A TRUSTED BLOCK CHAIN-BASED TRACEABILITY SYSTEM FOR FRUIT AND VEGETABLE AGRICULTURAL PRODUCTS

Ch. Ramya[1], B. Sushma[2], K. Kalyani[3], S. Shirisha[4], S. Sravanthi[5]

[1,2,3,4] Scholar, Department of CSE in Jayamukhi institute of technological sciences, Narsampet, Warangal, Telangana, India

[5]Assistant professor, Department of CSE in Jayamukhi institute of technological sciences, Narsampet, Warangal, Telangana, India

ABSTRACT

The traditional method of traceability suffers from the issues of centralized administration, opaque information, questionable data, and the simple creation of information islands. This study develops a traceability system based on blockchain technology for the storing and querying of product information throughout the supply chain of agricultural goods in order to overcome the difficulties that have been outlined above. By using the properties of blockchain technology, such as decentralization, tamper-proofing, and traceability, the level of transparency and reliability of traceability information was significantly improved.In order to alleviate the load strain that the chain is under and to achieve efficient information inquiry, a dual storage structure of "database + blockchain" on-chain and off-chain traceable information is being created. It has been suggested that using blockchain technology in conjunction with cryptography would make it possible to accomplish the secure exchange of confidential information inside the blockchain network. In addition, we develop a reputation-based smart contract as an incentive for network nodes to submit traceability data. This contract is a kind of smart contract. In addition, we offer a performance analysis as well as a practical application. The results demonstrate that our system enhances the efficiency of querying and the security of private information, ensures the authenticity and reliability of data in supply chain management, and satisfies the requirements of an actual application.

I INTRODUCTION

Fruit and vegetable agriculture products have strong production advantages in China, which is a vast agrarian nation with exceptional climatic conditions and numerous species supplies. These factors contribute to China's competitive edge in international agricultural markets. According to information provided by the National Bureau of Statistics of China [1,] the overall production of agricultural goods consisting of fruits and vegetables in 2019 was 995.03 million tonnes, which represented 54.48 percent of the total output of agricultural products (1826.55 million tons). People have a profound affection for agricultural items that come from the fruit and vegetable sector since these goods possess the qualities of being green, nutritious, and rich in nutritional content [2]. Nonetheless, the shorter storage duration and the low storage temperature of storage requirements for fruit and vegetable agricultural goods both contribute to an extraordinarily high likelihood of food safety events occurring [3].

In recent years, there has been an increase in the number of food safety events involving local and foreign agricultural goods including fruit and vegetables. Examples include the "poisonous ginger" event in China [4, the contamination of hami melons by listeria in the United States [5, and the epidemic of E. coli in Germany [6], all of which have significantly damaged the health of the vast majority of people. As a consequence of this, the state places a significant emphasis on the food supply chain's capacity to be tracked, and nations work to improve the management of food supply chain tracking by passing laws and regulations in this area. In accordance with the General Food Law that was enacted by the European Union in 2002 [7], the food industry is required to implement a comprehensive traceability system in order to meet the requirements of the law in terms of recalling products in a timely and accurate manner and communicating information to customers. According to China's Food Safety Law [8,] which went into effect in 2009, food producers and operators are required to set up a food safety traceability system in order to guarantee food traceability. "Traceable" has developed into a significant obstacle for all food and food-related businesses, and the system of traceability has developed into an efficient method of quality control in the supply chain for agricultural products [9–11].

There are many different aspects that go into ensuring the traceability of fruit and vegetable farm goods. It is possible to classify the entities involved in the supply chain as either internal or external, depending on the nature of their business connection [12, 13]. The enterprises that fall under the category of "internal entities" include production enterprises, processing enterprises, cold chain logistics enterprises, sales enterprises, and so on. The enterprises that fall under the category of "external entities" include consumers and regulatory agencies, among other things [14]. The entire supply chain has the characteristics of many production points and sales points, long production chains, and wide production areas, which makes supervision and tracing of food safety particularly difficult in practise [15]. Additionally, long production chains and wide production areas make it difficult to track back to the source of the food. Data in conventional traceability systems are often centralised in practical implementations, and authoritative authorities are responsible for managing the core database of the traceability system [16], [17]. Because enterprises are responsible for managing the traceability data of each node in the supply chain, it is simple to manipulate such data. For this reason, there is a need to improve the dependability of information transfer among the many roles that comprise the agricultural supply chain.

