IJTI | INTERNATIONAL JOURNAL OF THERAPEUTIC INNOVATION

Review article

Food Supply Chain using Blockchain Technology

Sunil Punjabi*[1], Siddesh Shetty[2], Shriraman Iyer[2], Pratik Thete[2], Suhas Jadhav[2]

[1] Assistant Professor, Department of Computer Engineering SIES Graduate School of Technology, Mumbai Maharashtra, India.
[2] Bachelor of Engineering in Computer Engineering, SIES Graduate School of Technology, Mumbai, India.

Corresponding author: Sunil Punjabi ✉ sunilp@sies.edu.in, **Orcid Id**: https://orcid.org/0009-0006-1570-0634

Received - 09-05-2023**, Revised** - 10-06-2023, **Accepted** - 12-07-2023 **(DD-MM-YYYY)**

Refer this article

Sunil Punjabi, Siddesh Shetty, Shriraman Iyer, Pratik Thete, Suhas Jadhav. Food Supply Chain using Blockchain Technology. International journal of therapeutic innovation, September - October 2023, V 1 - I 1, Pages - 0021 – 0030. Doi: https://doi.org/10.55522/ijti.V1I1.0010.

ABSTRACT

When a family in India consumes a piece of fish for dinner, they might be eating seafood that was first purchased by a distributor in Japan, then transported to a packing facility in Thailand, before arriving at a wholesaler in India and finally a supermarket chain in Delhi. The increase in complexity can cause serious food regulations fraud, Food regulations tend to focus on food safety to preserve human health. Transnational and frequently ocean-based food supply chains are extensive, contain a lot of weak points, and are open to contamination and criminal sabotage. Yet, illegal infiltration motivated by financial gain, where there is little chance of identification and even less chance of punishment, can endanger human health. New, decentralized technologies, like blockchain, offer affordable, immutable, and transparent ways to track every step of the trip from farm to fork—or, to put it another way, from sea to supper. Although some brands and products may gain more consumer trust if they embrace traceability technology, the expense will undoubtedly be passed on to the consumer.

Keywords: Blockchain, Food Supply Chain, Distributed Digital Ledger, DApps, Smart Contract, Chaincode, Ganache.

INTRODUCTION

The food supply chain refers to the journey of food products from the farm to the table. It involves a complex network of different stakeholders, including farmers, distributors, manufacturers, wholesalers, retailers, and consumers. The food supply chain has become increasingly complex over the years, with food products being sourced from different parts of the world and transported across different countries and continents. The food supply chain faces several challenges that can affect the quality, safety, and availability of food products.

These challenges include

Traceability

It can be challenging to trace the origin of food products, especially when they are sourced from different parts of the world. This can make it difficult to identify the source of contamination in case of a foodborne illness outbreak.

Food safety

The food supply chain is prone to contamination from pathogens, chemicals, and other hazards that can compromise the safety of food products. This can pose serious health risks to consumers.

Waste

The food supply chain is associated with a significant amount of waste, from food products that are lost during transportation and storage to food products that are discarded due to quality issues or expiry.

Sustainability

The food supply chain has a significant impact on the environment, from greenhouse gas emissions associated

with transportation and storage to the use of pesticides and fertilizers in agriculture.

Transparency

The food supply chain lacks transparency, with limited information available to consumers on the origin, quality, and safety of food products.

Addressing these challenges requires a coordinated effort from different stakeholders in the food supply chain. The use of blockchain technology can help to improve traceability, transparency, and food safety, as well as reduce waste and promote sustainability.

According to reports, food theft costs the global food business $49 billion annually. Food mislabeling, adulteration, misrepresenting the place of origin, misrepresenting weight, misrepresenting nutritional information, and repackaging are all examples of intentional deceit done for financial gain. It is a transnational crime that has gotten into supply networks to make money. Food fraud has been just as profitable as cocaine trafficking, with a lot less chance of being caught. Similar to cocaine trafficking, food fraud frequently coexists with supporting offenses including document fraud, corruption, and other methods of facilitating border crossings and evading food safety inspections. It seems that not many meals are immune to deception. Frauds target a variety of goods, including high-demand, low- to medium-cost common staples including wine, mineral water, seasoning cubes, seafood, and olive oil as well as highly treasured, rare, and expensive delicacies. The end effect is that no goods or locales are immune to food fraud, despite the fact that current regulations are far from ideal. Existing legal remedies cannot completely stop criminal activities in this field, but a technology-based approach to food regulation may be advantageous.

