Application of Blockchain and Internet of Things (IoT) in the Food and Beverage Industry

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Abstract

The blockchain with IoT technology aids organizations in achieving authenticity across peer-to-peer nodes, including keeping evidence of work, cutting out mediators, traceability, and so on. Increased input expenses and supply chain mechanisms that prevent direct connections between producers and consumers of the food and beverage industry have an impact on data gathering, safety, and exchange. Because of the lack of centralized IoT infrastructure, restrictions on data protection, tampering, and single-point breakdown are not met. The study suggests an IoT paradigm built on blockchain to overcome these problems. Additionally, this work demonstrates novel energy savings. This paper suggests a smart model framework for multiple IoT systems that observe crop growth and the agricultural surroundings and offer an open, decentralized blockchain monitoring system. At many stages of the supply chain management (SCM) procedures, it can be used in blockchain. All activities in decentralized supply systems were managed by smart agreements. Every 500 m2 cluster farm received a sum of 100 IoT units randomly. Nodes from the IoTs were utilized to measure data on food and beverage production. The suggested frameworks' duration of network stability and network lifespan show 90.4% accuracy. This study also collects secondary data from executives in the food and beverage sectors throughout India with an understanding of blockchain with IoT and SCM processes. The supply chain operations such as purchasing, pre-processing, transportation, warehouse, retail, management of inventory, distribution, and marketing operations were taken into consideration when analyzing. The blockchain and IoT offered the biggest benefits, namely cost savings, traceability, time savings, immutability, validation, and work proof, relying on the analysis of data.

Keywords: Blockchain, IoT, Food and Beverage Industry, Supply Chain.

Introduction

India is the biggest producer of food ingredients and processor of agricultural products worldwide. Among the other nations, its economy is expanding the quickest. Food and beverage products pass through 3 distinct phases before reaching end users, such as beginning with farmers in the sort of fresh product, being provided by manufacturers to shops, and then reaching users [1]. All parties involved have agreed to information governance, and their data sources are smoothly linked. Most developed nations have a system of food chains like this. Food and beverage are delivered from the producer to the end user, and the consumer, and controlling the supply chain involving many stakeholders is nothing more than food SCM-supply chain management [2]. Not just do individuals desire to eat, yet they also prefer to consume healthy foods. The Global Food Project reports that 2 billion individuals experience vitamin and nutrient deficiencies and that malnourishment is the primary reason for death for 45 percent of kids under the age of 5 [3].

To increase the number and value of food and beverage items, numerous businesses and individuals are operating. The majority of industry communications now take place in a digital format due to the Internet. This makes it easier for the sector to cut back on operating expenses, operating times, and operational efficiency, among other things. Industry-wide technological change could have a favorable effect [4]. Additionally, there are adverse effects. The potential to cover data within an organization, absence of working evidence, and vulnerability when employing digital data and transactions are the finest representation of the undesirable effects caused by Internet technology and associated software in the current environment. Various phases of the materials transfer procedure, such as purchasing, management of inventory, pre-processing, warehouse, stake, selection, and division of activities depending on the sector, include several mediators [5]. A simple chain, on the other hand, treats the commodity as a solitary unit that can be operated manually and handled more simply without significant assistance from technology or middlemen. Nevertheless, managing numerous commodities, particularly for large-scale operators, is thought to be a challenging process. It is essential to maintain a solid supply & continual management to achieve sustainable growth [6].

Distributing data processing capability among an extremely large number of individuals which makes data manipulation difficult or even unattainable, is an effective strategy to stop this prejudice. A blockchain involves a system where users may enter information about how a good or service is employed, bought, and consumed. The ledger is typically managed by all relevant parties jointly over a peer-to-peer connection [7].

The agricultural industry is being revolutionized by the introduction of various astonishing technologies due to precise agriculture, which is a major area of study in the twenty-first century. The rise of information & communications technologies (ICT) methods is exerting a big influence on food production; presently, farmers may use a smartphone to remotely check the circumstances of their fields and operate their machinery [8]. The usage of ICT has a big influence on the food and beverage industry; blockchain is one of the technologies that is well-known for its accountability in the food and beverage supply chain.

