

## Blockchain in the Food Industry: Enhancing Traceability and Trust

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### SUMMARY

Blockchain technology is revolutionizing the food supply chain by enhancing transparency, safety, and efficiency. Blockchain acts as a secure, decentralized digital ledger that allows food products to be tracked from the source to the consumer, ensuring quality and authenticity. It enables quicker response to food safety concerns by facilitating faster recalls, reduces food fraud by ensuring accurate labelling, and streamlines supply chain operations, cutting down delays and costs. Additionally, blockchain promotes sustainability by verifying ethical sourcing, such as fair-trade certifications, and helps maintain food quality by tracking key factors like temperature during transportation. While blockchain offers significant benefits, it also faces challenges, including scalability issues, regulatory hurdles, and high energy consumption. The article concludes that blockchain has the potential to reshape the food industry, but more research and innovation are needed to fully overcome these obstacles and unlock its widespread adoption.

### INTRODUCTION

Blockchain is a technology with unique combination of features such as decentralized structure, distributed notes and storage mechanism, consensus algorithm, smart contracting, and asymmetric encryption to ensure network security, transparency and visibility (Dutta et al., 2020). Blockchain is an emerging meta-technology and considered a new institutional technology with the potential to change the governance of vertically integrated food supply chains (Kramer et al., 2021). Blockchain is a digital system that records data in a secure and decentralized way, without needing a central authority to manage or control it. Instead, multiple computers (called nodes) work together to verify and store data in blocks, which are time-stamped and linked together using cryptography. Once the data is recorded, it can't be changed, making the system highly secure (Tripathi et al., 2023). The decentralized nature of blockchain builds trust by allowing all participants to see and verify the information without relying on a single party. This technology is used to improve security, transparency, and efficiency in many areas, including finance, business, and identity protection. Blockchain has the potential to digitally transform the way the world transacts by allowing the contracts to be digitally embedded in databases that are transparent and provide security against tampering. This key attribute of blockchain technology eliminates the need for third parties and intermediaries like banks, lawyers, etc. Blockchain is a digital distributed ledger that secures and links the digital records called “blocks” using cryptographic techniques. Although the term blockchain gained popularity in the year 2008 with the introduction of Bitcoin cryptocurrency, its underlying principles and concepts have been in use since the 1980s (Nakamoto, S. 2008).

Blockchain technology has become a disruptive force in many different industries because it provides unparalleled security, transparency, and efficiency (Kumar, 2024). Blockchain has immense potential to transform supply chain (SC) functions, from SC provenance, business process reengineering to security enhancement.

### Blockchain Technology:

Blockchain is a digital distributed ledger that stores data in the form of blocks that are linked together using a cryptographic function. Although similar data structures have existed for a long time, blockchain technology was truly conceived and defined only in the year 2008 (Yi, X. 2022)

### Benefits of Blockchain:

- **Traceability:** Quickly track food from farm to fork for improved transparency.
- **Safety:** Identify and remove contaminated food swiftly to ensure consumer safety.
- **Fraud Prevention:** Tamper-proof records reduce product mislabelling and food fraud.

- **Efficiency:** Streamlines supply chain processes, reducing delays and costs.
- **Sustainability:** Helps optimize logistics and reduce food waste.
- **Accountability:** Ensures each supplier meets quality and safety standards.
- **Ethical Sourcing:** Verifies fair trade and sustainable practices.
- **Compliance:** Simplifies regulatory checks for food safety and standards.