Blockchain technology is a distributed digital ledger that allows for secure and transparent transactions without the need for intermediaries. Each block in the chain contains a record of transactions, and once added to the chain, it cannot be altered, making it a tamper-proof and immutable record. The technology has gained significant attention in recent years, with its potential applications in various industries, including the food supply chain.

The use of blockchain technology in the food supply chain has several potential benefits, including

Traceability

Blockchain technology allows for the tracking of food products from the farm to the table, providing complete transparency on the origin and journey of the product. This can help to improve food safety by enabling faster identification and recall of contaminated products.

Transparency

The use of blockchain technology can improve transparency in the food supply chain by providing consumers with access to information on the quality, safety, and sustainability of food products.

Efficiency

Blockchain technology can help to streamline the food supply chain by reducing paperwork, automating processes, and reducing the time required for verification and authentication.

Trust: The use of blockchain technology can help to build trust between different stakeholders in the food supply chain, including farmers, distributors, manufacturers, wholesalers, retailers, and consumers.

Sustainability

Blockchain technology can help to promote sustainability in the food supply chain by enabling the tracking of sustainable practices, such as the use of organic farming methods and environmentally-friendly packaging.

Overall, the use of blockchain technology has the potential to transform the food supply chain by improving traceability, transparency, and food safety, as well as reducing waste and promoting sustainability.

Literature survey

"An agri-food supply chain traceability system for china based on rfid & blockchain technology" – Traditional agri-food logistics patterns cannot match the demands of the market anymore, building an agri-food supply chain traceability system is becoming more and more urgent. In this paper, they studied the utilization and development situation of RFID (Radio-Frequency Identification) and blockchain technology first, and then they analyzed the advantages and disadvantages of using RFID and blockchain technology in building the agri-food supply chain traceability system; Finally, they demonstrated the building process of this system [1].

"The impact of blockchain on food supply chain: The case of walmart" – This paper aims to exploring the adoption of blockchain technology in food supply chains with a thematic analysis. Desktop research is conducted and all the

data is collected from online databases, including Factiva, Nexis, and Google scholar. Then they carried out a qualitative thematic analysis, according to the investigation processes suggested by Creswell. The findings illustrate four categories of impacts of the adoption of blockchain on food supply chains [2].

"A content-analysis based literature review in blockchain adoption within food supply chain" – The present paper is aimed at 1) performing a systematic literature review (SLR) on applications in the perspective of the sustainable agri-food supply chain (SC) of blockchain technology (BCT); 2) analyzing the selected literature, focusing on the advantages of the sustainable uses of the blockchain of the aforementioned SC and 3) presenting an outlook and research directions capable of addressing unresolved problems [3].

"Boundary conditions for traceability in food supply chains using blockchain technology" – The goal of this paper is to identify boundary conditions for sharing assurance information to improve traceability. Four cases in the food supply chain have been investigated. Eighteen boundary conditions categorized in business, regulation, quality and traceability categories have been identified. Some boundary conditions were found in all supply chains, whereas others were found to be supply chain specific. Standardization of traceability processes and interfaces, having a joint platform and independent governance were found to be key boundary conditions before blockchain can be used [4].

"Blockchain Case studies in food supply chain visibility" – This paper aims to investigate how blockchain has moved beyond cryptocurrencies and is being deployed to enhance visibility and trust in supply chains, their limitations, and potential impact [5].

