

Block Chain Technology in Food Traceability: A new paradigm in Food Safety Practices

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ABSTRACT

Purpose: The aim of this paper is to understand the importance of Food Traceability in existing food supply chain, logistics and safety management. In the era of information technology, the gaps in current food and agriculture supply chain which possess serious threat to consumer safety can be filled through new emerging technologies like Block chain which will prove beneficial to entire stakeholders in the food chain from farm to fork.

Literature Review: In the preview of existing usage of block chain usage across the industry, primary research was done and existing implementation of block chain in food traceability were studied. Comparative analysis of food supply chains which are traditional in nature was done against the potential benefits of using the block chain in the same. Real time data implementation in the supply chain will increase the trust among the end users but also improve the accountability of various stakeholders present in the supply chain right from producer, processor, distributor, transporter and ultimately the end consumer. An inquisitive study was done as a part of the secondary research.

Research Findings: The nature of block chain and its implementation is very limited in the current business scenario of food and agriculture supply chain. There are examples available in the different industry segments where implementation of the block chain has significantly reduced the adulteration in the farm to fork supply chain with increased accountability of the stakeholders involved leading to an enhanced customer satisfaction. However lack of regulation from the monitoring agencies, high cost involved in the implementation aspect of block chain is leading to slow progress in the domain.

Implications: The study of this paper identifies the use cases of block chain technology in the area of food traceability and examines how the same are getting the entire end to end supply chain revolutionized both in terms of accountability of stakeholders involved and customer satisfaction. With the rise in consumer expectations in terms of quality of food product they consume and all the real time information they seek to determine the safety of the product makes this imperative for large multinational companies, regulatory agencies to address the issue and scale the technology like block chain which can reduce the problem of adulteration and enhance overall value in the supply chain.

Ingenuity/Value: The support has been taken from the existing literature about application of block chain technology in the various domains, primarily its applicability in the traceability. It gathers insights on how organizations are gaining advantage in the area of customer satisfaction and safety using block chain.

Keywords

Block Chain Technology, Food traceability, Food Supply Chain, Farm to fork, Food Safety, Internet of Things, Consumer Awareness

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Introduction

The entire food chain right from pre harvest to post harvest processing contains several points which are key to determine the safety of final material of consumption. The stakeholders who are responsible for managing the chain often find themselves in situation where they are unable to track the handling of material from its source to consumption. This leads to customer mistrust and impact the value generation in the entire supply chain.

Also, it lead to the problems faced by the inspection and health authorities. Track of information and authenticating its nature is critical to identify the contamination and ultimately lead to sustainability management in the existing food chains (Galvez et al., 2018; Zhao et al., 2017; Sun et al., 2017).

Present day traceability systems can track and record information in all stages involving production, transportation, storage, distribution and consumption like Radio Frequency Identification (RFID), Wireless Sensor Network (WSN), and Near Field Technology (NFC).

Mentioned systems of tracking are dependent over centralized client server process in which the end to end

process of data storage, transmission and sharing is concentrated to the stakeholders in the chain except the consumer and hence end user is relied on single point data source. (Khan and Salah, 2018; Mohanta et al, 2018 ;). Hence the consumer is not aware about the entire transactions in the food chain. The need of the hour is that the consumer should be aware of the entire chain in which pre harvest and post-harvest stop points are present. An effective information management system of the farm to fork cycle is necessary and urgently required for improving the food traceability.

Block chain as a technology is still in the nascent stage and gaining momentum across different industries with respect to its application. The transparency solutions that block chain offers to its user is unmatched and has widespread theoretical applications. As the technology evolves it has the potential to disrupt the traditional value chain of the food and its entire ecosystem from farm to fork.

Food Business models have always focussed on giving value-added services and products to its end consumer. As the customer is getting more educated with the onset of technology, a sharp change in consumer behaviour is observed across the industry segments which is leading to a

new collaboration and partnerships between producer, processor, distributor and retailer. This phenomenon will not only improve the quality of food products but also reduce system-wide wastage of food across the supply chain.

