Blockchain Tech-Enabled Supply Chain Traceability: A Meta-Synthesis

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Abstract

This research conducted a literature review on blockchain technology in small and medium entrepreneurs. It is a vital revolutionary technique that recuperates the food supply chain traceability process. More than 50 research revolving around food traceability were analyzed. This paper discussed the complexity of food traceability and food safety, the technical aspects of implementing blockchain, and the benefits and boundaries in applying food traceability using blockchain revolutionary technology. A straightforward implementation blockchain food traceability plan is jotted for medium and small food firms.

Keywords

Blockchain · Contaminations · Transparency · Decentralized applications, immutability

1 Introduction

Related to the complexity of the food traceability system, many countries issued legal standards and regulations to protect the customers from contamination and foodborne diseases that affect the customers' health and even their lives, as mentioned by Research Blog (2020). At the same time, the high demand for an effective food traceability system that offers an integrated view of the system opened a wide door for the priority to implement the revolutionary blockchain food tracing technology that offers practical, decentralized immutability, pure transparency system.

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The chapter intends to demeanor a literature review on using blockchain technology in food supply chain traceability systems. More specifically, we aim to (1) catch a birds-eye view of the food supply chain traceability complexity and emerge a high priority to apply the revolutionary blockchain technology related to the food traceability system; (2) illustrate the core advantages and boundaries of implementing a blockchain food traceability system. And (3) draw a crystal clear plan in launching blockchain technology in small and medium food supply firms.

There are three segments in this research: the complexity of food traceability system, system design and implementation techniques, the driving benefits and challenges of using the blockchain in food traceability, and finally, draw precise, realistic plan requirements to embark on the blockchain food traceability system.

2 Literature Review

Food safety considers the core milestone in the traceability system because of the contamination of toxins that can spread so fast (Gisela & Blazekovic-Dimovska, 2017). Many types of research have focused on the role of blockchain technology in food traceability in giant food firms. While Alissa (2018) addressed using the effectiveness of using blockchain in one of the most sensitive foods—the Garber Baby Food produced by Nestlé, Agricultural Informatics (2020) declared the process and the steps of overcoming challenges concerning the mango tracing supply chain in Walmart using blockchain technology. Moreover, Wilson and Auchard (2018) emphasized food safety management and time-saving in applying blockchain traceability in the chicken and eggs lines in Carrefour. The Bumble Bee Seafood Company (2021) mentioned that a crystal clear transparency seafood traceability vision had been created by blockchain technology, and Shamla Tech (2020) emphasized on the secured, free contaminated and foodborne fresh food blockchain traceability system.

On the other hand, the role of blockchain technology in food traceability for SMEs has not been elucidated. More research has to be addressed related to this area. The medium and small food enterprise requires detailed information concerning the benefits, including cost-saving, challenges, and boundaries, and an exclusive implementing plan of adopting a blockchain food traceability system.

Food traceability considers the core value of the food supply chain. It has to be secured and transparent from the production stage until it reaches the end customers. This will allow the operation management to adjust and correct any problems immediately. At the same time, an ineffective traceability system may mainly cause contamination and foodborne to the exclusive products that lead to death or illness. Furthermore, it will increase the cost consumption and decrease profits related to the waste of the contaminated, spoiled products and the disappointed customers' experience. While the blockchain revolutionary technology worked to eliminate the above challenges and develop safety management in the large firms, the traceability of the food supply chain still confronts middle and small firms.

Table 7.1 Complexity in Food Traceability

Food Traceability System—considerations	Illustration	Reference
Legal standard and regulations	Every country settled its own mandatory traceability rules and regulations and dropped documentary requirements to protect its citizens and people living in its territory. The traceability system that may work in one country may face boundaries.	Behnke and Janssen (2020)
Food and Drug Administration (FDA)	It enables the operation team to deduct the food product one step behind or ahead only.	FDA (2020)
International Organization for Standardization ISO 22005: 2007	It is a tool that allows food firms to deduct the history of their products.	PECB, University, (2014).
High customers awareness	Nowadays, customers prefer to deal with ethical firms that serve the community and save the environment.	Alfian et al. (2017)
High customers demand	The customers may not receive a product of high quality at a reasonable price as before. Today customers are looking to know the whole story of their purchase product.	Opara and Mazaud (2001)
Enormous channels of big data	The large scale of ample data storage restricts and confines the flow of massive data exchange among all participants in the supply chain.	Jarschel et al. (2020)
High risk of food contamination, foodborne, and food waste	The cost of food containing foodborne and nation food waste is overwhelming legally, ethically, and monetary. Moreover, it extends to the firm brand name and may lead to complete bankruptcy.	Yu et al. (2020)
Open door for illegal aspects and fraud procedures	Food fraud requires attentive tactics to detect and avoid it before it extends to be rigid food crime.	Van Ruth et al. (2017)

Note. 7.FDA Food and Drug Administration, From FDA, 2020. Copyright 2020 by US Food and Drug Administration
ISO = International Organization for Standardization, From PECB University, 2014.