"Blockchain technology toward creating a smart local food supply chain" – This paper explores the potential of blockchain technology to create a more efficient, transparent and secure food supply chain. The authors argue that traditional food supply chains are often opaque, with little visibility into the origins and quality of food products. This can lead to issues such as food fraud, safety concerns and waste.The paper provides several case studies of blockchain-based food supply chains, including the use of blockchain to track the origin of beef in Brazil and to trace the journey of coffee beans from Colombia to the United States [6].

"Food safety in the supply chain using blockchain technology" – Overall, the paper suggests that blockchain technology has significant potential to enhance food safety in the supply chain and create a more sustainable and transparent system. However, the authors note that there are still challenges to overcome, such as the need for standardization and interoperability across different blockchain platforms, and the need for greater collaboration and data sharing between stakeholders in the food supply chain [7].

"Blockchain adoption in food supply chains: A systematic literature review on enablers, benefits, and barriers" – The paper highlights several enablers for blockchain adoption, including the need for greater transparency and traceability in the food supply chain, the potential to reduce food waste and fraud, and the increasing interest in sustainable and ethical food production. The authors also identify several benefits of blockchain adoption, including improved food safety and quality, increased consumer trust, and enhanced supply chain efficiency and collaboration [8].

"Blockchain technology for a sustainable agri-food supply chain" – The paper highlights the need for further research to explore the long-term impacts of blockchain adoption in the agri-food supply chain, and to develop more robust frameworks for evaluating the effectiveness of blockchain solutions. The authors conclude that while blockchain technology has significant potential to transform the agri-food supply chain, there is still much work to be done to overcome the challenges and realize its full potential in creating a more sustainable and efficient system [9].

"An overview of the impact of blockchain technology on the meat, fruit and vegetable supply chains" – The paper highlights several benefits of blockchain adoption in the meat, fruit, and vegetable supply chains, including improved traceability and transparency, reduced food fraud and contamination, enhanced supply chain efficiency and collaboration, and increased consumer trust. The authors argue that these benefits can contribute to a more sustainable and ethical food system, by promoting responsible production practices, reducing waste, and ensuring fair compensation for farmers and other stakeholders [10].

"Blockchain changing the outlook of the sustainable food supply chain to achieve net zero?" – The paper identifies

several challenges and barriers to blockchain adoption in the sustainable food supply chain, including the high costs and technical complexity of implementing blockchain systems, the need for standardization and interoperability across different blockchain platforms, and the challenges of data management and privacy [11].

"Block-chain technology for food supply chains" – The paper explains how blockchain technology can be used to improve transparency, traceability, and food safety in the food supply chain, and how it can enhance collaboration and efficiency among different stakeholders. The authors also highlight several challenges and barriers to blockchain adoption in the food supply chain, including the need for standardization and interoperability across different blockchain platforms, the challenges of data management and privacy, and the high costs of implementation [12].

Methodology

Objective

Blockchains for the food supply can be utilized to improve performance, control, and system security while enabling trading partners to safeguard their business operations and the supply chain. In simpler terms, a blockchain is a network of several computers that keeps track of a digital "record."

4 important areas to make blockchain technology more useful for controlling the food supply chain:

- Smart contracts between corporate partners
- Improved product data protection
- Food supply chain disintermediation
- Improved product traceability and visibility.

With this research paper, we aim to contribute to the development of knowledge and understanding of the potential of blockchain technology to transform the food supply chain and improve the quality and safety of food products. This paper also plans to observe an overview of the current state of blockchain implementation in the food supply chain, including its benefits and limitations.

Implementation

There are 3 crucial aspects that form the core architecture of this application. These 3 layers include-