There are very limited resources and studies available on how block chain technology is to be used to improve the traceability across food chain ensuring the safety aspect as well as full transparency in the information management. Implementation of block chain is still very costly and hence the viability of the technology to be implemented in the industry which operates through thin margins across the globe is also a point to look into. The current status in the policy of governments across the globe as well the stakeholders in the process is also a very imperative question.

Hence this study aims to answer the following significant questions:

1. How the block chain based IOT solutions increase the value in food chain?
2. What is the benefit that will be pass on to the entire chain of stakeholders predominantly consumer?

Therefore this research summarizes the potential use of block chain as a viable technology in the area of food traceability, highlights the challenges which are present in the system as well as cover some of the use cases which reap a tremendous amount of benefit to the end consumer and also increases the trust among the stakeholders of the chain.

The paper consists of section 2 which deals which the research methodology/approach part, section 3 is the literature review in which the existing research across the globe on the same and relevant topics has been studied and used in building a solid case with respect to implementation of block chain, section 4 deals with design and system requirement, section 5 address the successes in the adoption of these methods by citing some use cases which is followed by section 6 benefits and challenges and ultimately future scope and conclusion has been discussed in section 7 of the research paper.

Research Methodology

First proceedings of the research paper were started by developing a thorough understanding of block chain as a technology and use of this as a platform technology for redefining trust and security among the users. A detailed literature review is conducted using existing resources both in terms of published research as well as online resources like videos as well. At the same time understanding of food and agriculture supply chain is very imperative for the scope of research. Contemporary as well as traditional farm to fork supply chains were studied keeping in mind about exposure of different industries, products and stakeholders. Understanding of problems which are faced by traditional agri supply chains like:

- a) Trust deficit between stakeholders
- b) Involvement of different parties
- c) Generation of real time data and its collection
- d) Customer expectations
- e) Model supply chains used by large food companies and multinationals

Once the link is established that block chain is an implementable tool which can address all the above mentioned problems simultaneously, we tried to identify the existing use cases across the food industry and good safety practices which are responsible for enhanced customer experience, a deep dive into the technicalities involving the characteristics of block chain, its benefits and challenges are looked into using existing published resources as well as reports of agencies of international repute.

Other factor which is being looked into is the issue of traceability, research tried to identify existing literature available to answer below mentioned questions:

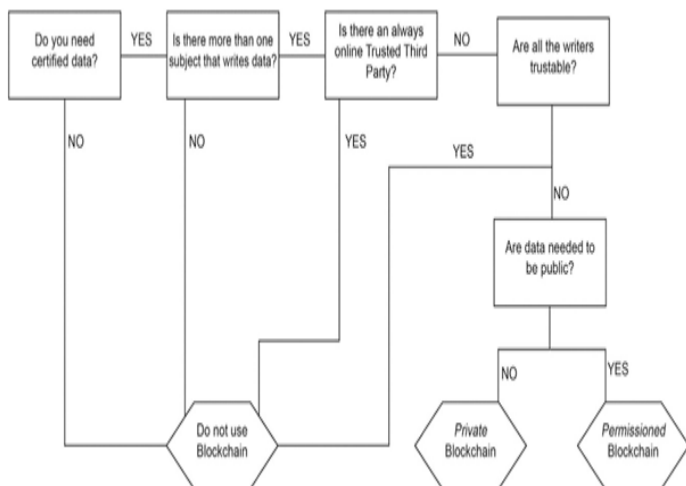
1. How to record the transactions across the supply chains? Propagation of data effectively between the entire stakeholders to hold the necessary accountability.
2. How to authenticate the validity of a transaction in the supply chain along with maintain the confidentiality and the safety of data?
3. How to link the traditional supply chain and its data collection mechanism to a new technology like that of block chain and to preserve historical data as well?