The dark effect of foodborne caused 76,000,000 illnesses and 325,000 hospitalizations. Moreover, it killed more than 400,000 adults and 18,000,000 children in 1998. Furthermore, The Government of Canada (2020) reported the leading causes of food contaminations. Food traceability is a complex critical process that has to follow varieties of rules and regulations, manage big data and entirely avoid or eliminate the risks of food contaminations, foodborne, and food waste while satisfying the customers' awareness, as illustrated in Table 7.1 and Fig. 7.1 depicts the high risks of foodborne and contaminations.

In Fig. 7.1, Graph 1 depicts the foodborne darkness effect in 1998. Adopted from "Food-borne diseases are caused by many agents such as bacteria, viruses, parasites, and fungus that enter the body and cause illness. Food Safety in the 21st Century,"

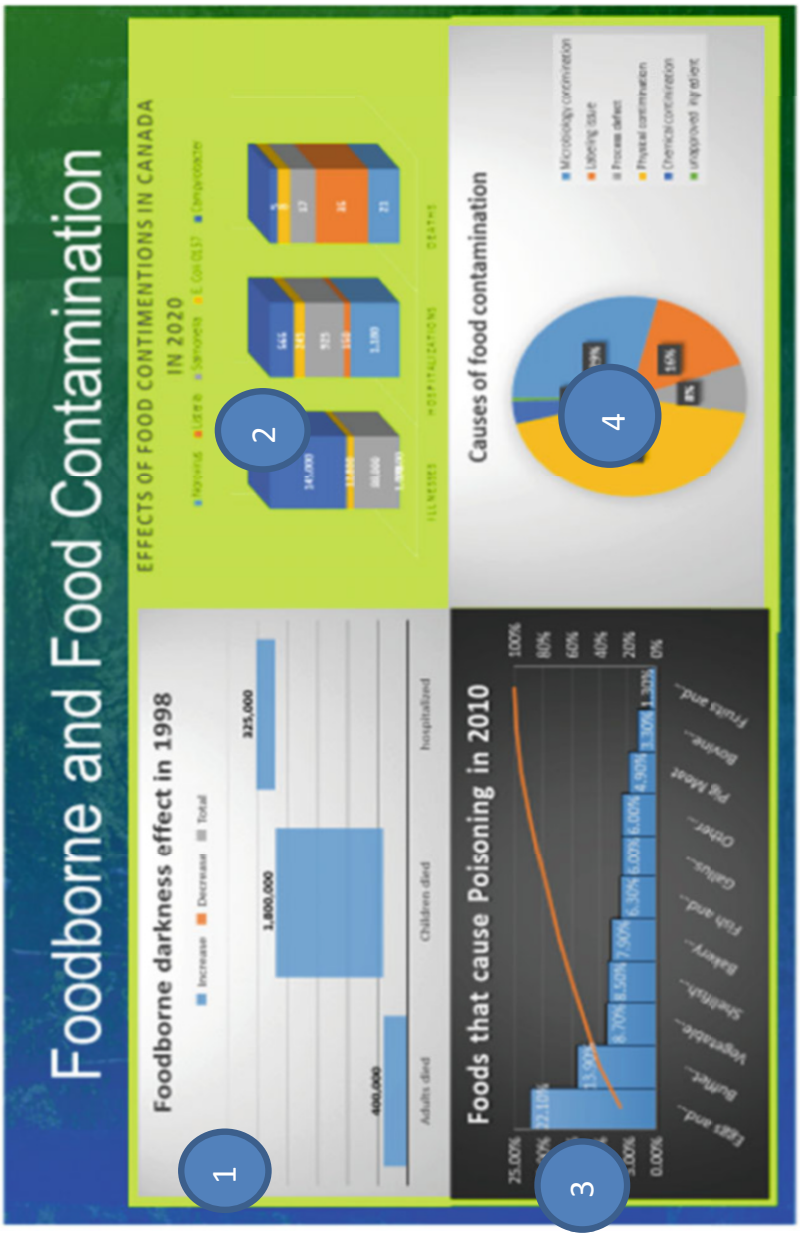

Fig. 7.1 The high risk of food contaminations and foodborne. Source: Composed by the authors

by Gisela & Blazekovic-Dimovska, 2017; Graph 2. Effects of food contamination in Canada in 2020. Adopted from "Fact sheet: Traceability Safe Food for Canadians Regulations Requirements for the Safe Food for Canadians Regulations," by Government of Canada, 2019; Graph 3. Main food types that cause poisonous. Adopted from Gisela & Blazekovic-Dimovska, 2017; and Graph 4. Causes of food contaminants. Adopted from "Why Our Food Keeps Making Us Sick America's food industry has a $55.5 billion safety problem," by Kowitt, 2016, Fortune.