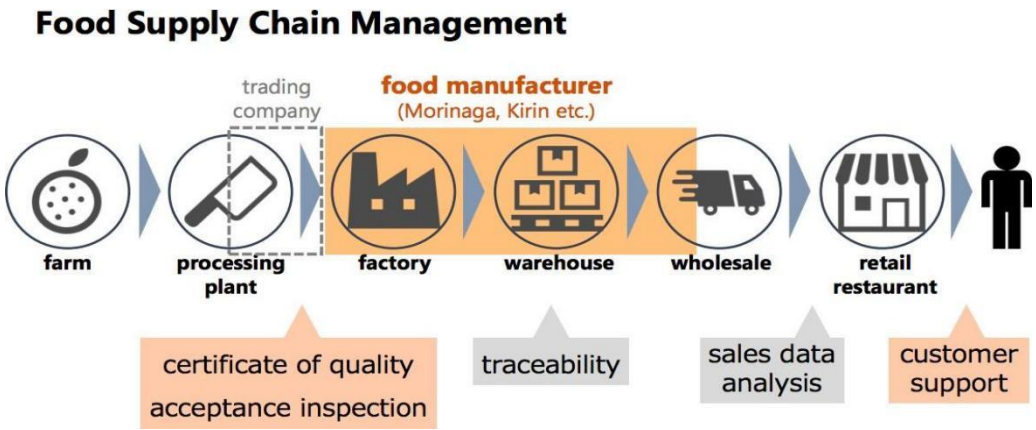
- Application Layer
- Blockchain Layer
- Infrastructure Layer

The applications that end users employ to create blockchain network connections make up the blockchain application layer. The application layer is made up of scripts, frameworks, UIs (user interfaces), APIs (application programming interfaces), chain code, smart contracts, and Dapps (decentralized applications).

In the blockchain layer, with the sender's wallet private key, every transaction is "digitally signed." The information can't be accessed or modified by anyone else because this key is only accessible to the sender. The digital signature, which is encrypted to guarantee the highest degree of safety, further protects the owner's identity. Tampering data in this layer is nearly impossible.

Blockchain platforms are built on P2P, i.e., peer-to-peer network architecture. Here, one node is connected to other nodes for quick access to data. The client-server architecture forms the basis for this structure. In this way, a distributed ledger is formed and the blockchain infrastructure layer is constructed.

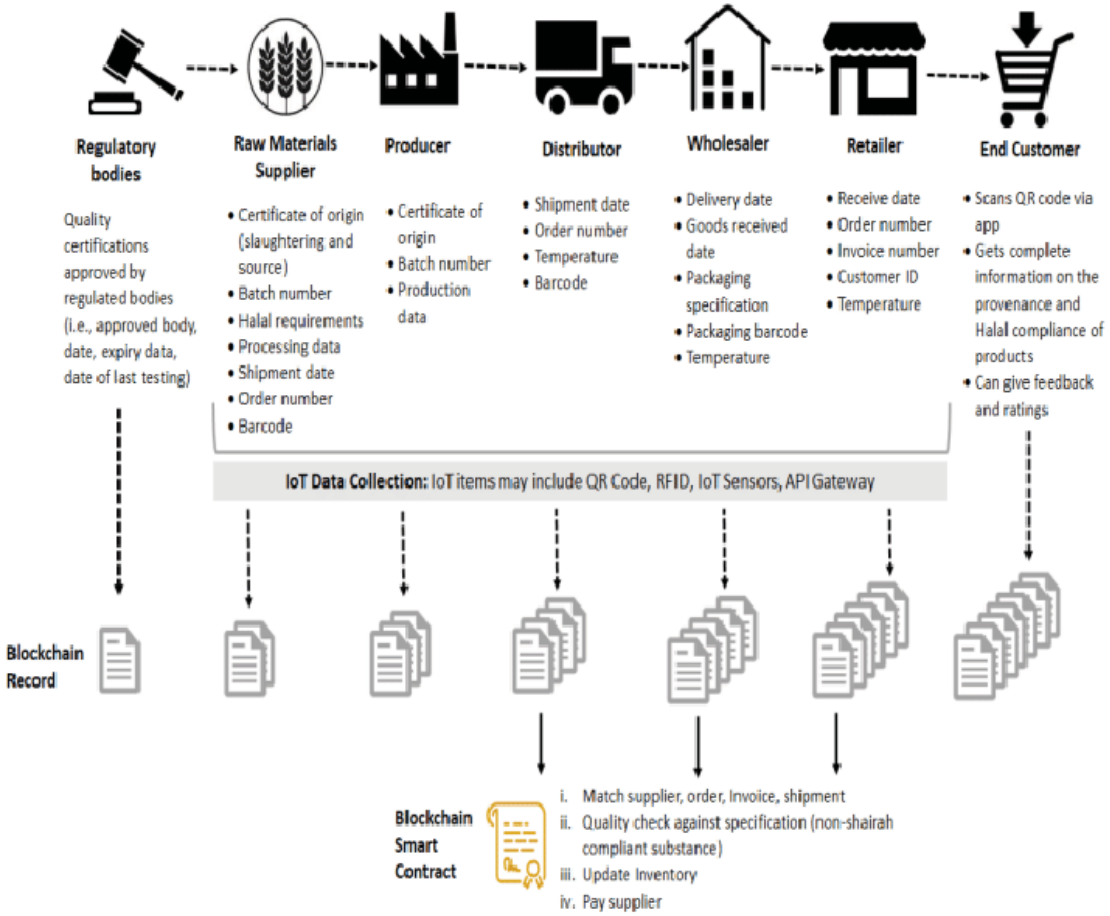
Figure1: Block diagram of food supply chain management



