors and applications. It is deemed to enhance information security and transparency through the usage of encrypted data which is shared within peer-to-peer networks in a decentralized way. These capabilities have led to a growing interest in applying blockchain across different industries, mentioning the technology of blockchain as a revolutionary concept (Komalavalli et al., 2020; Lee, 2019). A specific characteristic of settling transactions using blockchain technology is that there is no need for intermediation by a trusted third party. That is because all data entries are collectively recorded, versified as well as saved in the public ledger, which can be accessed by anyone publicly. Through the process of synchronization by the members in the blockchain network attacks on the network or falsifications are prevented (Yoo, 2017). The activity of mining ensures that records of past transactions are added to the distributed ledger, meaning that that blockchain is updated accordingly in a secure way (Mukhopadhyay et al., 2016). However, blockchain technology can be designed differently, depending on the network. Hereby, Bitcoin can be mentioned as a prominent application of blockchain technology, especially in the context of cryptocurrencies (Streng, 2018, p. 69). Ethereum also provides a peer-to-peer distributed blockchain network that is open-sources and based on cryptographic hash functions to gain trust by users (Lee, 2019). The blockchain in the Ethereum network can particularly be characterized as a blockchain that enables a higher capability level than traditional blockchains (Wilkens & Falk, 2019, p.8).

An example for an application of the blockchain technology can be found in the context of smart contracts. These allow a technologically enabled way of evaluating if contract conditions are met, whereby enforcement mechanisms can be performed automatically through the computer code (Fill & Meier, 2020, pp. 120-121). Such blockchain-based smart contracts can be used in for example in rent contracts (Karamitsos et al., 2018), in logistics and supply chain operations (Hinckeldeyn Johannes and Kreutzfeldt, 2019) or in the context of financing firm operations (Himmer, 2019). There are also options to use blockchain technology in the food industry, e.g. by applying smart contracts in supply chain networks to verify the quality and the source of inputs (Sunny et al., 2022) (Wilkens & Falk, 2019, p. 18). This has practical implications as firms such as Walmart use blockchain technology for tracking food distribution processes with the aim to increase reliability in the supply chain (Lee, 2019). However, these applications of blockchain technology in the food industry have a rather anecdotal character as there is insufficient academic research so far on the implications of blockchain technology for food-related process in terms of value generation and competitiveness (Berneis et al., 2021).

2 Methods and Data

The paper conducts a systematic review of the academic literature to provide a current picture on the state of the research in the field of blockchain applications in the food industry. Below, the methodological approach of the systematic literature review is introduced. Also, research questions are stated, and the search strategy is described.

2.1 Methodological approach

The method of a systematic literature review employs a structured approach to the analysis of the literature. It is hereby particularly relevant to explicitly state and describe the process how the literature search was carried out and how the relevant sources were identified and selected. This includes a qualitative judgement by which exclusion criteria are also applied as well. It is key to provide a documentation to the process through a protocol (Denyer & Tranfield, 2009; Kitchenham et al., 2009). The methodology of systematic reviews of the literature has become very prominent and applied in a variety of fields but has its sources in medical research (Saunders et al., 2009; Tranfield et al., 2003). Systematic literature reviews on blockchain applications can already be found in academic research with some of them showing applicability of the blockchain technology especially in supply-chain related processes of food production or in tracking process (e.g. (Berneis et al., 2021; Sunny et al., 2022).

The protocol for a systematic review includes an overview of the most relevant information that is describing the review. This includes information regarding research questions, information sources like the databases that have been used as well as the filter criteria and the keywords for the database research. Furthermore, the selection process and the methods of analysis are mentioned (Ton et al., 2023; Tranfield et al., 2003). The so-called PRISMA model can be used, which states the process of identification, screening, eligibility analysis, and the inclusion decision quantitatively (Moher et al., 2009). For the current paper, the details on the search strategy are mentioned in more detail below in paragraph 2.3, applying the basic principles of the PRISMA approach to determine the eligibility of sources for the review.

2.2 Research questions

Defining appropriate and sufficiently detailed research questions can be regarded as a necessary and very important first step in the process of conducting a systematic review. It is hereby relevant to accurately formulate the questions as these constitute the relevant input to the keyword-based research(Denyer & Tranfield, 2009; Tranfield et al., 2003). For the purpose of this thesis, the research questions must focus on ways for using the blockchain technology in the food industry. This might include applications in the entire food value chain like in sourcing, processing, sales or in other functions. However, as the purpose of this paper can be stated as providing a current overview of the usage of blockchain in the food industry, the focus on the key terms blockchain and food seems appropriate and useful for practical purposes. In addition, it is intended to pursue a focus on the bakery industry to provide a focus towards a particular industry. The function of a bakery can essentially be described within the process or value chain of producing bread. Here, the milling industry is transferring the ownership of the flour – which is its main product – to a deliverer which subsequently delivers the flower to the bakery. The flour is used by the bakery as an input to produce bread (Cocco et al., 2021). However, with respect to the bakery industry, it can be mentioned that there is very few research available so far. It is therefore considered suitable to use rather general research questions for practical purposes. However, if possible, the evaluation of the questions shall be made by taking the bakery industry into account, given that there is research available for this very specific context. The research questions are formulated as follows:

RQ 1: Which blockchain applications exist in the food industry?

RQ 2: Which actors in the food industry are impacted by blockchain technology?

RQ 3: Which future potential does blockchain have in the food industry?

RQ 4: What challenges and risks is blockchain technology associated with in the food industry?

2.3 Search strategy

The search was conducted via a keyword-based search strategy which was carried out in the scientific databases ScienceDirect and Web of Science (Web of Science Core Collection). Other potential options for the search such as using Emerald or EconPapers were considered for inclusion but have not been finally included as these are not deemed as contributing to the quality of the search. Furthermore, to identify the latest research, the time period of the results was set from the year 2018 until 2023. In addition, a selection with respect to the subject or research areas was performed as well. The overview of the database search and the raw results in terms of identified publications are shown below in Table 1:

Table 1: Overview of database search

Database	Key-words	Other Criteria	No of re-sults
ScienceDi-rect	blockchain AND food AND trace	Only review and research arti-cles selected; Search con-ducted within title, abstract or author-specified keywords; Subject area selection[1]	36
Web of Sci-ence	blockchain AND food AND trace	Only articles and review articles selected; Search conducted within abstract; Research area selection[2]	53

Source: Own presentation

Using the search strategy, described above, a total of 89 sources have been identified for a potential inclusion. Three duplicates have been eliminated from the total number of sources and the remaining 86 sources have been checked for eligibility due to a thematical connection to the research questions. This has led to a further reduction of the total number of sources by eliminating three sources which have not shown a clear thematical connection. Finally, a total number of 83 sources have been included for a thematical review. The approach is hereby characterized as similar to the use of the PRISMA checklist. This checklist provides a guidance for the conduction of systematic literature reviews as it helps in the selection process of eligible literature (Moher et al., 2009).

Generally, it can be mentioned that due to the current character of the research topic which is based on the novelty of the blockchain technology, no selection regarding a qualitative ranking of the publication was conducted. This decision was made in order to be able to include the latest research findings. However, it must be mentioned that such qualitative selection is found with other technology-related themes, where systematic reviews are conducted (e.g. Kitchenham et al., 2009).