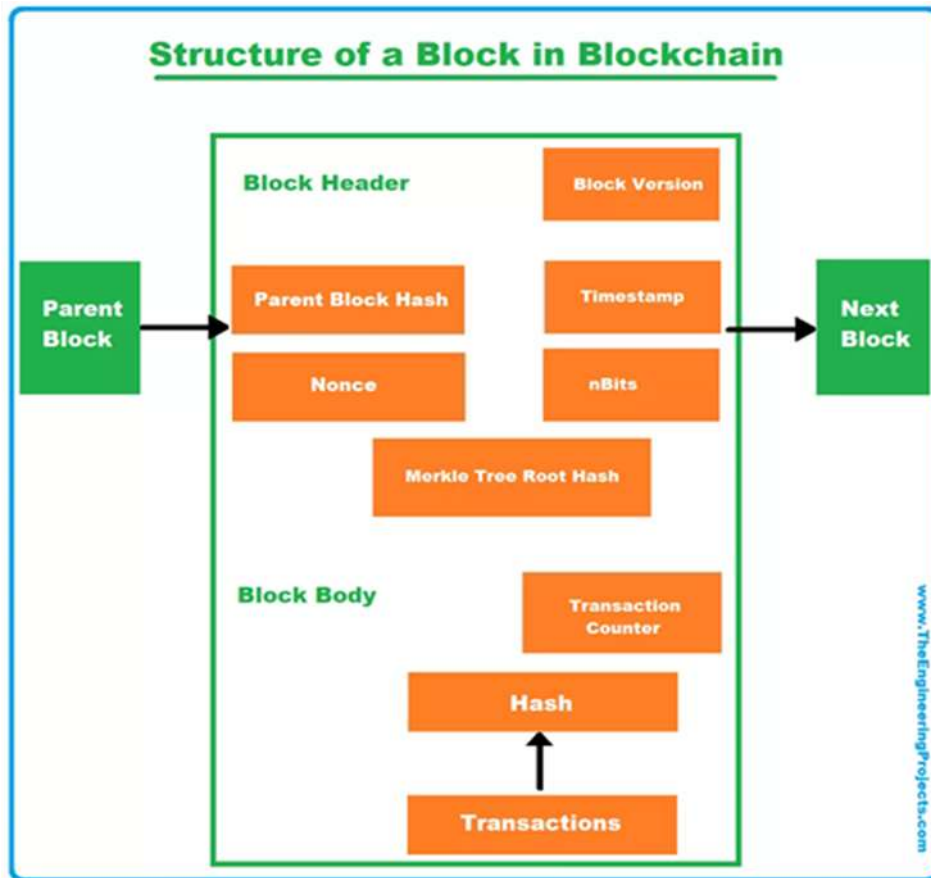


Fig. 1: Structure of Blockchain

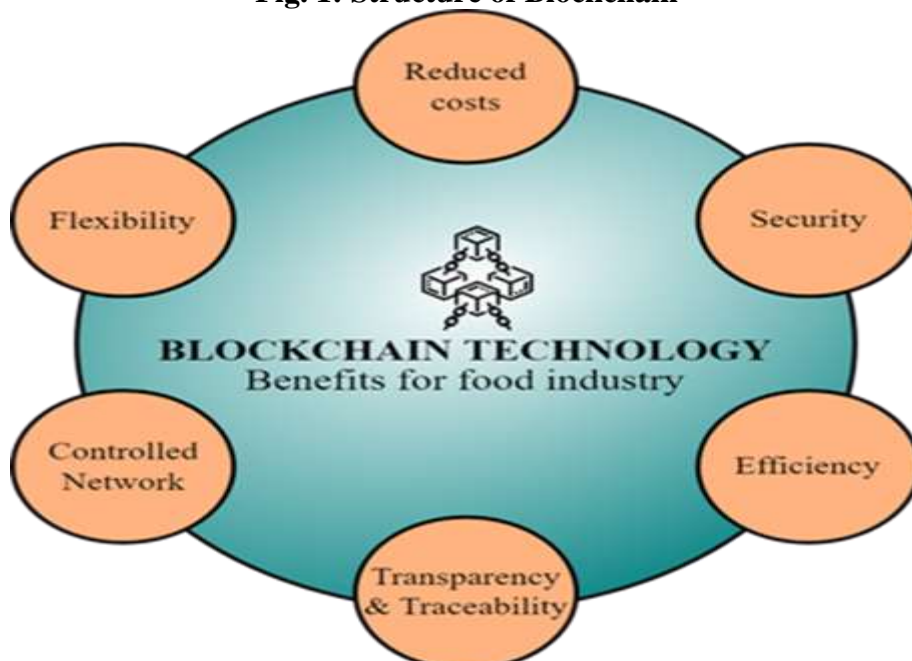


Fig. 2: Benefits of blockchain for food industry

**Challenges in Block Chain Technology:**

Blockchain technology is currently gaining momentum across various industries, holding the promise of modernizing our economic system. However, it also faces several significant challenges, including

scalability, energy consumption, interoperability, and regulatory concerns (Tripathi et al., 2023). Blockchain technology today faces many challenges and potential limitations that are both internal and external. The major challenges faced by blockchain can be seen from the perspective of the developers, users, and policymakers. The implementation of blockchain-based solutions faces issues related to low scalability, limited interoperability, lack of standardization, and shortage of skilled developers. Further, at the organizational level, there is still a lack of awareness, understanding, lack of governance, and regulatory protocols about the technology.