Initially, the traceability system takes center stage, to trace the product from its origin to its delivery. Each item is marked with a special serial number. A number that is stored on an externally-owned account on Ethereum. The transaction is recorded on a smart contract and simultaneously the product's serial number is also linked to the contract. Only

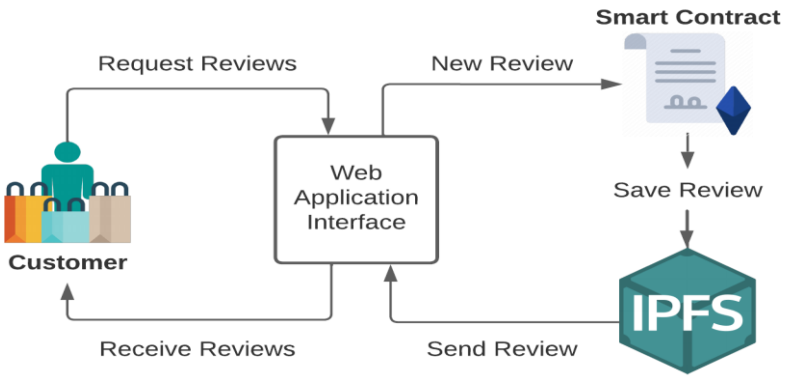
authentic users are allowed to carry out specific transactions in this case.

Figure 2: Proof of delivery in the food supply chain using blockchain



In the trading stage, the blockchain tracks and records the shipment of goods from one entity to another. The customers must first register in the system and request to buy the item with the assigned serial number. Once the purchase is completed, the product owner receives a request and modifies the product ownership to reflect the new owner. This procedure helps to curb the duplicity of products, as retailers cannot sell products with duplicate serial codes.

Figure 3: Smart contract for customer



One of the most important goals is to build a reputation system, a layer of trust between customers and retailers. With the reputation system mechanism, only the actual customers can write reviews about the product. Because the reviews on the blockchain are irreversible, no retailer or merchant can edit or remove negative reviews to raise their overall rating.

This ensures transparency when it comes to overall customer reviews. In this way, integrity is preserved and the customer can make proper research about the retailer before making a purchase.

System requirement

A. The following hardware components are required for implementing the system –

- Personal PC or Laptop
- Intel Core i8 8 GB RAM equivalent
- 64Bit windows/Linux or Apple Mac
- Smartphone