3 The Advantages and Challenges of Implementing Blockchain in Food Traceability System

Many motivations can drive food firms to implement the revolutionary blockchain technology in tracing their food supply chain regardless of their size. Table 7.2 illustrates the main advantages of implementing the blockchain: transparency, decentralization, cost- and time-saving, effective food safety management, and high customer satisfaction. At the same time, Fig. 7.2 declares the effects of implementing blockchain technology in the food traceability system using a fishbone diagram.

The fishbone diagram in Fig. 7.2 below depicts the blockchain food traceability system in terms of managerial, cost and time efficiency, security and sustainability of operations.

On the other hand, the challenges that may restrict applying the blockchain in food traceability are high initial cost, limited knowledge, and regulatory issues, as illustrated by Nestor (2021) in Table 7.3.

4 Implementing Blockchain Food Traceability Systems in Small and Medium Enterprises (SME)

The execution of the blockchain food traceability system plan begins to settle the food firm's goal and determine the required data by answering the 4 W's questions as illustrated by TE Food (2020). What is the vital data that must be stored?

When can this data be collected? Where is the information that must be gathered? And why is this valuable data to all supply chain participants?

Once the above questions have been answered, the operation team has to identify the proper tools to pile up the required data as written by João & Pedro. These tools can be a variety of types of sensors, smart cameras, pallet-level tagging, barcodes, radio frequency identification (RFID), and even food-sensing technologies that deduct any contaminations as written by IGPS (2020) and Arrow (2020).

The technical tools that will support the system have to be identified, too, as illustrated by Microsoft (2020), followed by installing the Modum.io AG that will combine gathered data and implement it in the blockchain technology as written by Bocek et al. (2017). At this time, the hashed-related blocks will be created, and data stored there securely. Finally, output mobile devices will be required with all

Table 7.2 The driving advantages of applying blockchain in the food traceability system

Major Concern	Driving Advantages	Reference
Sustainability and transparency	Blockchain technology traces the food product from fam to fork using extreme visibility while the probability of changing stored data is eliminated.	Feng et al. (2020).
Decentralization	All participants in the food supply chain can interact directly without intermediates, which saves time, cost, and effort.	Prashar et al. (2020)
Secured	Blockchain is fully secured since data is stored in strongly connected sequencing blocks. Every block carries the data of the previous one, which in turn eliminates hacking procedures.	Tao et al. (2021).
Cost-saving and lower expenditure	The cost of contaminations, foodborne, losing customers are painful. Still, a blockchain-effective traceability system can be entirely avoided. It allows the operation team to deduct any defect in the supply chain within seconds and adjust it immediately.	Demestichas et al. (2020) and Panuparb (2020).
Time-saving	The clear vision deducting of any defect in the supply chain may take seconds while it may take hours or even days in the traditional traceability system. Furthermore, it eliminates bottleneck time-consuming.	David et al. (2022)
Immutability	Blockchain technology guarantees fixity traceability data that can't change by any participant. This eliminates fraud procedures and shapes a trustful energetic food traceability system.	Caro et al. (2018), Pearson et al. (2019).
Efficiency	Blockchain stores and shares data effectively while using smart contracts to facilitate the work and allow sustainability.	Friedman and Ormiston (2022).
Effective food safety management	By using blockchain technology, the detection and response time for any contaminations or foodborne will be within minutes or even seconds, allowing the logistic team to get the accurate decision to adjust the process immediately.	Lin et al. (2019); Feng et al. (2020).
Consensus	All data onto the blockchain requires a covenant from all participants where the sole control power is not restricted to one hand.	Yiannas (2018)
High customers satisfaction	While the main goal for any firm is to create and maintain loyal customers, this can be achieved simply by applying blockchain techniques that enable building trust in the producers–customers relationships by offering a clear vision about their products.	Tayal et al. (2021); Stranieri et al. (2021)