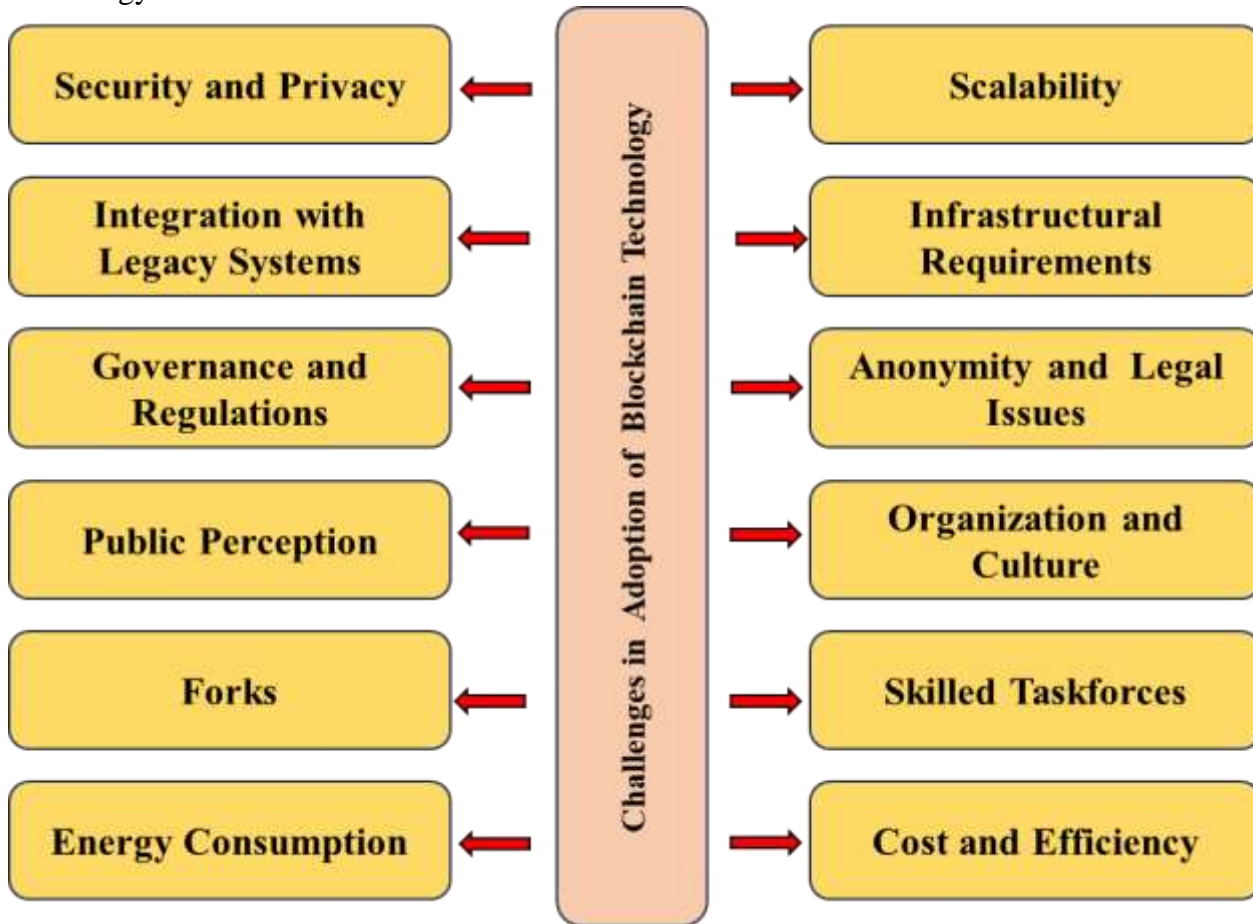


Fig. 3: Challenges in Adoption of Blockchain

**Application of Blockchain Technology:**

In recent years, with the rise of digital currency, its underlying technology, blockchain, has become increasingly well-known. This technology has several key characteristics, including decentralization, time-stamped data, consensus mechanism, traceability, programmability, security, and credibility, and block data is essentially tamper-proof. Due to these characteristics, blockchain can address the shortcomings of traditional financial institutions (Dong et al., 2023).

Blockchain in the food industry can be used as a digital tracking tool that makes the entire food supply process more transparent, efficient, and safer.

**1. Tracking the Food's Journey:**

Imagine being able to know exactly where your food comes from — blockchain makes that possible. It records every step of a food product’s journey, from the farm to fork, so you can be confident in its quality and origin.

**2. Faster Recalls in Case of Problems:**

If there is an issue, like contaminated lettuce or bad meat, blockchain helps quickly trace the source. This means faster recalls and fewer people affected, keeping you safer as a consumer.

**3. Fighting Fake Labels:**

You will be able to know if that “organic” or “fair-trade” label is real or not? Blockchain ensures that what’s on the label is true by creating a tamper-proof record of how the food was produced and sourced.

**4. Speeding Up the Food Supply:**

Blockchain reduces paperwork and speeds up processes. By automating things like transactions and deliveries so food gets to you faster and with fewer middlemen.

**5. Proving Ethical and Sustainable Sourcing:**

Now a days people want to buy food that's ethically sourced and produced in a sustainable way. Blockchain lets companies prove they're doing this, so you know you're supporting good practices when you buy certain products.