B. The following software and firmware are required for implementing the system

- Solidity - Solidity is a high-level programming language for constructing smart contracts that is contract-oriented.
- Ganache - A personal blockchain called Ganache makes it simple to create distributed applications for Ethereum and Corda. You can build, deploy, and test your dApps with Ganache at every stage of the development process in a controlled and secure environment.
- Metamask - Users may save and manage account keys, broadcast transactions, send and receive Ethereum-based money and tokens, and securely connect to decentralized apps using MetaMask either a compatible web browser or the built-in browser of the mobile app.
- Ubuntu – Is a Linux distribution based on Debian and composed mostly of free and open-source software
- Web Browser – Application software for accessing websites. Ex: Google Chrome, Brave etc. The web browser should be compatible with running blockchain applications.
- Javascript – Is a lightweight, interpreted or just-in-time compiled programming language.
- Visual Studio – A code editor optimized for building and debugging modern web and cloud applications.
- Git- An open source distributed system to handle small and large projects and publish them on the Internet for collaborating with other developers
- Node JS >=10.16 A cross-platform open-source server environment based on Javascript
- NPM>=5.6 Package manager for Javascript

RESULT

Figure 4 shows the partial operation of the food supply chain platform, as follows:

- Farmer: Farmer, after logging in successfully, can add raw products to the blockchain network. Thus, the records of the raw products are registered in the blockchain.
- Manufacturer: The manufacturer can check the blockchain records to find out the status of the raw materials, and can thereafter verify their authenticity to produce new products.
- Distributor: The distributor verifies the shipped products from the manufacturer and keeps track of important shipping details through the records on the blockchain network.
- Retailer: The retailer can analyze the sales data provided by the distributor and keep track of all the products shipped to the stores.
- Consumer: The consumer can track the entire journey of the product from the farm to the shelf of the retail store. The consumer can verify the raw materials used in each stage, and the time taken for the product to arrive on the shelves.

Limitations

While working on the system we identified the following limitations of our current implementation –

- Implementing blockchain technology in the food supply chain can be complex and costly, requiring significant investment in hardware, software, and expertise. We used a test Ethereum network to test our application.
- Different stakeholders may use different formats for their systems and products, which leads to a general lack of standardization.
- Using blockchain technology for a food supply chain on a public blockchain like Ethereum exposes personal information, which could be a privacy concern.
- Interoperability with other systems and technologies may be necessary for the usage of blockchain technology, which can be challenging to acquire for our application.
- The system is also affected by internet connectivity and other compatibility issues.