Existing academic resources along with use cases which are showing positive results are being treated as the fundamental of this research and the findings and suggestions are based on the mentioned lines.

Literature Review

With the rise in consumer awareness regarding the Food Safety and with diminishing trust in the quality of the products, it is important to develop a transparent system to monitor the product throughout the supply chain. The present solutions to achieve the same are primarily Internet of Things (IoT) based devices that are locally installed at different levels of supply chain and they record relevant data. Though these systems are efficient in recording the information in real time but there exist no infrastructure to share this data in real time with all the stakeholders. Also, this lack of transparency and centralized approach of data collection raise the concerns of data tempering and hence reduces the trust on the system.

Decentralization, safety, immutability, and transparency are the primary requirements of the system. Block chain technology seems to be a promising approach to solve this problem. Developing a block chain infrastructure in parallel to the IoT based existing structure can help in storing and distributing the data in live time. Also, the decentralized nature and inability to alter the data without having a public consensus makes the system more secure and trustworthy. The figure below gives a fair idea about the usability of block chain in the agri-food traceability area.



There have been a number of developments in the area. All the major block chain providers have developed proof of concepts for the use of block chain technology in this area. Amazon Web Services, Oracle and Ethereum are to name a few.

Ethereum built up a BC detectability project for coffee (<https://www.rwaltz.com/blockchain-coffee-supply-chain/>), demonstrating the versatility of this Block chain technology to the food production network. Beef Ledger (<https://beefledger.io/>) is a second illustration of traceability project dependent on Ethereum that is focused on the Australian beef in Chinese market. This is a legitimate Block chain framework as base innovation with its own token, for transaction. This token is followed through Ethereum and it is utilized as the vehicle of instalment and trade inside the Beef Ledger Block chain. Every exchange can be followed, hence guaranteeing end to end monitoring and traceability.

Also, Amazon Web Administrations (<https://aws.amazon.com/it/partners/blockchain/>) is presently utilizing Farmobile (<https://www.farmobile.com/>) to act as an illustration of utilization of Block chain technology to cultivating and agribusiness, to make a block chain including ranchers, agronomists, vendors, retailers, etc. Strangely, Farmobile might be applied not only to the food supply chain, but also additionally to cultivating the incredible probability of BCTs for the agri business. A comparative venture is AgriLedger (<http://www.agriledger.io/>), a framework custom fitted to ensure computerized personality, advanced detectability, and unchanging records and data by mean of DLT.

With comparable purposes, Oracle utilized its block chain stage for the Alpha Acid Brewery (<https://www.alphaacidbrewing.com/beer-finder/>), to improve the detectability of a little high quality brew maker situated in California that chose to guarantee its store network (Qadoumi, 2019). This BC application guaranteed

the high calibre of the items and permitted clients to gather more data about their particular brew perusing an enormous QR code with their cell phone (Bozicevic, 2019). Oracle likewise has the venture Certified origins (<https://www.certifiedorigins.com/>), a Block chain-based open record zeroed in on Additional Virgin Olive Oil to improve straightforwardness about the source of the olive oil imparting to clients a few data (Biagianti, 2019).

In order to understand the suitability of block chain network in the traceability, the following characteristics of block chain technology are needed to be incorporated:

Decentralized Network:

A block chain network is made of a number of information points called as nodes. There is no centralized storage of information and hence there the system is unaffected by the malfunction at any particular point in the system. Also, the data as a whole is accessible to all the nodes and hence can be verified at any given instant of time by any actor in the system, removing the need of trust on one particular actor.