Because of Bitcoin, blockchain was originally developed. Bitcoin is the most recent advancement in financial computation, enabling users to trade money online quickly, reliably, and at a minimal cost [9]. In numerous cases, including those involving logistics and cost saving, blockchain has now proven to be the best option. Connecting equipment and sensors is made easier by the Internet of Things (IoT), and the application of blockchain in association with IoT is promising to be a money and time-saving technique that also produces a lot of information. IoT and smart production are used by a relatively modest number of enterprises in the food and beverage sector [10]. Industry 4.0 is made possible by blockchain, which serves to safeguard sensor data since the data there is cryptographically protected. As a result, blockchain is a safe and reliable technology. There are 2 keys for each user: private and public. The sender encrypts a signal using the public key before sending it, and anyone with access to the recipient's public key can decode the signal and view it [11].

Among the most helpful applications of blockchain is the capability to monitor a commodity along the whole supply chain. The distributed ledger on the blockchain, which is virtually hard to alter, makes it the ideal instrument for keeping complete track of property transfers across supply chains. The benefits of blockchain technology have drawn researchers to explore how it may be applied in the supply chain. This technology can improve the supply chain, oversee and oversee risk reduction measures, and even help avoid security problems [12].

Blockchain is nevertheless viewed as a cryptocurrency in the thoughts of the majority of industry professionals, even though blockchain technologies may be used as a distribution system of information like a digital ledger. For improved outcomes concerning authenticity, reliability, validity, cost savings, favoring transactions, maintaining digital ledgers, etc., SCM should take into account the characteristics of blockchain technology. All of the organizations now operating in the nation will switch to blockchain technology by 2030 [13]. This study discusses the viability of blockchain and IoT technology for food and beverage organizations in India depending on the data gathered from executives. India is the globe's widest food production processor and supplier of food ingredients and therefore must embrace this safest innovation as soon as feasible to be a rapid and efficient runner in the contest of globalization.

Literature Review

Application of IoT and Blockchain in the Food and Beverage Industry

As per [14], the food products supply chain method involves countless and geographically distributed key players, such as numerous and unconnected farmers, large numbers of farmers of a particular commodity, and vendors of that commodity. The provenance platform of food and beverage products is crucial to ensuring food safety. It is challenging to establish a centralized tracking platform for data due to the incompatibility of technology or information formats among the companies engaged in the food and beverage products supply chain, each of which possesses its particular information-collecting techniques.

Smart blockchain technology and IoT-based framework for farming were developed by [15]. This technology allows all parties involved to enter data via smartphones, and it also automatically gathers information from IoT equipment without the involvement of a third party. They employed the virtualized trustworthy transaction blockchain technology networks Cloud System as the foundation of their design to guarantee the efficacy of this concept. This framework states that two different kinds of operations are carried out: the first is company asset preparation, which comprises statistics on commerce, transportation, distribution, and warehouse management; the latter encompasses data from IoTs equipment, like statistics of the agricultural land. Since this paradigm is built on blockchain technology, all information is communicated via nodes after being hashed and signed with an electronic signature. Such technologies can address end-users concerns about food and beverage safety. Using blockchain technology and IoT together can help create a reliable, autonomous, open, and environmentally friendly smart agriculture platform. 3 key areas in which IoT and blockchain technology can alter the food and beverage sector are as follows:

- Transactions
- Proveniences
- Management

The key requirements of blockchain technology with IoT in the food and beverage business are summarized in Figure 1. It covers the key components of the various parts.