Figure 4: Initial implementation

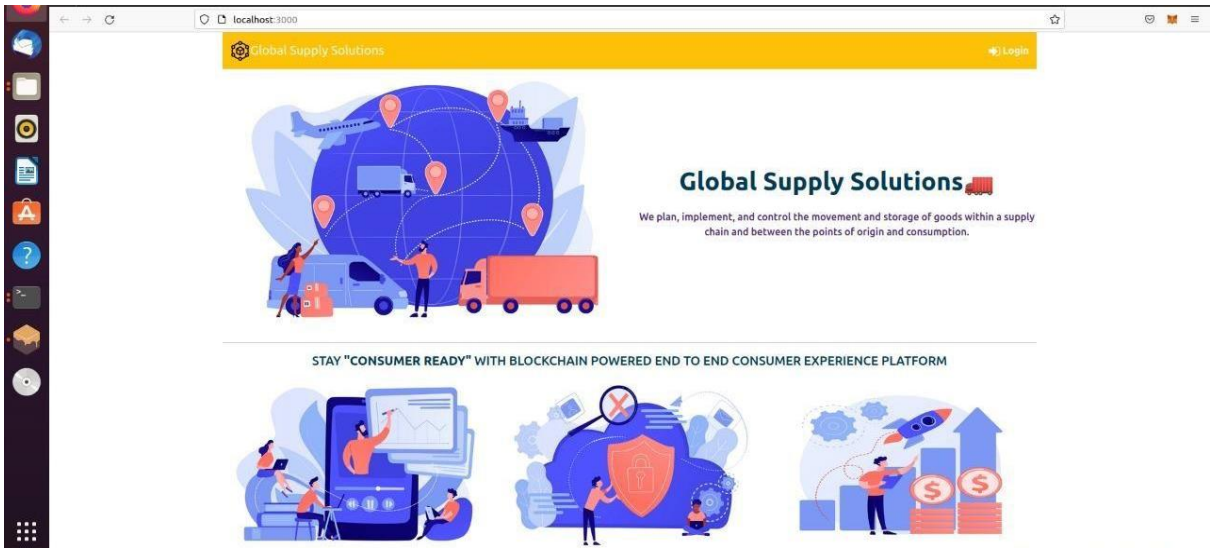
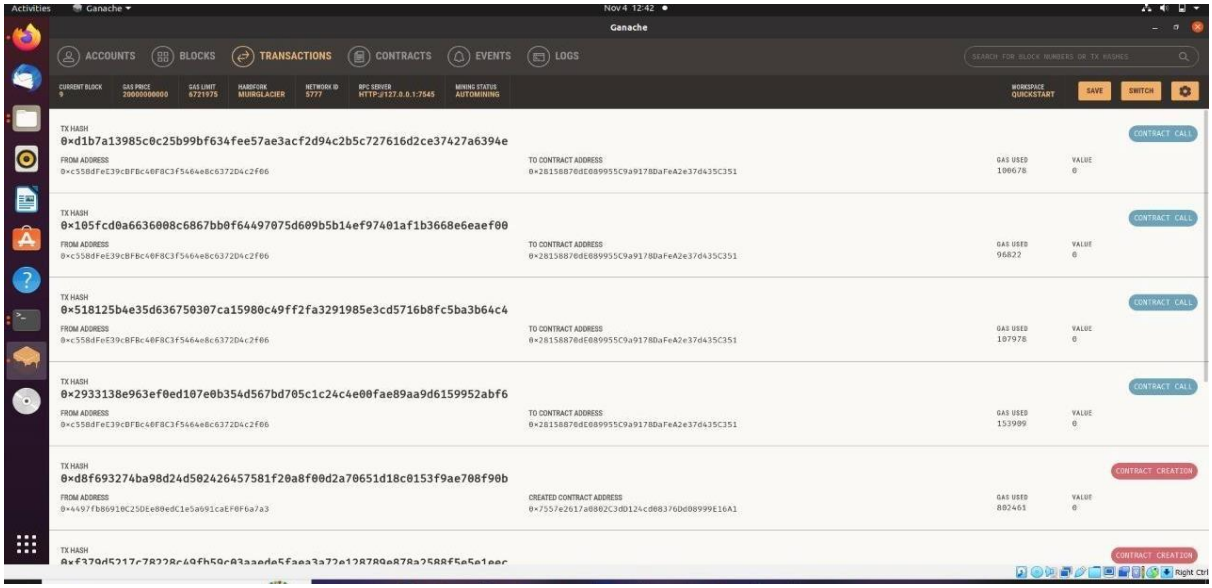


Figure 6: Transaction Page



Future enhancements

The following improvements are expected to take place in future implementations –

Evaluation

More research is required to see whether blockchain applications can effectively solve certain issues in the food supply chain, such as enhancing traceability or lowering waste.

Privacy and security

The application of blockchain technology in the food supply chain raises privacy and security concerns that require more exploration, including the development of privacy-preserving methods.

Economic analysis

Economic analysis can be used to better understand the costs and advantages of integrating blockchain technology into the food supply chain, as well as any potential ROI and stakeholder effects.

Development of industry standards

With the new development of industry standards, we can ensure interoperability and consistency across different stakeholders and systems.

Consumer behaviour

It is necessary to conduct more research to comprehend consumer behaviour and the adoption of blockchain technology in the food supply chain, as well as the factors that affect adoption and perceptions of transparency and trust.

Integration with other emerging technologies

We need to explore the potential for combining blockchain technology with other cutting-edge technologies, such as the Internet of Things and Artificial intelligence.

CONCLUSION

In conclusion, the food supply chain is a complex and challenging system that requires the cooperation of multiple stakeholders to ensure the safety, quality, and sustainability of food products. One of the most promising technological developments for preventing food theft is blockchain. By digitizing secure transactions, or "blocks" at each stage of the supply chain and making them directly viewable by anybody with access to the blockchain ledger, it does away with the need for middlemen.