Smart Contracts

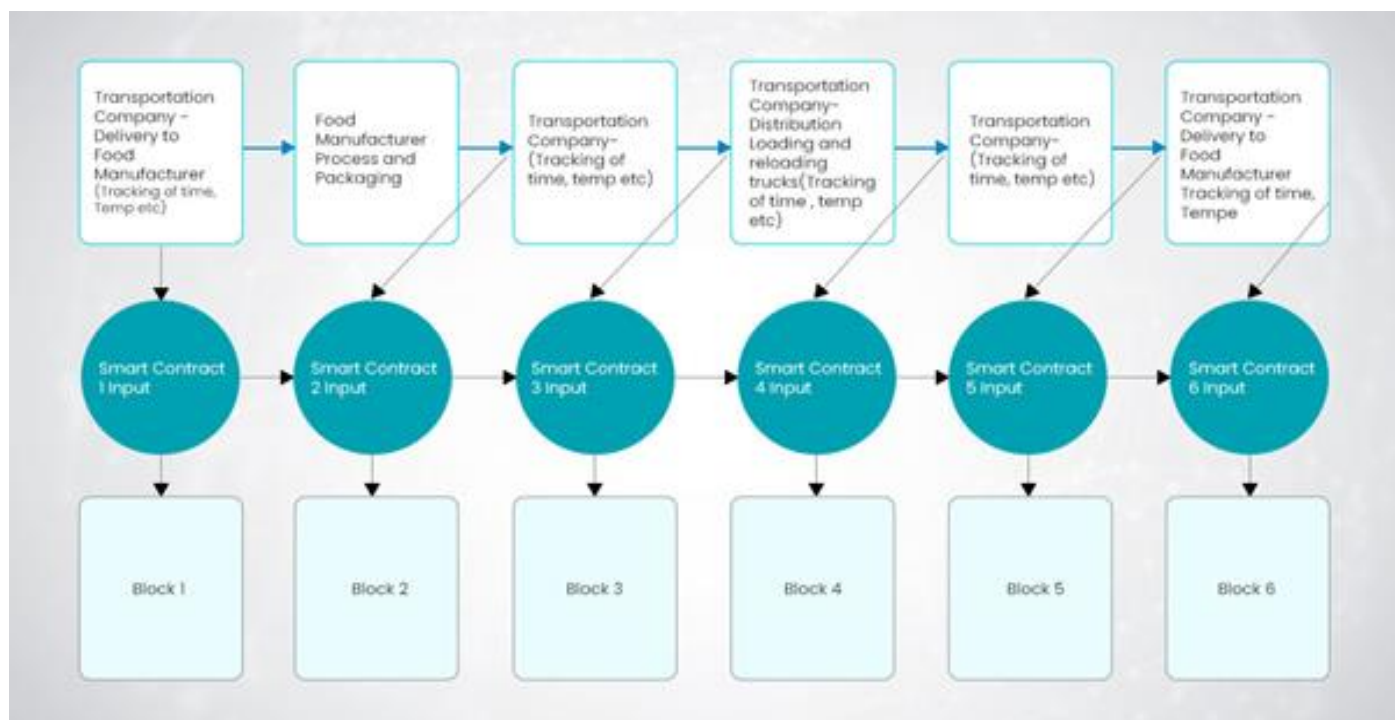
Transactions in a block chain are recorded using smart contracts. It makes sure that the participants in the system can record the transactions based upon the contract rules defined in the system. A smart contract can help in reducing the transaction costs, and hence helps in increasing margins and boosting productivity. The following figure aims to explain the Smart contract solution:

Consensus Mechanism

This helps in avoiding any sort of data tempering by involving all the participants of the network before altering any data. Also, all the rules regarding the block chain contract are visible at all the nodes and all the transactional records are accessible to all the nodes keeping each participant node as anonymous.

Immutable Data

Data records are not allowed to be altered or deleted by any one actor. Hence the data is temper proof, making the system trust worthy. This is the biggest advantage in the food supply chain as it minimizes the risk of adulteration as well as altering of data at the different stages involved in the transaction from producer to end user. It also increases the accountability of the stakeholders involved in the system which result in answerability to the monitoring agencies leading to a high level of customer satisfaction.