The analysis of the literature contents is performed with reference to the research questions from the preceding section 2.2. Otherwise, the analysis is based on the identified themes and presented accordingly in the next chapter.

3 Results

Below, the results from the analysis of the themes is presented and discussed in chapter 4. A large part of that discussion is related to the first research question, which deals with the field of applications as there had been several sub-themes found for this question. Beside the applications of

[1] Regarding the search at ScienceDirect, the subject areas a) Business, Management and Accounting, b), Decision Sciences, and c), Computer Science were included.

[2] Regarding the search at the Web of Science Core Collection, the research areas a) Computer Science, b), Food Science Technology, and c), Business Economics were included.

blockchain technology in the food sector (RQ 1), the actors are discussed (RQ 2) as well as the future potential and the challenges and risks (RQ 3 and 4). Albeit information regarding the topic of bakery has not been directly found within the results, the discussion aims to provide some insights into relevance and applicability for this part of the food industry.

3.1 Field of Application of Blockchain in Food industry (RQ 1)

There are quite a few different types of applications of blockchain technology in the food industry. The findings from the review for these shall be shown below. It is hereby worth, noting, that the categorization is not deemed as definitive, and it should not be understood as a taxonomy. Themes can overlap as well.

3.1.1 General supply chain applications

The general supply chain of food products is the key topic of the literature, for which a lot of applications are mentioned. For example, Iftekhar et al., (2020) have developed a method for tracking the journey of a food package, starting from the farm while ending at the end consumer. Their method includes the employment of a distinctive identifier for each package. This system maintains the integrity of business transaction records, ensuring their security, and provides access to stakeholders in accordance with predefined policies and rules while eliminating the need for the interference of a central governing authority. Another method was developed by Hao et al., (2020). This novel method integrates both, blockchain technology, and visualization technology, where a Hyperledger is used for the design of the information storage platform. Features include distribution and tamper-resistance. This is done to assure the validity and authenticity of the supply-chain data. Other models using a Hyperledger are proposed as well (e.g. Bragadeesh & Umamakeswari, 2020; Li et al., 2021; Wang et al., 2022). Using Hyperledger smart contracts eliminates the need for having intermediaries in the agricultural supply chain traceability environment (Patel et al., 2022; Y. Y. Wang et al., 2021).

3.1.2 Production

Evaluating the production process with the help of blockchain technology requires that the entire production is broken down into its specific components. This includes for example food cultivation, harvesting as well as shipping (El Hathat et al., 2023). It is hereby necessary to take the specific conditions of a particular type of product carefully into account. For example, Maity et al., (2021) provides a five-level supply chain model for sausage production, carefully addressing the supply chain steps of the product. A similar approach is possible for bakery products. Here, the study of Cocco et al., (2021) might be integrated in terms of the specifics of the bakery supply chain.

3.1.3 Traceability, quality control, and fraud prevention

The tracing or tracking of food is part of the technology associated with Industry 4.0, which has gained in momentum since the outbreak of the COVID-19 pandemic. It aims to establish a digital footprint that will allow for more reliable information on food, including issues of concern such as food fraud (Hassoun et al., 2022). It concerns the provenance of physical goods such as the ingredients within some type of food (Kim & Laskowski, 2018).

Existing methods of tracking inputs are heavily associated with a variety of problems, including difficulties in hazardous-material information management or data tampering. Generally, supply-chain related information is typically fragmented, isolated, or stored in separate and disconnected databases or repositories, which is called the information isolated island problem. Consequently, there is a low level of traceability efficiency in food supply chains (Hao et al., 2020; X. Zhang et al., 2020). Technologies involved with traditional forms of tracing include Radio Frequency Identification (RFID), data mining, or sensor networks amongst others (Singh et al., 2023).

3.1.4 Smart contracts and audit functionality

Smart contracts refer to "a transaction protocol that execute automatically when a predefined set of conditions are met (Valencia-Payan et al., 2022, p. 37857). Smart contracts can be based or constructed on a blockchain for example the Ethereum blockchain. (Lin et al., 2019) propose such a system for food safety and tracking through a prototype application that shows low information query responses. Majdalawieh et al., (2021) and Kechagias et al., (2023) similarly use an approach based on the Ethereum blockchain; focusing particularly on food safety issues as well as on general traceability concerns.

The possibility to use smart contracts in the form of token solutions is mentioned in the literature as an approach for tracking and tracing. For example, Chiacchio et al., (2022) proposes a decentralized solution which uses non-fungible tokens (or NFTs) for improving the traceability of the standard serialization process. Such NFTs are minted in the blockchain, hereby using the advantages that are key parts of the blockchain technology. The authors emphasize the usefulness of this technology especially for sectors such as drugs and food, where safety concerns are of major importance. NFTs hereby serve to authenticate the ownership of an asset. Hawashin et al., (2023) suggest the use of NFTs for streamlining the management transactions in the realm of high-value food products. This method is based on digitally certifying ownership of food products and employing smart contracts to enhance and automate the food trading process. Through their solution, the transparency and security of the data in terms of authenticity and traceability can be improved in a cost-efficient manner. Such solutions are potentially also interesting for use in a bakery product-related context as well.

3.1.5 Accounting and audit functionality

Furthermore, the functions of accounting and auditing can be improved with the help of blockchain technology as well. Generally, the use of blockchain applications in the food supply chain lowers transaction costs by increasing the timeliness and the quality of information flows (M. Liu et al., 2022). However, this requires that the information within the blockchain is adequate and reliable, which cannot be assured. In this context, (Y. Tan et al., 2023) mention that there is insufficient literature on the risk of traceability information being falsified before this information is stored on the blockchain. The claim that trust-related issues are removed with the help of blockchain technology (Kamble et al., 2020) cannot be fully supported, given the risk of falsified information entering the blockchain. However, identification methods can contribute to ensure the reliability of blockchain-related supply chain data (Saranya & Maheswari, 2023).

3.1.6 Sustainability

Blockchain applications in the supply chain of the food industry also enable several advantages in terms of sustainable business practices, including the sustainable development goals (Tsolakis et al., 2021). For example, (El Hathat et al., 2023) provide a study on the role of blockchain technology in measuring greenhouse gas emissions in the palm oil supply chain. Here, the production process is examined with the help of predictive modelling, where the emissions throughout the production process are modelled to gain insights into the carbon footprint that is associated with palm oil production. Generally, blockchain applications are strongly associated with "improvements in the sustainable performance of the agriculture supply chains" (Kamble et al., 2020, p.1). It is mentioned in the literature that sustainability-related goals such as the reduction in food waste or harmful emission in the food sector are expected to be reduced as a result of using blockchain technology (Astarita et al., 2020). There are also societal impacts discussed (Mangla et al., 2021) as well as water management (Zhao et al., 2019). Generally, blockchain has a vital role as it serves to create trust in supply chain (Patel et al., 2022).