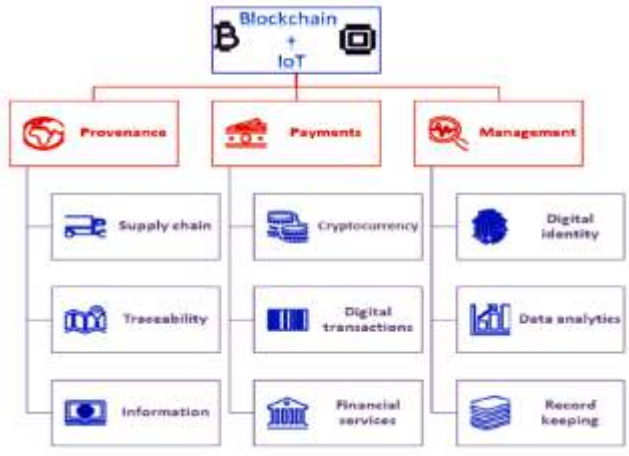

Figure 1: Application of blockchain technology with IoT in the food and beverage industry

Food safety and user confidence are largely dependent on provenance and radical openness. Producers can use blockchain technology to conduct mobile transactions and incentives, and transaction costs will be reduced. The food and beverage industries stand to gain much from the real-time control of supply chain activities and funding. With the help of blockchain, a closer connection between provider and retailer may be created to guarantee that farmers are compensated properly for their goods and that merchants are receiving commodities they paid for [16]. The end consumers of blockchain-oriented agriculture may have access to a plethora of data. For instance, if a user purchases a box of cereal from a store close to their home, they can follow the trail of that food from the warehousing to the fields in which it was raised or perhaps farther, to the store where the seeds were bought. All they need to do is use their mobile phone to scan the QR code, which will display all transactional data connected to it, such as the package date entered the sector, the plantation from which the food products were generated, the duration and day it was generated, the farm owner and staff member ID who gathered the crops, data about the gathering gadget, packaging data, etc. Without human involvement, blockchain technology could evaluate all of this data.

Utilizing a blockchain technology basis, ICT agriculture systems are localized, immutable recordkeeping systems. A system concept for an ICT e-food system incorporating a blockchain architecture was suggested by [17], and it uses BCT to hold the data from water quality surveillance. This technique can assist in keeping track of how much water is necessary to get a good yield. The researcher also suggested an assessment instrument, which was implemented as an ICT e-food system model and employed the GCOIN blockchain technology to track the accuracy of statistics on irrigation water acquired by distant sensing at different farming sites.

As per [18], a food and beverage supply chain system rely on a double-chain structure and the idea of the open blockchain. This idea holds that blockchain technology could be either open or confidential depending on who has the authority to capture the information. In contrast to private blockchains, which have high transactional and agreement speeds, open blockchains cannot guarantee consumers' data privacy and have slow transaction speeds. An open blockchain was created by researchers for food and beverage enterprises. The initial wide examination of blockchain applications for food supply data safety was done by [19]. They included concepts from various scientific disciplines, like IT, administration, systems, and experimental investigation methodologies, in their article. The goal of substituting the paper monitoring method with blockchain technology, as per their research, can be accomplished and might have a lasting, unchangeable log of each transaction. The PEST assessment analytical framework, which examines political aspects, economic factors, sociological issues, and technical elements, was applied. In light of this approach, the administration must foster an atmosphere that will allow food supply data networks to develop, and regulating agencies should take care of those systems. The administration is ultimately responsible for ensuring the integrity of the food.

Relying on hazard assessment, [20] presented a food and beverage supply chain traceability platform that combined blockchain technology with the IoT. This system collects information using various IoT technologies, including GPS, RFID, and wireless sensors. BigchainDB is employed to hold and handle data due to its fast speed, reduced lag, and robust query function. The restoration of users' faith in the food and beverage sector may be aided by this strategy.

Research Objective

- To investigate the application of IoT and blockchain technology in food and beverage technology.
- To propose a smart model that makes use of blockchain and IoT to provide accountability throughout the food and beverage supply chain.
- To empirically analyze the blockchain and IoT adaption in the food and beverage industry of India.