Blockchain offers a truly decentralized, transparent, and traceable chain of custody that starts with the source and is encrypted with a unique, immutable identifier (assuming the producer is not engaging in fraud). Blockchain has been effectively used outside of the food business, and it is being tested more frequently there and it enables real-time tracking, doing away with the need for labor intensive and potentially fraudulent document processing.

Despite the potential advantages of blockchain technology, there are also drawbacks and difficulties that must be overcome. These issues include complexity, standardization, data privacy, acceptance, scalability, regulation, and interoperability. These issues need to be explored in more detail in order to find answers that will help us go past them.

In conclusion, the use of blockchain technology in the food supply chain has the potential to transform the way we produce, distribute, and consume food products, and to create a more secure, sustainable, and transparent food system.

ACKNOWLEDGEMENT

We would like to convey our heartfelt appreciation to our principal, Dr. Atul Kemkar, South Indian Education Society's Graduate School of Technology, Mumbai, affiliated with the University of Mumbai, our department head Dr. Aparna Bannore and our mentor Prof. Sunil Punjabi for giving us this wonderful opportunity. We gained a lot of knowledge from studying blockchain technology, and it also provided us with first-hand experience using this technology. We are very appreciative of them.

REFERENCES

1. Tian F, 2016. An agri-food supply chain traceability system for China based on RFID & blockchain technology. 13th International Conference on Service Systems and Service Management (ICSSSM). IEEE. Doi:10.1109/ICSSSM.2016.7538424
2. Tan B, Yan J, Chen S, et al, 2018. The Impact of Blockchain on Food Supply Chain: The Case of Walmart. The Impact of Blockchain on Food Supply Chain: The Case of Walmart. Springer Link. Doi: 10.10 07/978-3-030-05764-0_18.
3. Duan J, 2020. A content-analysis based literature review in blockchain adoption within food supply chain. International Journal of Environmental Research and Public Health. 17(5), Page-1784-1788. Doi: 10.3390/ijerph17051784.
4. Behnke K, Janssen MFWHA, 2020. Boundary conditions for traceability in food supply chains using blockchain technology. International Journal of Information Management. 52, Page-101969. Doi: 10.1016/j.ijinfomgt.2020.101969.
5. Rogerson M, Parry G, 2020. Blockchain: case studies in food supply chain visibility. Supply Chain Management: An International Journal. Doi: 10.1108/SCM-08-2019-0300.
6. Damoska Sekuloska J, Erceg A, 2022. Blockchain Technology toward Creating a Smart Local Food Supply Chain. Computers. 11, Page 95. Doi: 10.339 0/ computers11090095.
7. Jarka S, 2019. Food safety in the supply chain using blockchain technology. Acta Scientiarum Polonorum. Oeconomia. 18, Page-43. Doi: 10.22630/ASPE.2019.1 8.4.43.
8. Mohammed A, Potdar V, Quaddus M, et al, 2023. Blockchain Adoption in Food Supply Chains: A Systematic Literature Review on Enablers, Benefits, and Barriers. IEEE Access. Doi: 10.1109/ACCESS.20 23.3236666.
9. Rana R, Tricase C, Cesare L, 2021. Blockchain technology for a sustainable agri-food supply chain. British Food Journal. Doi: 10.1108/BFJ-09-2020-08 32.
10. Rezaei L, Babazadeh R, 2022. An Overview of The Impact of Blockchain Technology on the Meat. Fruit and Vegetable Supply Chains. Doi: 10.22068/I jiepr.33.4.1.
11. Saha A, Raut R, Yadav V, et al, 2022. Blockchain Changing the Outlook of the Sustainable Food Supply Chain to Achieve Net Zero? sustainability. Doi: 10.3390/su142416916.
12. Sathya D, Nithyaroopa S, Jagadeesan D, et al, 2021. Block-chain Technology for Food supply chains. Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV). Tirunelveli, India. Pages-212-219. Doi: 10.1109/ICICV50876.2021.9388478.