Blockchain solutions enable a transformative solution to for tracing food flows within large and complicated supply chain networks. By providing a useful tool for tracking and monitoring, information to stakeholders can largely be improved using smart contracts. This can be achieved in a cost effective and a scalable way so that relationships can also be improved (Bumblauskas et al., 2020; Yakubu et al., 2022). To achieve such an aim, a specific information technology architecture is required. An example of a multi-layered architecture for sustainability-related traceability, utilizing a blockchain-enabled framework is developed by (Cao et al., 2023). This model allows for signalling customers the trustworthiness of particular food product attributes in terms of their sustainability features. Also, blockchain technology enables consumers to better identify products with a lower environmental impact level as well (Castellini et al., 2022).

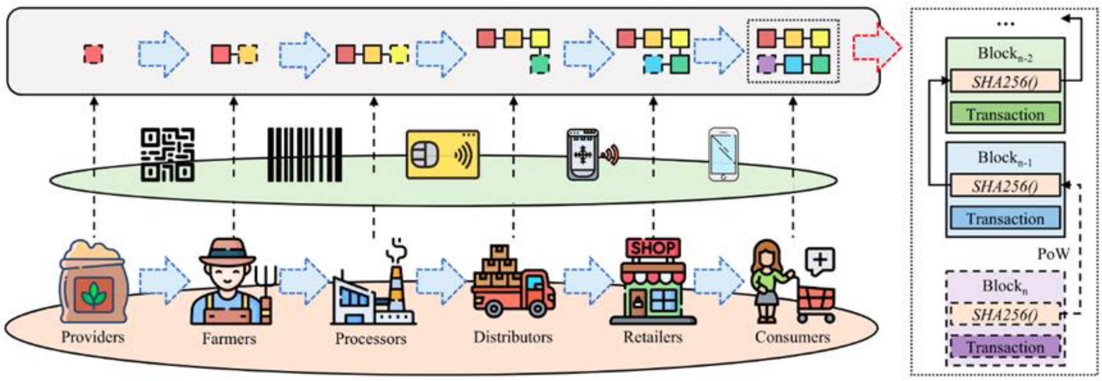
IJARBM – International Journal of Applied Research in Business and Management
Vol. 05 / Issue 02, July 2024
ISSN: 2700-8983 | an Open Access Journal by Wohllebe & Ross Publishing

3.2 Actors in Food Supply Chain using Blockchain (RQ 2)

There are quite a few different types of applications of blockchain technology in the food industry. The findings from the review for these shall be shown below. It is hereby worth, noting, that the categorization is not deemed as definitive, and it should not be understood as a taxonomy. Themes can overlap as well.

There is a large variety of actors in the food industry, or in food supply chains. These include for example retailers, raw material suppliers, manufacturers and producers, or wholesalers (Casino et al., 2019; Maity et al., 2021). There are also various logistical, or transportation providers involved throughout the value chain of food production (Astarita et al., 2020; Lin et al., 2019). A distinction of the actors can be made into upstream as well as downstream supply chain members (Casino et al., 2019). An overview of typical actors within the agricultural value chain that are impacted by blockchain applications is depicted below in Figure 1:

Figure 1: Hypothetical agricultural value chain with blockchain-based applications



Source: Chen et al., 2021, p. 36010)

With respect to the actors in the food supply chain, it is of less interest to mention them but to particularly investigate how blockchain technology might lead to an impact to a particular group. This includes an analysis of the way how the market dynamics might change as a result of disruptive technology (Balzarova et al., 2022). For example, blockchain technology is mentioned as being a threat to the dominance of wholesalers in the food market, which is characterized as having oligopolistic characteristics. That is because blockchain technology would reverse asymmetries regarding price, trade and origin information. It is even mentioned that supply chain actors are hesitating to implement blockchain technology, given a perceived risk to damaging relations with powerful wholesalers (Thompson & Rust, 2023).

Consumers can also be mentioned as relevant actors in the food supply chain as they are impacted by blockchain technology as well. This group is currently showing a high interested in the safety of food. Therefore, customers are placing a value on traceability as well as on an assurance for the authenticity of food (Casino et al., 2019; Yaşanur Kayikci Nachiappan Subramanian & Bhatia, 2022). They are willing to pay a premium for example for fairly traded food items which are considered more ethical and of superior quality (Balzarova et al., 2022). With respect to blockchain applications and traceability, research shows that blockchain is of particular relevance for local food, as there is the strongest impact of consumers' trust levels (Cozzio et al., 2023). The same can be stated for the case of purchasing organic food or fresh food, where blockchain applications can contribute to a stronger role of trust (Y. Tan et al., 2023; Zhai et al., 2023) or regarding specific types of wheat (Bandinelli et al., 2023). Consequently, these applications can also be integrated for products sold in bakeries as well.

A recent study from (Rao et al., 2007), based on Chinese survey data also states that blockchain-based traceability is particularly evaluated positively amongst highly educated and high-income consumers. It is also evaluated as more important than other qualitative characteristics of food as well. Consequently, blockchain technology works like a signalling mechanism that consumers can rely on (Treiblmaier & Garaus, 2023). This implies that customer segmentation may have a role regarding the interest on blockchain-related applications.

3.3 Future potential as well as challenges and risks (RQ 3 and 4)

Blockchain technologies are expected to become a dominant part of the food supply chain in the future. The tracking of the flow of inputs in the food value chain is furthermore not necessarily an add-on that is provided to customers but a regulatory issue as well. As such it must be mentioned that the regulations in the European Union require food producers to track and document all raw materials and ingredients which are used across supply chain activities (Casino et al., 2019). However, to use blockchain technology to track and provide greater transparency as to food origin, there are still many unresolved technology issues. (Martínez-Castañeda & Feijoo, 2023) investigate this issue with respect to the regulation within the European Union.

Nevertheless, despite the challenges that the blockchain technology is facing regarding its wider implementation and role in the food industry, the literature review has also shown that steps are taken to solve existing issues. It is evident that solutions for enabling technology-related demands on blockchain technology exist. For example, farm data can be recorded in the InterPlanetary File System (IPFS). By storing encrypted file IPFS hashes the problem of blockchain storage explosion can be mitigated (Babu & Devarajan, 2023). For a blockchain-based supply network, metrics are offered that show the overall performance of such a system. Chatterjee et al., (2023) proposes three metrics: transaction efficiency, trust between participants, and the system's ability for risk reduction. Generally, the choice on the specific application for a blockchain technology type is deemed as a key determinant for the economic success of the specific use case that is intended by the user (Kramer et al., 2021). Research has also identified boundary conditions which must be adhered to in order to implement blockchain-based solutions in the food supply chain (Behnke & Janssen, 2020).

4 Discussion

4.1 Existing blockchain applications in the food industry

With regard general supply chain of food products, it can be generally said that many studies show a highly technical character with most of them being directly applicable to a specific type of the food industry. While bakery was not mentioned as an industry, it can be argued that general technical models or frameworks are applicable there as well in case a sufficient adjustment to the industry conditions is made.

In the field of production, blockchain applications can also be used to track the temperature for food items as well (Rehan et al., 2023), which might also be an issue for bakeries. Due to the traceability of food items in the agricultural supply chain with the help of blockchain technology, it becomes possible to use this information for the purpose of optimization and profit maximization as well. Hereby, sophisticated methods of deep reinforcement learning can be used to provide a benefit in terms of production and storage. (Chen et al., 2021) can be mentioned as having developed such a framework, where deep reinforcement learning algorithms are used based on a blockchain supply chain system.