Research Layout

Therefore, the subsequent of this research article is structured as below. The review of the literature is examined in section 2, and the research methodology is analysed in section 3. The outcomes are illustrated in

Section 4 and analysed. The research article's conclusion is depicted in the last section 5.

Methodology

To satisfy the needs of all players, we created a smart future framework that makes use of blockchain and IoT to provide accountability throughout the food and beverage supply chain. Hence, a distributed, effective, and safe network is required for product surveillance and the suppression of food theft. Using transaction records and smart agreements, end-to-end security of data is offered.

The empirical study was also carried out with the use of secondary data from food and beverage company executives. The data was gathered from several food and beverage firms throughout India. The data was acquired from executives who are familiar with Blockchain and IoT technology and its implementation in the food and beverage supply chain. The acquired data were analyzed and evaluated using descriptive data, the ranking testing of the Hendry Garrett, and the mean score in MS Excel & SPSS. The demographic data of the participant is provided in the table beneath.

The Proposed Framework

The smart model framework for numerous IoT sensors that track food and beverage growth is depicted in Figure 2 is defined in this part. A GPRS gateway is utilized for wireless instrumentation, as well as the RFG gateway joins 2 data channels to provide distant monitoring and control of clustered farm machinery. Data is maintained at the logical data level of the SQL database system. The database of SQL is used to retrieve unprocessed data as a result of a SQL search.

Figure 2: Blockchain with IoT smart model

As each network needs resources, saving energy is the study's main objective. Cluster-head, nodes, and sinks are examples of these. IoT units send data to CH, which then distributes it to sinks for the ground station relay. A single-board chip of TS7260 was used to construct an RFG server. The system changes between phases, the UPS powers the SBC in a sleep state, and the majority of the clustered farm gadgets use RS232 serial. To conserve battery life when the device is dormant, wireless networks are turned off. Data is pulled or pushed into the SQL server, which enables the server to respond fast to fresh data. The data is found by SQL, and missing data packages can be recovered and sent again by the data manager. Every novel data source necessitates a small amount of database and internet display level changes. Endpoints and observations are connected by codes.

To guarantee that users obtain nutritious food, unique blockchain features will integrate farms and the supply chains of food activities into a unified smart framework. The system's mining units exchanged information using blockchain smart agreements in this study. Mining nodes keep a record of every corporate transaction and add it to the shared ledger. Smart agreements obtain all payments through the blockchain in the type of feature calls and produce functions. They also give the parties to the transaction access to transfer control tracking and the ability to obtain notifications in the occurrence of a breach. The optimal circumstances are maintained and misuse in the food supply chain is addressed due to smart agreements. A novel LEACH-oriented clustering approach for IoT-oriented applications for the food and beverage industry was created as a consequence of this work.

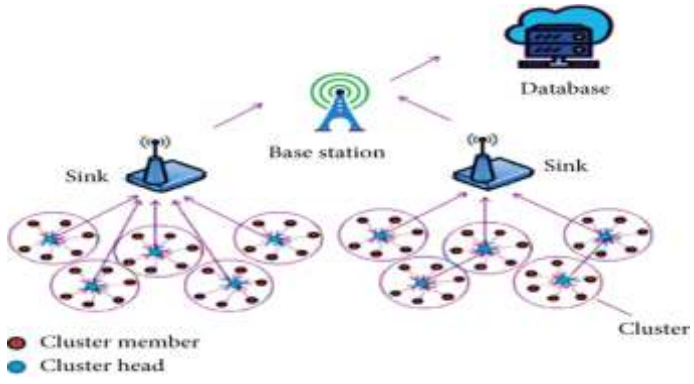

Figure 3: IoT-oriented cluster protocol for the food and beverage sector

Blockchain and IoT Sector Profile

Table 1: Blockchain and IoT Sector Profile

Demographic data		Participants %
Type of sectors	Bakery	4
	Beverage	4
	Beer Industry	4
	Cold Storage	4
	Collateral Management	4
	Dairy	8
	Food technology	4
	F&B	8
	Food Ingredients	4
	FMCG	16
	Meat	8
	Paperboards and packaging	16
	Retail	4
	Others	8
Blockchain and IoT Backup Management	No	8
	Yes	52
	Maybe	40
Blockchain and IoT Business Management	No	16
	Yes	40
	customizable to suit needs	44
Business Reporting	North India	4
	South India	8
	a specific state in India	8
	In whole India	56
Size of the sector	Large	40
	Small	12
	medium	48
Blockchain and IoT novel technology	No	32
	Yes	32
	Don't know	36