Design and System Requirements

This section in particular deals with the design aspect of the block chain based food traceability system. Here one of the fundamental classification has been done with respect to the system requirements. They are categorized into two main categories:

Data Gathering requirements

Traditional points of collecting the data in the food supply chain works in an unsupervised environment and there is no properly defined set of rules which act a method of checks and balances in the system. The given environment is completely trust less, unreliable and not sustainable. The situation in the unorganized food chain is far worse, only the multi nationals and some government regulated bodies which deal in this segment take enough measures to record the data of collection, storage, transportation and other steps which are part of the value chain.

Block chain on the other hand works on the system in which data gathering is an integral part and in continuous manner. It focuses on the fundamental of distributed data sharing and hence the system is accountable and trustworthy, at the same time reduces the risk of tempering the data significantly within the food supply chain. All the participants are aware of and agree to the transaction points. Since the data collection points are pre-defined in the system it enforces the checks and balances in the system which act as a deterrent to disrupt the quality of food from the farm to fork.

Transaction Authenticators

The agri-food supply chains are continuously growing and require more resources for transactions in terms of man and machine power. Due to heavy reliance of block chain technology over real time data the primary concern is to

gather the data and authentication of this data as per the traceability requirements of the product keeping in mind its entire processes during the supply chain and end customer expectation.

Following factors are the determining pivots in developing the transaction authentication system for a block chain based supply chain of food products.

1. Internet of Things based data acquisition – Like Transport mode, temperature sensors, and sensory parameters of food at different sites.
2. Security of the data collected as there is informational risk involved in the same for the stakeholders
3. Transparency in maintaining the information security, sharing of data between third parties and monitoring agencies.
4. Scalability of the system and standardization across the geographies to maintain the cost controls

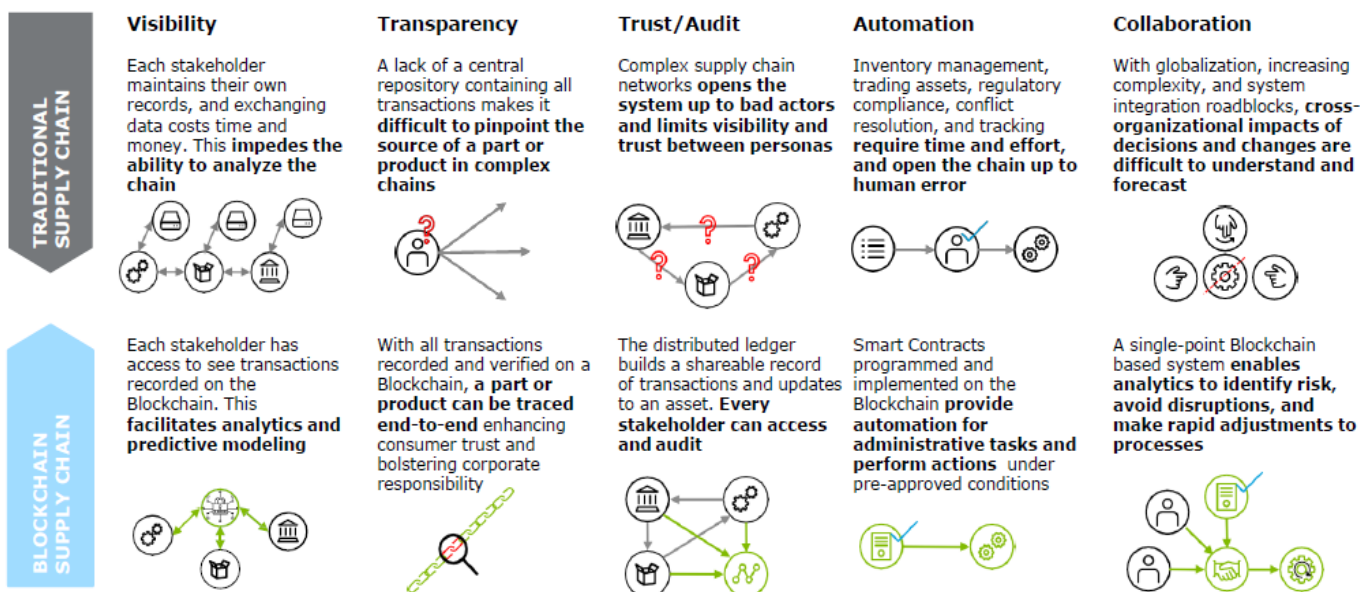
Existing Food Supply Chain VS A block chain enabled Supply Chain