Focussing on the traceability, decentralized systems based on blockchain are therefore considered to provide better solutions to the traceability issue and to apply a food anti-counterfeiting system (Lu et al., 2022). In this regard, it must be mentioned that each supply chain does have its unique and specific character regarding traceability. This must be considered adequately within the blockchain environment (Patelli & Mandrioli, 2020). Various solutions do exist, even with respect to the conditions of small firms (Compagnucci et al., 2022).

It is possible for blockchain applications to provide suitable solutions even for multi-stage tracking systems for example in cold chain logistics from aquaculture from production over logistics, and circulation to sales (Y. Zhang et al., 2021) but also within other food supply segments such as in the grain supply chain (X. Zhang et al., 2020) or in monitoring livestock for farming (Alonso et al., 2020; Alshehri, 2023; A. Tan & Ngan, 2020). Traceability is possible to undertake globally, enhancing bilateral trust levels also regarding cross-border food trade (Qian et al., 2020). These examples show that blockchain applications for tracking purposes in the food industry provide a general usability across different food segments, whereby the specific conditions of the food segment can be integrated in the system as well. It can be argued that this also has implications for a bakery as well because of the general ability to adequately track the inputs to the final bakery products with the help of blockchain technology.

The ability to accurately trace the flows of inputs in the production process is a key benefit of using the blockchain technology in the supply chain. This is vital for the food industry, as quality control and food safety are considered as very important for the livelihood of people and the overall economy (Tao et al., 2022). For example, blockchain applications can be used to detect food fraud (Kshetri & Loukoianova, 2019). They are also able to be applied in the case of perishable food as well, which is characterized as having a comparatively low product life (Manisha & Jagadeeshwar, 2023). Potentially, blockchain applications theoretically allow for a backward as well as a forward tracing of products. This is particularly helpful in the case of product recalls (Buss, 2021).

Blockchain applications can also help to detect sources of contamination or similar issues in the supply chain. As such it can also help suppliers to enhance their reputation by providing a mechanism for better quality control (Kshetri & DeFranco, 2020). Therefore, blockchain technology for tracing food supply chains contributes to more reliability as it leads to the establishment of rapport between food producers and their customers (Babu & Devarajan, 2023).

There are also specific benefits of using smart contracts for tracing of food or agricultural products mentioned in the literature. This includes for example the automated manner, in which transactions are processed and stored within the blockchain. As the system is operating automatically, there is no risk involved from human intervention (Son et al., 2021). Consequently, blockchain-based smart contract technology is mentioned as a promising field in the food industry (Peng et al., 2023) due to its characteristics of decentralization, immutability, and transparency (L. Wang et al., 2022).

However, it must be mentioned that the development of smart contracts requires sophisticated work regarding the development of the associated code. There is a technology-related risk that bugs in the smart contract can prevent its optimal functioning (Hawashin et al., 2023). Also, problems arise if supply chain related information are sourced from only one organization. To solve this problem, Gao et al., (2020) propose the integration of up-stream and downstream trading data. Otherwise, the benefits of the block-chain cannot be realized. However, such an integration seems currently not available so far as crucial meta data such as the age of food and the processing history of products is seldom passed on within the supply chain, given its various stages (Pearson et al., 2019).

Beside the functioning of blockchain applications as a tool for traceability that also improves audit functionality, these technological solutions can be combined with other types of technology as well. For example, Shahzad et al., (2023) shows that blockchain functionality is positively connected to the consumers' willingness of using mobile food delivery apps as the technology is useful in creating higher levels of trust.

Generally, blockchain allows for the transformation of supply chains to become circular, rather than linear. Such a circular economy is a key feature of sustainability (Anastasiadis et al., 2022). At this point it can be argued that there is a clear link to applications of accounting and audit in the food chain. Generally, blockchain technology empowers information processing and information reliability, which in turn can contribute to an improvement in the quality of sustainability-related business practices as well as sustainability reporting.

4.2 Actors impacted by blockchain technology

Blockchain technology can also lead to changes in the pricing of food as well. For example, if the blockchain enables a higher goodwill due to a more reliable method of tracing, the price of fresh food is expected to increase. Consequently, business strategies or channel selections for selling food can be impacted because of the technology (Y. Liu et al., 2021). However, it must be mentioned that this finding is restricted to fresh food and may not apply to staple food such as grain or other commoditized food items. Furthermore, with respect to the economic impact from using blockchain technology, empirical research has found that retailers as well as retailers benefit the most in terms of profit (S. Liu et al., 2022). Nevertheless, providers and servicers in the supply chain are advised to evaluate how technology might require a change in business models or in selected business strategies to create more value.

4.3 Future potential of blockchain technology

Blockchain technologies are expected to become a dominant part of the food supply chain in the future. The technology is mentioned to “emerge as a game-changer to ensure food safety and security” (Yadav et al., 2022). However, beside its potential, there are current issues in terms of scalability, interoperability as well as the high cost of implementing the technology (Pandey et al., 2022). High performance requirements do exist for block-chain technology to be widely used (Jia et al., 2021). Blockchain is still in a very early stage of technological development and use in the food industry with only a very limited number of applications that are practically used so far (Kouhizadeh et al., 2021; Mirabelli & Solina, 2020).

The solutions shown in sub-chapter 3.3 can also help mitigate the risks of the technology, which are barely mentioned in the literature, which as it is mainly directed towards potential benefits. Falsification of data before entering the blockchain (Y. Tan et al., 2023) was mentioned already in the section on accountability and audit. This can be stated as a key issue, as the blockchain technology can-not detect falsified inputs. Apart from this, it is typically mentioned that blockchain technology can mitigate or prevent risks like for example in food safety issues (Hao et al., 2020) or in data-related themes, where blockchain contributes to risk reduction (Hawashin et al., 2023).

5 Conclusion

The study provides a current picture on the role of blockchain technology in the food industry by covering the latest academic literature, published from 2018 to 2023 with the help of a systematic review. This approach has several limitations, which should be shortly discussed, here. For example, it can be stated that only two scientific databases have been searched, using a limited set of keywords when conducting the research. By potentially using more databases and keywords, additional findings might be identified. Also, by complementing the search with forward or backward search methods, an improvement in the focus on specific topics might also be enabled, which in turn may lead to more depth in the analysis. This might be particularly relevant in order to address the bakery segment with respect to the blockchain applications.

Generally, there are many recommendations for future research mentioned for example in the context of material provenance. These include the exploration of the practical implementation of digital twins or the development of efficient regulatory frameworks able to address scalability and information security challenges (Xu et al., 2023). It is also mentioned that blockchain applications are only part of the total set of digital technologies that can be used for a further innovative development of food supply chains or the enabling of more food security via tracing (Mantravadi & Srai, 2023; Zhou et al., 2022). Future research might therefore use a focus on the complementation of different types of technologies. Nevertheless, blockchain is one of the key topics within the field of supply chain-related research, as stated in a recent review of (Mahdikhani et al., 2023). This is also evidenced by the increase in blockchain and supply chain related patent activity that has increased heavily since the year 2019 (Mastilović et al., 2023).