To determine the level to which blockchain and IoT were adapted for their food and beverage operation, the ranking assessment of Hendry Garett was used. It has been determined six elements, depending on the research analysis, that impact the firm to embrace blockchain and IoT technology in the food and beverage sector: reliability, distribution consistency, financial savings, traceability, evidence of task, time savings, and immutability. The mean result for the adaption of BCT and the Garret ranking level are both discussed in depth in the table.

Results and Discussion

The MATLAB model is tested for the food and beverage sector with the existing LEACH method to gauge the

effectiveness of the suggested IoT. In the simulations of 5000 iterations, IoT units were placed at randomization in each simulated method. Every operational IoT unit in the field of 500×500 m^2 sends data to its corresponding cluster head, while cluster heads send signals to the base unit through sink nodes. Following are the findings of the simulations.

The network stability duration is the duration before the first node dies. Figure 4 shows the suggested IoT as well as the network stability duration of LEACH for the food and beverage sector. The stability duration of LEACH is less than that of the suggested method. The suggested method only transfers information when there is a discrepancy between previously acquired data and present data, which is the cause for the enhancement. The findings reveal that the suggested method's initial site lasts 463 times instead of 168 times for LEACH, demonstrating a 23% increase in network stability for the IoT-based agri-food method.

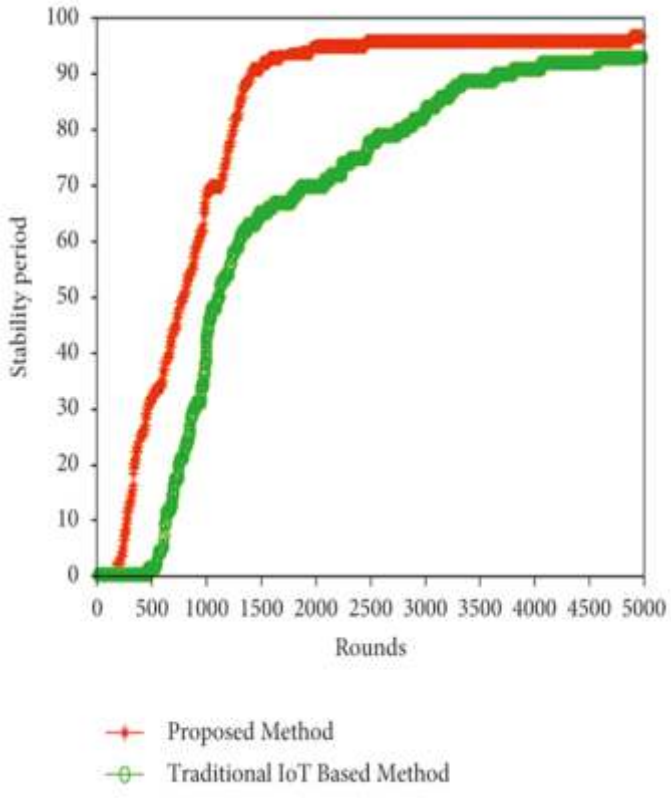

Figure 4: Duration of network stability and conventional IoT-based food method

The duration requires for the initial node to exhaust its energy determines how long the network will last. Figure 5 shows how effectively IoT-oriented and LEACH's network life operate together in the food and beverage sector. The IoT-oriented protocol chooses CHs depending on the leftover power of the terminals and the ideal clusters, leading to a 112 % improvement in network life, as opposed to LEACH, which chooses CHs depending on the assumption that CHs release an identical amount of power each round.