Source: Composed by the Authors

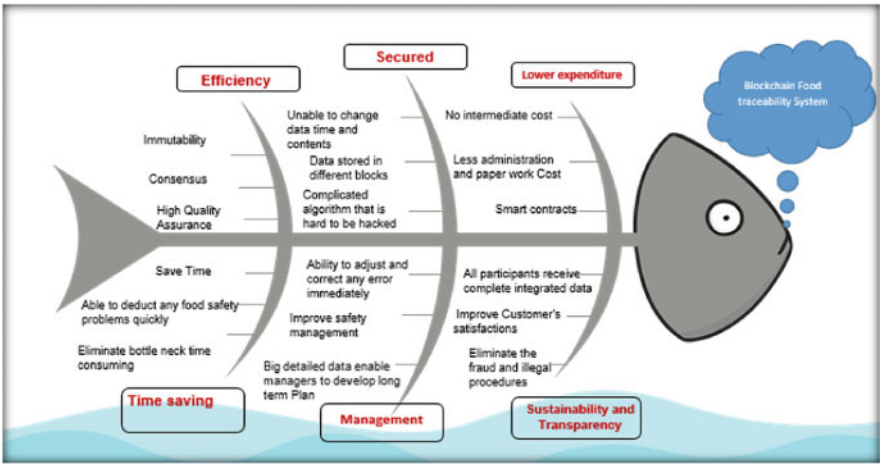

Fig. 7.2 Fishbone diagram: The advantages of blockchain food traceability system. Source: Composed by the authors

Table 7.3 The boundaries of implementing blockchain food traceability system

Major concern	Main challenges	Reference
High initial cost	While initiating any new technique is costly, the same concept applies to blockchain revolutionary technology.	Tan et al. (2020); David et al. (2022)
Limited knowledge	Since blockchain is a new technology, there are scarce professional human resources who know the process.	Hastig and Sodhi (2020); Stranieri et al. (2021)
Regulatory issues	Since the blockchain is a decentralized system that doesn't require intermediate to facilitate the process, it requires regulatory issues to manage the whole process among all participants.	Van Hilten et al. (2020); Van Hilten et al. (2020).
Privacy concern	Since the blockchain technique depends on high transparency among all participants, it faces redundancy and a lack of privacy.	Rejeb et al. (2020)

Source: Composed by the Authors

participants to integrate the system and reflect a crystal clear vision of the supply chain in all its stages, as written by Tapscott (2017). Table 7.4 briefly illustrates the putting into practice steps of the blockchain food traceability system. At the same time, Fig. 7.3 depicts the stages of launching a blockchain food traceability plan.

Table 7.4 How to implement a blockchain food traceability system

Implementation steps	Declaration	Reference
Determine the required data	What information is needed? When does it have to be collected? Where has it been gathered and recorded? Why is it vital information in the supply chain?	TE Food (2020).
Identify the tools of collecting data	PH sensors (soil type and condition) Accelerometer sensor GPS sensors Temperature monitoring Smart cameras Pallet-level tagging Barcodes Radio frequency identification (RFID) Food-sensing technologies that deduct any contaminations	IGPS (2020); Arrow (2020)
Technical tools	Enterprise resource planning Dashboards Business intelligence Internet of things (IoT) technology (inventory management) Automated storage and retrieval systems Warehouse management systems	Microsoft (2020); van der Lans (2019)
Modum.io AG	Combine the gathered database to the blockchain after issuing smart contract Ethereum blockchain network PostgreSQL HTTP servers that host an Ethereum node Application programming interface	Bocek et al. (2017); Bitcoin (2020); Start up (2016).
Mobile devices	For all supply chain participants to trace the food supply chain Send all the traceability details to the end customers.	Jason (2020); Research Blog (2020).

Note. Modum.io AG = Modum offers digital supply chain monitoring and analytics by Start-Up, 2016

5 Conclusion

A literature review on implementing blockchain revolutionary technology in food traceability systems that consider the effective strategy for medium and small firms' development and expansion was conducted in this paper. The complexity of the food traceability system and the high risk of food management created an urgent demand for transparency integrated and secured traceability techniques. Blockchain technology has fully offered this, driving fruitful rewards and a brief implementation plan.

Fig. 7.3 The steps of launching blockchain food traceability plan. Source: By author. Note. Modum.io AG = Modum offers digital supply chain monitoring and analytics by Start-Up, 2016

Furthermore, this paper mentioned the boundaries of implementing blockchain technology and illustrated how to reduce or eliminate it.

The limitations of this research are represented mainly by the scarcity of adopting blockchain technology in the food traceability supply chain in medium and small firms. Moreover, there is a significant gap in the research on how blockchain food traceability technology works as a vital key growth concept for medium and small food firms.

In addition, more consideration and research should be focused on plans, benefits, and challenges in implementing blockchain food traceability technology in medium and small firms. Future research can focus on how to integrate and enforce blockchain food traceability and logistics procedures to medium and small firms' growth and development.