Currently, there is still only a limited number of studies that aim to explore the impact of blockchain technology food-related sustainability issues (Friedman & Ormiston, 2022), albeit examples have been shown that point towards wide applicability for sustainable business practices or for sustainability reporting. In any case, more academic research in this field is highly encouraged.

In this paper, a systematic literature review of the academic literature on blockchain technology in the food industry was undertaken. The review of 83 selected publications found in the databases ScienceDirect and Web of Science has shown that there are various applications for blockchain technology in the supply chain of firms. Blockchain enables a convenient and safe way of tracing and hereby contributes to higher safety and reliability of information in the supply chain. This contributes positively to auditing functions and can have a valuable impact on sustainability-related business practices. Various actors in the supply chain are impacted by the technology like for example consumers as they will have better and more reliable information on food. Businesses furthermore need to take the technology into account and evaluate if changes to business strategies might be necessary. However, despite the progress and the potential benefits to blockchain technology, it is evident that the technology is still in a rather low state of maturity. Further work is required to implement blockchain applications in wider practice. In this respect it must be noted that individual supply chain conditions for particular types of food need to be considered and defined appropriately. This applies also to the bakery industry, where there is nearly no direct research to be found. As such it can be concluded that the findings from other segments of the food industry on blockchain technology need to be individually assessed for their applicability.

6 Author

Multicultural Senior Finance Manager with more than 20 years of industry experience in large corporations as well as in globally operating medium-sized companies. Experience in a variety of specialized and management positions in the power generation, metal processing and bakery industries. Expertise in the areas of finance, law, international project business, commercial and tax law, M&A, restructuring, integration, turnaround measures and auditing. Constant endeavour to shape the company's performance culture, develop long-term business success and improve the company's reputation among all stakeholders. The author holds a Bachelor of Laws (LL.B.) and a Master of Laws (LL.M.) in international business and tax law and has been a doctoral student at the Hungarian University of Agriculture and Life Sciences in Kapósvar since 2020.

7 References

Abdo Hassoun Nour Alhaj Abdullah, A. A.-K. M. G. A. B. O. Z. B. Ö. R. M. A. J. M. L. A. M. K., & Regenstein, J. M. (2024). Food traceability 4.0 as part of the fourth industrial revolution: key enabling technologies. *Critical Reviews in Food Science and Nutrition*, *64*(3), 873–889. https://doi.org/10.1080/10408398.2022.2110033

Alonso, R. S., Sittón-Candanedo, I., García, Ó., Prieto, J., & Rodríguez-González, S. (2020). An intelligent Edge-IoT platform for monitoring livestock and crops in a dairy farming scenario. *Ad Hoc Networks*, *98*, 102047. https://doi.org/10.1016/J.ADHOC.2019.102047

Alshehri, D. M. (2023). Blockchain-assisted internet of things framework in smart livestock farming. *Internet of Things*, *22*, 100739. https://doi.org/10.1016/J.IOT.2023.100739

Anastasiadis, F., Manikas, I., Apostolidou, I., & Wahbeh, S. (2022). The role of traceability in end-to-end circular agri-food supply chains. *Industrial Marketing Management*, *104*, 196–211. https://doi.org/10.1016/J.INDMARMAN.2022.04.021

Astarita, V., Giofrè, V. P., Mirabelli, G., & Solina, V. (2020). A Review of Blockchain-Based Systems in Transportation. In *Information (Switzerland)* (Vol. 11, Issue 1). MDPI AG. https://doi.org/10.3390/info11010021

Babu, S., & Devarajan, H. (n.d.-a). Agro-Food Supply Chain Traceability using Blockchain and IPFS. In *IJACSA) International Journal of Advanced Computer Science and Applications* (Vol. 14, Issue 1). www.ijacsa.thesai.org

Babu, S., & Devarajan, H. (n.d.-b). Agro-Food Supply Chain Traceability using Blockchain and IPFS. In *IJACSA) International Journal of Advanced Computer Science and Applications* (Vol. 14, Issue 1). www.ijacsa.thesai.org

Balzarova, M., Dyer, C., & Falta, M. (2022). Perceptions of blockchain readiness for fairtrade programmes. *Technological Forecasting and Social*

Change, *185*, 122086. https://doi.org/10.1016/J.TECHFORE.2022.122086

Bandinelli, R., Scozzafava, G., Bindi, B., & Fani, V. (2023). Blockchain and consumer behaviour: Results of a Technology Acceptance Model in the ancient wheat sector. *Cleaner Logistics and Supply Chain*, *8*, 100117. https://doi.org/10.1016/J.CLSCN.2023.100117

Behnke, K., & Janssen, M. F. W. H. A. (2020). Boundary conditions for traceability in food supply chains using blockchain technology. *International Journal of Information Management*, *52*, 101969. https://doi.org/10.1016/J.IJINFOMGT.2019.05.025

Berneis, M., Bartsch, D., & Winkler, H. (2021). Applications of Blockchain Technology in Logistics and Supply Chain Management—Insights from a Systematic Literature Review. In *Logistics* (Vol. 5, Issue 3). MDPI. https://doi.org/10.3390/logistics5030043

Bragadeesh, S. A., & Umamakeswari, A. (2020). Development of a reliable supply chain system using blockchain. *Journal of Intelligent & Fuzzy Systems*, *39*, 8377–8387. https://doi.org/10.3233/JIFS-189156

Bumblauskas, D., Mann, A., Dugan, B., & Rittmer, J. (2020). A blockchain use case in food distribution: Do you know where your food has been? *International Journal of Information Management*, *52*, 102008. https://doi.org/10.1016/J.IJINFOMGT.2019.09.004

Buss, D. (2021). Food Safety Gets Smarter - New technologies, policies, and partnerships are making the U.S. food supply safer. *FOOD TECHNOLOGY*, *75*(3), 38–47.

Cao, S., Johnson, H., & Tulloch, A. (2023). Exploring blockchain-based Traceability for Food Supply Chain Sustainability: Towards a Better Way of Sustainability Communication with Consumers. *Procedia Computer Science*, *217*, 1437–1445. https://doi.org/10.1016/J.PROCS.2022.12.342

Casino, F., Kanakaris, V., Dasaklis, T. K., Moschuris, S., & Rachaniotis, N. P. (2019). Modeling food supply chain traceability based on blockchain technology. *IFAC-PapersOnLine*, *52*(13), 2728–2733. https://doi.org/10.1016/J.IFACOL.2019.11.620

Castellini, G., Lucini, L., Rocchetti, G., Lorenzo, J. M., & Graffigna, G. (2022). Determinants of consumer acceptance of new technologies used to trace and certify sustainable food products: A mini-review on blockchain technology. *Current Opinion in Environmental Science & Health*, *30*, 100403. https://doi.org/10.1016/J.COESH.2022.100403

Chatterjee, K., Singh, A., & Neha. (2023). A blockchain-enabled security framework for smart agriculture. *Computers and Electrical Engineering*, *106*, 108594. https://doi.org/10.1016/J.COMPELECENG.2023.108594