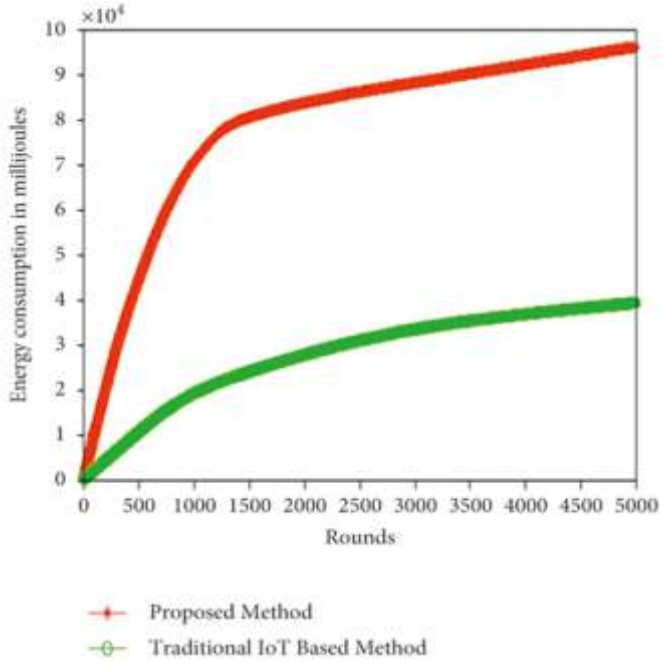

Figure 5: Suggested method's network lifetime, and conventional IoT-based food method

Analysis of Blockchain and IoT Adaption in the Food and Beverage Industry

Table 2: Results of Hendy Garret's ranking for adopting blockchain and IoT technology

Blockchain and IoT adaption	Score of garrets	Average	Rank
Reduction of costs	1259	50.3	7
Immutability	1287	51.4	6
Trustworthiness	1337	53.4	5
Saving of time	1345	53.8	4
Proof of content/task/payment	1356	54.2	3
Distribution integrity	1360	54.4	2
Traceability	1413	56.5	1

The traceability criterion was scored first in the analysis of Garret's rank with the value of 1413.

The function of blockchain and IoT technology in managing the food and beverage supply chain is described in figure 7. As depicted in Figure 7, outlines the 3 tiers of blockchain and IoT technology as the level of integrity, high barriers of communication, and linkage of backward-forward to its SCM actions corresponding to the storage of commodities, logistics, retail, management of inventories, actions of marketing, distribution, and procurement.