Major Challenges that are observed in the existing supply chain are as follows:

a) Information sharing: Lack of direct link between the trading partners (other than immediate/direct trading partners), making final integration of collected data difficult and resulting in data loss at various levels. Also, the possibility of data tempering diminishes the trust.

b) Reputational Risk: Degraded quality products causes defamation of not only the concerned brand but also the whole industry. Also, due to lack of proper traceability system, it becomes difficult to rectify the issue and provide proper documentation to the end consumer.

c) Lack of transparency: A lack of transparency exists among various levels in food chain. Each level tries to optimize the internal data use and not to the benefit of entire supply chain.



Block chain as a solution

A block chain equipped supply chain provides following advantageous parameters:

- a) **Visibility:** Instead of having a localised information store at each level, block chain provides each stakeholder an access to see transactions record. This helps in efficient analysis of the data.
- b) **Transparency and Traceability:** As all the transactions recorded in a block chain (in forms of blocks of information) are verified and follow a given data schema, a product can be easily traced end to end.

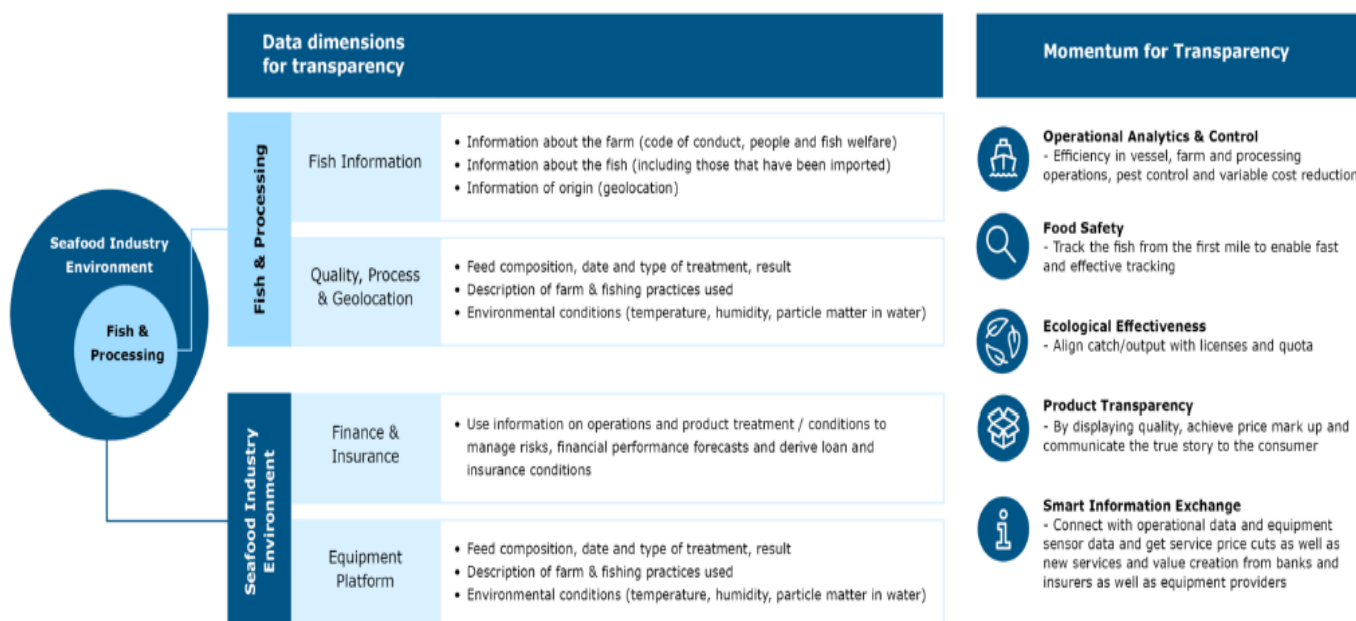
c) **Trust/Audit:** As the transaction records are accessible to stakeholders, data changing requires the permission form the stakeholders, hence avoiding any possible data tempering at any level of supply chain.