Chen, H., Chen, Z., Lin, F., & Zhuang, P. (2021). Effective management for blockchain-based agri-food supply chains using deep reinforcement learning. *IEEE Access*, *9*, 36008–36018. https://doi.org/10.1109/ACCESS.2021.3062410

Chiacchio, F., D'urso, D., Oliveri, L. M., Spitaleri, A., Spampinato, C., & Giordano, D. (2022). A Non-Fungible Token Solution for the Track and Trace of Pharmaceutical Supply Chain. *Applied Sciences (Switzerland)*, *12*(8). https://doi.org/10.3390/app12084019

Cocco, L., Mannaro, K., Tonelli, R., Mariani, L., Lodi, M. B., Melis, A., Simone, M., & Fanti, A. (2021). A Blockchain-Based Traceability System in Agri-Food SME: Case Study of a Traditional Bakery. *IEEE Access*, *9*, 62899–62915. https://doi.org/10.1109/ACCESS.2021.3074874

Compagnucci, L., Lepore, D., Spigarelli, F., Frontoni, E., Baldi, M., & Di Berardino, L. (2022). Uncovering the potential of blockchain in the agri-food supply chain: An interdisciplinary case study. *Journal of Engineering and Technology Management*, *65*, 101700. https://doi.org/10.1016/J.JENGTECMAN.2022.101700

Cozzio, C., Viglia, G., Lemarie, L., & Cerutti, S. (2023). Toward an integration of blockchain technology in the food supply chain. *Journal of Business Research*, *162*, 113909. https://doi.org/10.1016/J.JBUSRES.2023.113909

Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In *The Sage handbook of organizational research methods.* (pp. 671–689). Sage Publications Ltd.

El Hathat, Z., Venkatesh, V. G., Zouadi, T., Sreedharan, V. R., Manimuthu, A., & Shi, Y. (2023). Analyzing the greenhouse gas emissions in the palm oil supply chain in the VUCA world: A blockchain initiative. *Business Strategy and the Environment*, *32*(8), 5563–5582. https://doi.org/https://doi.org/10.1002/bse.3436

Fill, H.-G., & Meier, A. (2020). *Blockchain kompakt: Grundlagen, Anwendungsoptionen und kritische Bewertung*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-27461-0

Friedman, N., & Ormiston, J. (2022). Blockchain as a sustainability-oriented innovation?: Opportunities for and resistance to Blockchain technology as a driver of sustainability in global food supply chains. *Technological Forecasting and Social Change*, *175*, 121403. https://doi.org/10.1016/J.TECHFORE.2021.121403

Gao, K., Liu, Y., Xu, H., & Han, T. (2020). Design and implementation of food supply chain traceability system based on Hyperledger Fabric. *International Journal of Computational Science and Engineering*, *23*(2), 185–193. https://doi.org/10.1504/IJCSE.2020.110547

Hao, Z., Mao, D., Zhang, B., Zuo, M., & Zhao, Z. (2020). A novel visual analysis method of food safety risk traceability based on blockchain. *International Journal of Environmental Research and Public Health*, *17*(7). https://doi.org/10.3390/ijerph17072300

Hawashin, D., Salah, K., Jayaraman, R., & Musamih, A. (2023). Using Composable NFTs for Trading and Managing Expensive Packaged Products in the Food Industry. *IEEE Access*, *11*, 10587–10603. https://doi.org/10.1109/ACCESS.2023.3241226

Himmer, K. (2019). *Blockchain-basiertes Fundraising als innovative Alternative der Unternehmensfinanzierung*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-26816-9

Hinckeldeyn Johannes and Kreutzfeldt, J. (2019). Blockchain in der Logistik – Ein Vergleich prototypischer Anwendungen. In K. Schröder Meike and Wegner (Ed.), *Logistik im Wandel der Zeit – Von der Produktionssteuerung zu vernetzten Supply Chains: Festschrift für Wolfgang Kersten zum*

60. Geburtstag (pp. 527–543). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-25412-4_24

Iftekhar, A., Cui, X., Hassan, M., & Afzal, W. (2020). Application of Blockchain and Internet of Things to Ensure Tamper-Proof Data Availability for Food Safety. *Journal of Food Quality*, *2020*(1), 5385207. https://doi.org/https://doi.org/10.1155/2020/5385207

Jia, D., Xin, J., Wang, Z., & Wang, G. (2021). Optimized Data Storage Method for Sharding-Based Blockchain. *IEEE Access*, *9*, 67890–67900. https://doi.org/10.1109/ACCESS.2021.3077650

Kamble, S. S., Gunasekaran, A., & Sharma, R. (2020). Modeling the blockchain enabled traceability in agriculture supply chain. *International Journal of Information Management*, *52*, 101967. https://doi.org/10.1016/J.IJINFOMGT.2019.05.023

Karamitsos, I., Papadaki, M., & Barghuthi, N. B. Al. (2018). Design of the Blockchain Smart Contract: A Use Case for Real Estate. *Journal of Information Security*, *09*(03), 177–190. https://doi.org/10.4236/jis.2018.93013

Kechagias, E. P., Gayialis, S. P., Papadopoulos, G. A., & Papoutsis, G. (2023). An Ethereum-Based Distributed Application for Enhancing Food Supply Chain Traceability. *Foods*, *12*(6). https://doi.org/10.3390/foods12061220

Kim, H. M., & Laskowski, M. (2018). Toward an ontology-driven blockchain design for supply-chain provenance. *Intelligent Systems in Accounting, Finance and Management*, *25*(1), 18–27. https://doi.org/https://doi.org/10.1002/isaf.1424

Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering – A systematic literature review. *Information and Software Technology*, *51*(1), 7–15. https://doi.org/10.1016/J.INFSOF.2008.09.009

Komalavalli, C., Saxena, D., & Laroiya, C. (2020). Overview of Blockchain Technology Concepts. *Handbook of Research on Blockchain Technology*, 349–371. https://doi.org/10.1016/B978-0-12-819816-2.00014-9

Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021). Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. *International Journal of Production Economics*, *231*, 107831. https://doi.org/10.1016/J.IJPE.2020.107831

Kramer, M. P., Bitsch, L., & Hanf, J. (2021). Blockchain and its impacts on agri-food supply chain network management. *Sustainability (Switzerland)*, *13*(4), 1–22. https://doi.org/10.3390/su13042168

Kshetri, N., & DeFranco, J. (2020). The Economics Behind Food Supply Blockchains. *Computer*, *53*(12), 106–110. https://doi.org/10.1109/MC.2020.3021549

Kshetri, N., & Loukoianova, E. (2019). Blockchain Adoption in Supply Chain Networks in Asia. *IT Professional*, *21*(1), 11–15. https://doi.org/10.1109/MITP.2018.2881307

Lee, J. Y. (2019). A decentralized token economy: How blockchain and cryptocurrency can revolutionize business. *Business Horizons*, *62*(6), 773–784. https://doi.org/10.1016/J.BUSHOR.2019.08.003

Li, J., Yu, Y., Hu, S., Shi, Y., Zhao, S., & Zhang, C. (2021). A blockchain-based authority management framework in traceability systems. *International Journal of Computational Science and Engineering*, *24*, 42. https://doi.org/10.1504/IJCSE.2021.113639