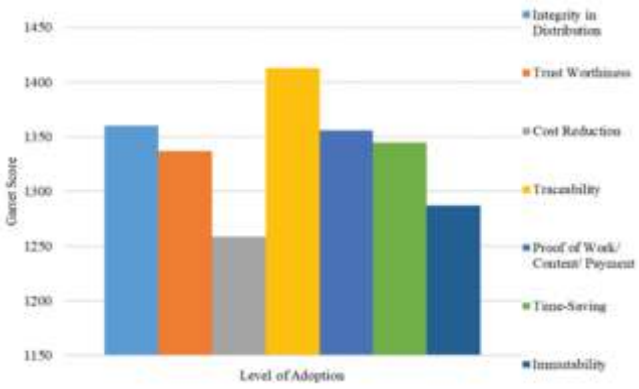

Figure 6: Blockchain and IoT adaption

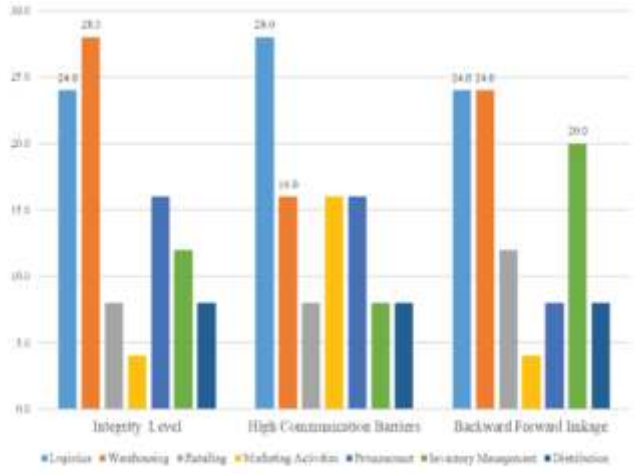

Figure 7: Blockchain with IoT in SCM

It was shown that 24 percentage logistics and 28 percentage warehousing exhibited a higher integrity level. Additionally, 28 percent of warehousing and 16 percent of logistics reported having a barrier in communication. According to the preceding figure 7, inventory control had 20%, while transportation and warehousing had 24% of the forward and backward links. Retail market, distribution, inventory control at all stages, communications, and forward and backward connection received about 8% of the votes. The marketing actions showed the lowest inclination of 4%, both in terms of the level of integrity and the forward and backward connectivity.

Conclusion

In India, blockchain and IoT technology are applied in a variety of industries, including the food and beverage industry, which has the greatest potential to enhance data distribution. While blockchain might help to build a flawless setting, it can be difficult to build confidence between users and buyers. There exists a shortage of direct communication between market consumers and manufacturers as a result of present IoT technologies. For the food and beverage supply chain, we merged IoT and blockchain. To increase the system's lifespan, we developed an energy-efficient routing strategy. Producers will receive training on fresh crop data as part of the upcoming concept of smart farming and the supply chain of food and beverages. The IoTs will be used to monitor soil temperatures, soil conditions, insect attacks, and agriculture yield. Effective crop tracking is made possible through crop monitoring. Decentralized information systems are secure, easier to use, and increasingly entertaining due to blockchain technologies. The supply chain of food and beverage would be highly effective and reliable using a smart approach. SCM is more open and effective due to blockchain technologies. We offer state-of-the-art blockchain technology to enhance conventional supply chains. Multi-agent networks control the entire supply chain since smart agreements do away with the requirement for middlemen. This automated technology can secure and improve any supply chain. Through the use of blockchain technology, food and beverage production is being protected. This method can follow the movement of freight, confirm the legitimacy of products, and keep transactions on file. The research also guarantees that both sides follow the rules of the smart agreement. A user is penalized if the agent determines they have broken the rules. Improve the model's reliability and effectiveness while keeping track of and validating transactions. To prove the theory, we developed an Ethereum smart agreement in

Solidity. A smart place to begin is by evaluating current supply chain problems and looking into ways blockchain and IoT technology could help to solve them. A well-investigated and posted study on the topic discusses the advantages of blockchain incorporation with supply systems. Evidence of validity agreement method and extraterrestrial system files are features of the Ethereum blockchain. Smart agreements might directly manage transactions, which enhances functionality. Explore studies, entity-relationship graphs, and the suggested smart agreement framework. The ledger technology immutability, which might be applied to a range of supply systems, may strengthen safety and confidence in the supply chain. Blockchain technology enables the monitoring, security, and decentralization of food and beverage data, enhancing transparency. A key perk for users and one of a blockchain's distinctive characteristics is the data immutability of its store. The details of each transaction that has taken place on the system are available to everybody who is a member.

Better corporate development is made possible by this technology change due to factors like traceability of activity proof, open communication, and lower intermediary expenses. Having the right blockchain and IoT model, high integrity must be preserved in the areas of procurement, logistics, and warehouses. Businesspersons claimed that for the management of inventory, logistics, and warehouse, blockchain with IoT technology would be the optimum option.

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Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Declaration of Conflicts of Interests

Authors declare that they have no conflict of interest.

Consent for Publication

All authors read and aware of publishing the manuscript in Pacific Business Review International

Data Availability Statement

The database generated and /or analysed during the current study are not publicly available due to privacy, but are available from the corresponding author on reasonable request.

Declarations

Author(s) declare that all works are original and this manuscript has not been published in any other journal.

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