Title: Application of Block Chain Technology in food safety and quality assurance

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Introduction

Numerous food safety incidents, such as diluted milk in developing countries (Yang et al., 2019), mad cow disease in Britain, E. coli infected cucumber in Germany, and peanut butter infected with bacteria in the U.S. (Lethbridge, 2018), have raised substantial public interest and academic awareness in food traceability (e.g., Liu et al., 2019; Robson et al.,2020; Schroeder & Tonsor, 2012). Each year, millions of populations suffer and thousands die from food-borne illnesses. This is a preventable problem that is damaging to both individuals and the economy. Ongoing food safety improvements can yield economic and social benefits, in addition to reducing food-borne illnesses. A safer food supply, from farm to table, with minimal loss of productivity, reduced burden on the country's health care system through improved public health, reduced loss of income and health care costs for the affected individual, enhanced consumer confidence in food supply leading to economic stability throughout the food sector. The quality assurance (QA) process establishes all product quality and compliance specifications, along with best practice guidelines for suppliers, farms, factories, and shippers during the development stage of production. The globalization of food supply chains and the increasing complexity of modern food systems are changing the relationship consumers have with food. "Enhanced focus towards food safety and quality has reshaped the way contemporary consumers evaluate food and make purchase decisions." ("Consumer Trust in Food and the Food System: A Critical Review") Specifically, several serious food safety incidents, cases of food fraud, and changes in food production practices have violated consumer trust across the globe. While not all these incidents have directly imposed risks to public health and safety, they do represent a breach of consumer trust and have reduced consumer confidence in the integrity of the food system. Since modern food supply chains intense collaboration between governments, producers, and consumers is needed as the provision of accurate and timely information is an important prerequisite for safe and secure food supply chains (World Health Organization, 2019).

Nowadays, consumers are becoming increasingly concerned about the origins of their food, and they expect retailers to offer fully transparent food-related information and higher safety levels throughout the whole supply chain (Asioli et al., 2014; Busby, 2019; Gallo et al., 2021). Recent technological advancements offer new opportunities to implement a new blockchain-based food traceability system. In this regard, blockchain represents a promising technology by ensuring food traceability (Creydt & Fischer, 2019). A blockchain is a digital system for recording trade transactions among multiple trading parties in a tamper proof way. It can be defined as "a digital, decentralized, and distributed ledger in which transactions are logged and added in chronological order with the goal of creating permanent and tamper-proof records" (Treiblmaier, 2018, p. 547). Blockchain's robust and decentralized functionality can be used to tackle food fraud and security (Sharma and Singh, 2021). Retailers who employ a blockchain-based traceability system benefit from the ability to better predict the freshness as well as the shelf life of food and, hence, can better assess delivery intervals (Creydt & Fischer, 2019).

Food safety and quality assurance are some of the biggest factors in effective food marketing and are subject to changing standards. As consumers become more aware of the foods they eat and the demand for food quality increases, so the necessity for safer food production required. Food safety practices of food production demonstrate economic and environmental sustainability by preventing food spoilage and human sickness. With blockchain, locating the contaminated ingredients and tracing the affected batches can be done in seconds, making the recall process much faster and easier. Consumers can verify whether their product is part of a contaminated batch, simply by scanning.

Blockchain technology in food safety

In case of food safety issues or recalls, blockchain can facilitate the process by identifying the affected products and their distribution pathways. By accessing immutable records on the blockchain, authorities and stakeholders can rapidly pinpoint the origin and movement of contaminated or unsafe products, enabling timely recalls and reducing the

potential impact on public health. “Blockchain for the food supply chain provides 100% traceability of the food-related data and multi-party transactions, enables backtracking the food provenance in seconds rather than days, facilitates food safety and quality compliance verification, enhances protection of supply chain data.” The traditional approach requires a lot of resources and time to find the sources and routes of food with safety issues (Kohler and Pizzol 2020). Humankind has seen various disease outbreaks like Escherichia coli due to hazardous food. Wal-Mart, too, suffered a considerable food scandal with milk and infant formula across China. It was estimated to negatively affect over 300,000 people. Due to many suppliers, customers, workforce, and documentations, it took several days to identify the origin of products. But this led to consensus at Wal-Mart that better traceability is required in their supply chain. They started a pilot project with the IBM Food Trust program to track Mangoes and Pork products (Kshetri 2018). With blockchain, they can track pork production from pork farms to the Wal-Mart stores in china and ensure food safety. In 2017 in the Wal-Mart Global Responsibility Report, they also discuss the monitoring of Mangoes coming from Latin America to the United States. They track in real-time information like origin (food), batch number, Plant, processing data, and transportation details at each step of delivering food from suppliers to a consumer. This has tremendously reduced the tracking to obtain the original records for Wal-Mart. For example, in the past, it would take six days (paper-based tracking system) for Wal-Mart to track mangoes from Mexico, but with blockchain, it takes 2.2 s only (Kshetri 2018).

Around the globe, different guidelines, and regulations (i.e., EU Regulation 178/2002, ISO 9000: FDA Food Safety Modernization Act (FSMA)) regulate the required information provided by traceability systems at different destinations (Asioli et al., 2014). In contrast, European countries must follow the EU Legislation 178/2002 (general principles and requirements of food law) and ensure the “ability to trace and follow a food, feed, food-producing animal, or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing, and distribution” (EUR-Lex, 2002). Precision (the tracking unit dimension, Golan et al., 2004) and breadth (amount of recorded information, Golan et al., 2004) have been reported to represent important drivers of four different benefits of traceability systems: regulatory, recall and risk management, supply chain operations, and market and customer response (Asioli et al., 2014). “Food traceability enables retailers to react immediately to potential safety hazards (Matzembacher et al., 2018). Food traceability systems offer consumers reassurances on the origin and history of food products, raise the standards of food safety and quality across the international markets, and help build consumer confidence and trust in the traced food products.

Five ways in which blockchain is being used in the food industry

1. *Supply chain traceability:* The blockchain technology can be used to track the origin and journey of food products from the farm to the table. By creating a tamper-proof record of every step in the supply chain, blockchain can help identify the source of contamination in case of foodborne illness outbreaks and facilitate faster recalls.
2. *Certification and compliance:* The blockchain technology can be used to store and share information about food certifications and compliance with food safety regulations. This can help reduce the time and cost of audits and inspections and ensure that food products meet the required standards.
3. *Food fraud prevention:* The blockchain technology can be used to authenticate the origin and quality of food products and prevent food fraud. By creating a transparent and immutable record of every step in the supply chain, blockchain can help identify counterfeit or adulterated food products.
4. *Supply chain financing:* The blockchain technology can be used to facilitate financing for small and medium-sized enterprises (SMEs) in the food industry. By creating a transparent and auditable record of transactions, blockchain can help SMEs access credit and reduce the risk of default.
5. *Smart contracts:* The blockchain technology can be used to automate various processes such as payments, shipments, and quality assurance through self-executing programs known as smart contracts. Smart contracts can help reduce the risk of fraud and error, streamline processes, and improve the efficiency of the supply chain.

Conclusion

The benefits of using blockchain for food traceability are clear and distinct. The data stored by blockchain systems are irreversible and transparent to all the stakeholders, thus making it unique and providing credibility to the entire system. The information on the blockchain system will allow the companies to strengthen their relationship with current customers and attract new ones (EU Food Fraud Network 2018) by sharing processes and record-keeping (Babich and Hilary 2020). A key driver of blockchain adoption in the agri-food industry is food safety concerns. Contamination or food fraud that can be detected in the supply chain and the potential of rapid product recalls are spurring the implementation of blockchain projects in the agrifood industry.

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