Lin, Q., Wang, H., Pei, X., & Wang, J. (2019). Food Safety Traceability System Based on Blockchain and EPCIS. *IEEE Access*, *7*, 20698–20707. https://doi.org/10.1109/ACCESS.2019.2897792

Liu, M., Robin, A., Wu, K., & Xu, J. (2022). Blockchain's Impact on Accounting and Auditing: A Use Case on Supply Chain Traceability. *Journal of Emerging Technologies in Accounting*, *19*(2), 105–119. https://doi.org/10.2308/JETA-2021-002

Liu, S., Hua, G., Kang, Y., Edwin Cheng, T. C., & Xu, Y. (2022). What value does blockchain bring to the imported fresh food supply chain? *Transportation Research Part E: Logistics and Transportation Review*, *165*, 102859. https://doi.org/10.1016/J.TRE.2022.102859

Liu, Y., Ma, D., Hu, J., & Zhang, Z. (2021). Sales mode selection of fresh food supply chain based on blockchain technology under different channel competition. *Computers & Industrial Engineering*, *162*, 107730. https://doi.org/10.1016/J.CIE.2021.107730

Lu, Y., Li, P., & Xu, H. (2022). A Food anti-counterfeiting traceability system based on Blockchain and Internet of Things. *Procedia Computer Science*, *199*, 629–636. https://doi.org/10.1016/J.PROCS.2022.01.077

Mahdikhani, M., Mahdikhani, M., Gonzalez, M., & Teixeira, R. (2023). High-technology within the supply chain: a systematic review. *Management Decision*, *61*(8), 2257–2279. https://doi.org/10.1108/MD-05-2022-0697

Maity, M., Tolooie, A., Sinha, A. K., & Tiwari, M. K. (2021). Stochastic batch dispersion model to optimize traceability and enhance transparency using Blockchain. *Computers & Industrial Engineering*, *154*, 107134. https://doi.org/10.1016/J.CIE.2021.107134

Majdalawieh, M., Nizamuddin, N., Alaraj, M., Khan, S., & Bani-Hani, A. (2021). Blockchain-based solution for Secure and Transparent Food Supply Chain Network. *Peer-to-Peer Networking and Applications*, *14*(6), 3831–3850. https://doi.org/10.1007/s12083-021-01196-1

Manisha, N., & Jagadeeshwar, M. (2023). BC driven IoT-based food quality traceability system for dairy product using deep learning model. *High-Confidence Computing*, *3*(3), 100121. https://doi.org/10.1016/J.HCC.2023.100121

Mantravadi, S., & Srai, J. S. (2023). How Important are Digital Technologies for Urban Food Security? A Framework for Supply Chain Integration using IoT. *Procedia Computer Science*, *217*, 1678–1687. https://doi.org/10.1016/J.PROCS.2022.12.368

Martínez-Castañeda, M., & Feijoo, C. (2023). Use of blockchain in the agri-food value chain: State of the art in Spain and some lessons from the perspective of public support. *Telecommunications Policy*, *47*(6), 102574. https://doi.org/10.1016/J.TELPOL.2023.102574

Mastilović, J., Kukolj, D., Kevrešan, Ž., Ostojić, G., Kovač, R., Đerić, M., & Samek, D. U. (2023). Emerging Perspectives of Blockchains in Food

Supply Chain Traceability Based on Patent Analysis. *Foods*, *12*(5). https://doi.org/10.3390/foods12051036

Mirabelli, G., & Solina, V. (2020). Blockchain and agricultural supply chains traceability: research trends and future challenges. *Procedia Manufacturing*, *42*, 414–421. https://doi.org/10.1016/J.PROMFG.2020.02.054

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Antes, G., Atkins, D., Barbour, V., Barrowman, N., Berlin, J. A., Clark, J., Clarke, M., Cook, D., D'Amico, R., Deeks, J. J., Devereaux, P. J., Dickersin, K., Egger, M., Ernst, E., Gøtzsche, P. C., … Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. In *PLoS Medicine* (Vol. 6, Issue 7). Public Library of Science. https://doi.org/10.1371/journal.pmed.1000097

Mukhopadhyay, U., Skjellum, A., Hambolu, O., Oakley, J., Yu, L., & Brooks, R. (2016). A brief survey of Cryptocurrency systems. *2016 14th Annual Conference on Privacy, Security and Trust (PST)*, 745–752. https://doi.org/10.1109/PST.2016.7906988

Pandey, V., Pant, M., & Snasel, V. (2022). Blockchain technology in food supply chains: Review and bibliometric analysis. *Technology in Society*, *69*, 101954. https://doi.org/10.1016/J.TECHSOC.2022.101954

Patel, D., Sinha, A., Bhansali, T., Usha, G., & Velliangiri, S. (2022). Blockchain in Food Supply Chain. *Procedia Computer Science*, *215*, 321–330. https://doi.org/10.1016/J.PROCS.2022.12.034

Patelli, N., & Mandrioli, M. (2020). Blockchain technology and traceability in the agrifood industry. *Journal of Food Science*, *85*(11), 3670–3678. https://doi.org/https://doi.org/10.1111/1750-3841.15477

Pearson, S., May, D., Leontidis, G., Swainson, M., Brewer, S., Bidaut, L., Frey, J. G., Parr, G., Maull, R., & Zisman, A. (2019). Are Distributed Ledger Technologies the panacea for food traceability? *Global Food Security*, *20*, 145–149. https://doi.org/10.1016/J.GFS.2019.02.002

Peng, X., Zhao, Z., Wang, X., Li, H., Xu, J., & Zhang, X. (2023). A review on blockchain smart contracts in the agri-food industry: Current state, application challenges and future trends. *Computers and Electronics in Agriculture*, *208*, 107776. https://doi.org/10.1016/J.COMPAG.2023.107776

Qian, J., Wu, W., Yu, Q., Ruiz-Garcia, L., Xiang, Y., Jiang, L., Shi, Y., Duan, Y., & Yang, P. (2020). Filling the trust gap of food safety in food trade between the EU and China: An interconnected conceptual traceability framework based on blockchain. *Food and Energy Security*, *9*(4), e249. https://doi.org/https://doi.org/10.1002/fes3.249

Rao, N., Al-Yahyaee, K., & Syed, L. (2007). Capital Structure and Financial Performance: Evidence from Oman. *Indian Journal of Economics & Business*, *6*, 1–14.

Rehan, M., Javed, A. R., Kryvinska, N., Gadekallu, T. R., Srivastava, G., & Jalil, Z. (2023). Supply Chain Management Using an Industrial Internet of Things Hyperledger Fabric Network. *Human-Centric Computing and Information Sciences*, *13*. https://doi.org/10.22967/HCIS.2023.13.004

Saranya, P., & Maheswari, R. (2023). Proof of Transaction (PoTx) Based Traceability System for an Agriculture Supply Chain. *IEEE Access*, *11*, 10623–10638. https://doi.org/10.1109/ACCESS.2023.3240772

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson education.