d) **Automation:** With the help of Smart Contracts and Contract rules, human error can be avoided while performing various administrative tasks like inventory management, regulatory compliance, conflict resolution etc.

e) **Collaboration:** A single global block chain helps in making rapid adjustments in processes with the change in policy at the organizational level.

Solution spaces for seafood trade transparency

Four "data angles" will cater the issue areas and at the same time provide incentives for stakeholders to disclose their data



Benefits and Challenges

As discussed via examples and existing literature review, we can say that Block chain seems like a promising technology to counter the transparency and traceability issue that the agri-food supply chain is facing. We would like to list down the major points of benefits associated with the use of block chain technology in the sector. After that we would also like to shed some light on the major challenges that technology brings into the picture.

Benefits

Data Integrity

As explained, due to the presence of Consensus Mechanism in block chain, the information stored is much more reliable and stored securely. The data is protected from possible tampering and hence increases the trust in the system.

Efficient Cross-Organisational collaboration:

For efficient cross-organizational collaboration, the availability of standardized non-tampered data is important. Having a block chain traceability system provides this functionality to the supply chain. This helps in efficient analysis and prediction.

Sustainable Production and Management:

Having a secure and transparent traceability system provides all the stakeholder a complete picture of all the levels of block chain. This helps in keeping a check on each step of the production. Companies can also use the records as legal proof for traceability management. This in total helps in developing a sustainable supply chain altogether.

It is also imperative to note down the major challenges that the adoption of block chain technology will bring in and are needed to be addressed as this technology will get advanced and implementable in coming future.

a. Technology Scalability: Block chain as a system to achieve traceability for a global supply chain requires highly scalable infrastructure, while preserving the significance of consensus mechanisms. Also, the security of IoT platforms is a concern that is needed to be kept in mind.

b. Standardization: There exists some fundamental limitations for block chain food traceability systems. For block chain to be effective, there must be participation from all stakeholders involved. Additionally, data integrity lies in the hands of the data collectors and needs a system of validation to avoid tampering. Having a unified system with definitive standards and regulations is the major barrier to adoption

Legalities: As the block chain technology is still in its formative years, countries lacks clear regulations on the implementation of same. There is possibility of legal conflict arising due to absence of standard procedures and laws on Data privacy associated with block chain systems.

Conclusion and Future Scope of study

It is clear that block chain as a technology is by far most secure platform for transactional services. Since the entire industrial output is getting influenced by decisions which are primarily driven by data on a real time basis, implementation of block chain enabled IoT systems across food supply chain is still in nascent stage and a major factor behind the same is the costs involved in the implementation and also the benefits and the challenges faced by the entire chain of stakeholders in the line right from producer to the ultimate consumer.

This research provides an overall view of the ongoing good practices around the world regarding implementation of block chain in food traceability practices, providing a base for future research which can be deep dived into industry specific approach or can provide a holistic view of block chain in food and agri supply chains around the world.

However as review based study, this also has certain limitations. Primarily much of the concepts are existing the theory and their practical implications can be felt only when they are implemented in the food supply chains. Specific emphasis should be given to regulatory frameworks which are yet to be decided and designed by governments and agencies/institutions around the world.

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