**6. Keeping Food Fresh:**

You will be able to know your food was kept at the right temperature throughout its journey. Blockchain records data like temperature and humidity, ensuring food stays fresh and safe from the farm to your plate.

**7. Reduce Food Waste:**

With better tracking of where food is and how long it's been there, companies can manage their inventory better. This means less food spoils before it even reaches the shelves, reduce waste.

**8. Building Consumer Trust:**

When you scan a code on your food packaging and see everything about where it came from and how it was handled, it builds trust. You feel more secure about the food you're eating and the brand you're buying from.

In short, blockchain makes it easier to see where your food comes from, keeps it safer, speeds up deliveries, and helps reduce waste, all while giving you peace of mind about the quality and ethics behind your food.

**Trends in Blockchain Technology:**

At present times, Blockchain technology is gaining more attraction with every passing day, as it has revolutionized the traditional trade due to its distributed ledger feature, every record in this ledger is secured by rules of cryptography which makes it more secure and tamper-free. This naturally led to the emergence of various types of cryptocurrencies, such as Bitcoin, which builds on a technology commonly known as Blockchain. (Gad et al., 2022).

**CONCLUSION**

Blockchain technology has the potential to revolutionize the food industry by enhancing transparency, safety, and efficiency in the supply chain. While it offers significant benefits like improved traceability, fraud prevention, and sustainability, challenges such as scalability and regulatory issues remain. Continuous research and development are necessary to fully realize its potential.

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