Shahzad, K., Zhang, Q., Zafar, A. U., Ashfaq, M., & Rehman, S. U. (2023). The role of blockchain-enabled traceability, task technology fit, and user self-efficacy in mobile food delivery applications. *Journal of Retailing and Consumer Services*, *73*, 103331. https://doi.org/10.1016/J.JRETCONSER.2023.103331

Singh, A., Gutub, A., Nayyar, A., & Khan, M. K. (2023). Redefining food safety traceability system through blockchain: findings, challenges and open issues. *Multimedia Tools and Applications*, *82*(14), 21243–21277. https://doi.org/10.1007/s11042-022-14006-4

Son, N. M., Nguyen, T. L., Huong, P. T., & Hien, L. T. (2021). Novel system using blockchain for origin traceability of agricultural products. *Sensors and Materials*, *33*(2), 601–613. https://doi.org/10.18494/SAM.2021.2490

Streng, M. (2018). Blockchain – the Case for Market Adoption of the Distributed Ledger. In R. and Z. M. Linnhoff-Popien Claudia and Schneider (Ed.), *Digital Marketplaces Unleashed* (pp. 65–70). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-49275-8_9

Sunny, F. A., Hajek, P., Munk, M., Abedin, M. Z., Satu, M. S., Efat, M. I. A., & Islam, M. J. (2022). A Systematic Review of Blockchain Applications. In *IEEE Access* (Vol. 10, pp. 59155–59177). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACCESS.2022.3179690

Tan, A., & Ngan, P. T. (2020). A proposed framework model for dairy supply chain traceability. *Sustainable Futures*, *2*, 100034. https://doi.org/10.1016/J.SFTR.2020.100034

Tan, Y., Huang, X., & Li, W. (2023). Does blockchain-based traceability system guarantee information authenticity? An evolutionary game approach. *International Journal of Production Economics*, *264*, 108974. https://doi.org/10.1016/J.IJPE.2023.108974

Tao, H., Hu, Y., Li, H., Fan, D., & Chen, H. (2022). The Credibility Measurement Model of Food Safety On-chain Data based on Blockchain. *Journal of Internet Technology*, *23*(4), 719–725. https://doi.org/10.53106/160792642022072304007

Thompson, B. S., & Rust, S. (2023). Blocking blockchain: Examining the social, cultural, and institutional factors causing innovation resistance to digital technology in seafood supply chains. *Technology in Society*, *73*, 102235. https://doi.org/10.1016/J.TECHSOC.2023.102235

Ton, A. D., Hammerl, L., & Szabó-Szentgróti, G. (2023). FACTORS OF CROSS-FUNCTIONAL TEAM COOPETITION: A SYSTEMATIC LITERATURE REVIEW. *Performance Improvement Quarterly*, *36*(1), 27–40. https://doi.org/10.56811/PIQ-21-0037

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, *14*(3), 207–222. https://doi.org/https://doi.org/10.1111/1467-8551.00375

Treiblmaier, H., & Garaus, M. (2023). Using blockchain to signal quality in the food supply chain: The impact on consumer purchase intentions and the moderating effect of brand familiarity. *International Journal of*

Information Management, *68*, 102514. https://doi.org/10.1016/J.IJINFOMGT.2022.102514

Tsolakis, N., Niedenzu, D., Simonetto, M., Dora, M., & Kumar, M. (2021). Supply network design to address United Nations Sustainable Development Goals: A case study of blockchain implementation in Thai fish industry. *Journal of Business Research*, *131*, 495–519. https://doi.org/10.1016/J.JBUSRES.2020.08.003

Valencia-Payan, C., Grass-Ramirez, J. F., Ramirez-Gonzalez, G., & Corrales, J. C. (2022). A Smart Contract for Coffee Transport and Storage With Data Validation. *IEEE Access*, *10*, 37857–37869. https://doi.org/10.1109/ACCESS.2022.3165087

Wang, L., He, Y., & Wu, Z. (2022). Design of a Blockchain-Enabled Traceability System Framework for Food Supply Chains. *Foods*, *11*(5). https://doi.org/10.3390/foods11050744

Wang, Y. Y., Tao, F., & Wang, J. (2021). Information disclosure and blockchain technology adoption strategy for competing platforms. *Information and Management*. https://doi.org/10.1016/j.im.2021.103506

Wilkens, R., & Falk, R. (2019). *Smart Contracts*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-27963-9

Xu, J., Lou, J., Lu, W., Wu, L., & Chen, C. (2023). Ensuring construction material provenance using Internet of Things and blockchain: Learning from the food industry. *Journal of Industrial Information Integration*, *33*, 100455. https://doi.org/10.1016/J.JII.2023.100455

Yadav, V. S., Singh, A. R., Raut, R. D., Mangla, S. K., Luthra, S., & Kumar, A. (2022). Exploring the application of Industry 4.0 technologies in the agricultural food supply chain: A systematic literature review. *Computers & Industrial Engineering*, *169*, 108304. https://doi.org/10.1016/J.CIE.2022.108304

Yakubu, B. M., Latif, R., Yakubu, A., Khan, M. I., & Magashi, A. I. (2022). RiceChain: secure and traceable rice supply chain framework using blockchain technology. *PeerJ Computer Science*, *8*. https://doi.org/10.7717/PEERJ-CS.801

Yaşanur Kayikci Nachiappan Subramanian, M. D., & Bhatia, M. S. (2022). Food supply chain in the era of Industry 4.0: blockchain technology implementation opportunities and impediments from the perspective of people, process, performance, and technology. *Production Planning & Control*, *33*(2–3), 301–321. https://doi.org/10.1080/09537287.2020.1810757

Yoo, S. (2017). Blockchain based financial case analysis and its implications. *Asia Pacific Journal of Innovation and Entrepreneurship*, *11*(3), 312–321. https://doi.org/10.1108/apjie-12-2017-036

Zhai, Q., Li, Q., Sher, A., & Cheni, C. (2023). The role of information heterogeneity in blockchain-based traceability systems: evidence from fresh fruits buyers in China. *International Food and Agribusiness Management Review*, *26*(3), 489–517. https://doi.org/10.22434/IFAMR2022.0080

Zhang, X., Sun, P., Xu, J., Wang, X., Yu, J., Zhao, Z., & Dong, Y. (2020). Blockchain-based safety management system for the grain supply chain.

IEEE Access, *8*, 36398–36410. https://doi.org/10.1109/ACCESS.2020.2975415

Zhang, Y., Liu, Y., Jiong, Z., Zhang, X., Li, B., & Chen, E. (2021). Development and assessment of blockchain-IoT-based traceability system for frozen aquatic product. *Journal of Food Process Engineering*, *44*(5), e13669. https://doi.org/https://doi.org/10.1111/jfpe.13669

Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H., & Boshkoska, B. M. (2019). Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions. *Computers in Industry*, *109*, 83–99. https://doi.org/10.1016/J.COMPIND.2019.04.002

Zhou, X., Zhu, Q., & Xu, Z. (2022). The mediating role of supply chain quality management for traceability and performance improvement: Evidence among Chinese food firms. *International Journal of Production Economics*, *254*, 108630. https://doi.org/10.1016/J.IJPE.2022.108630