A blockchain is a kind of distributed database that cannot be altered in any way, can be traced back to its original owner, and is managed by a number of different entities [18]. It does this by using a cryptographic technique to create a chain structure that is made up of data chunks that are ordered chronologically. In order to implement information sharing and information supervision among various parties, every party must first get the approval of all other parties in advance in accordance with the norms that have been agreed upon [19]. In addition, blockchain is capable of incorporating a wide range of technologies, including peer-to-peer (P2P) networks, cryptographic technologies, smart contracts, consensus processes, timestamps, and the structure of blockchains, amongst others [20], [21].

As a result, it is able to conduct data management and self-verification without having to depend on the services of a third party. The adoption of blockchain technology for the purpose of tracking agricultural goods may provide solutions to the issues that plague the conventional traceability system that is now in place. Public chains, consortium chains, and private chains are the three primary classifications that may be used to blockchains [22].

The term "consortium chains" refers to the distributed ledger that several organisations work together to administer and participate in. When it comes to privacy, Consortium chains fall somewhere in the middle of Public chains and Private chains. The data on these chains can only be accessed by members of the consortium that created them. In addition, the transaction efficiency of Consortium chains is much greater than that of Public chains.

The primary responsibility bodies of the supply chain of agricultural goods are connected to the cooperative connection that exists between the various players in the supply chain when using a system that enables product tracing.

However, one cannot put their whole faith in these organisations of duty.

In point of fact, the primary responsible entities that make up the supply chain are initially connected to one another via either a vertical transaction link or a horizontal interaction relationship. As a result, for the purposes of this article, the Consortium chain will serve as the fundamental network.

The primary objective of this research study is to provide an explanation of how blockchain technology might be used to improve the tracability of agricultural goods. We have built and implemented a traceability system for agricultural items such as fruits and vegetables that is based on a blockchain that can be trusted. This system makes use of blockchain technology's characteristics such as distributed storage, hash encryption, and programmable smart contracts. In the following, we will provide an in-depth description of the system's design process as well as a clarification of its most important breakthrough technologies. Some of these technologies include the on-chain and an off collection structure as well as the combination of cryptography and privacy data protection. In order to demonstrate that the agricultural product traceability system can be implemented in a realistic manner, we will construct the cryptocurrency environment on the basis of Hyperledger Fabric for the aim of performance testing and pragmatic deployment of the system.

The following are some of the most important contributions made by this paper: • We expanded on the most important flaws in the existing system for tracing agricultural products and provided alternatives.

• We provide answers to the problems of high load, sluggish query speed, and privacy data protection that are present on the current blockchain technology, and we use blockchain technology to the traceability of agricultural goods. A significant portion of the study will focus on the in-depth planning and design of the on-chain and off-chain storage structures, as well as the security of personal information.

• We create a blockchain environment based on Hyperledger Fabric, and we utilise the C# programming language to construct and implement a traceability system. This allows us to actualize the process of storing and accessing information pertaining to agricultural product tracing. In addition, by means of the system real application case assessment as well as the system function test.

II RELATED WORK

Tracking is the difficulty in accessing any and all data relevant to that which is being considered, throughout its full life cycle, by means of documented identifications. This capacity is referred to as "recorded identifications." [22]. Traceability for agricultural products ensures that, in the event that quality issues arise, the natural resources or preparation links that are causing the issues can be checked in a timely and efficient manner; in addition, product recalls are carried out only when necessary, and targeted penalties are implemented in order to improve the overall quality and safety of agricultural products.

Traceability has emerged as a significant obstacle for all food and food-related businesses, and the implementation of traceability systems has developed into an efficient tool for quality control in the agricultural supply chain. Over the last several years, a large number of academics have conducted exploratory study in the topic of tracing the origin of agricultural goods. In order to design and implement a Wheat Flour Milling Traceability System (WFMTS), Qian et al. [24] combined the technologies of 2D barcodes and RFID tags. They did this by adhering a QR code label to the wheat package in order to link to information regarding the wheat's processing, and they adhered an RFID label to the storage box in order to record information regarding the wheat's logistics. In the flour mill, the central database is utilised to handle the information from raw materials to completed products. This allows the flour mill to accomplish whole-process monitoring from the source, all the way through circulation, and finally to sales. However, the information in the conventional traceability system is handled by the businesses that make up each link. As a result, the transparency of the information is minimal, and it is simple to manipulate the information.

The developing technology known as blockchain, which has the properties of being decentralised, tamper-proof, and traceable, offers the opportunity of finding solutions to the issues that are present in the conventional agricultural product traceability system that is now in use.

The use of distributed ledger technology in the tracing of agricultural goods is starting to get the attention of an increasing number of academics. The use of merging blockchain technology with Internet of Things technology was shown by Bumblauskas et al. [25], who tracked items in real time as they moved from the farm to the dinner table using a combination of Internet of Things technology and blockchain technology. Using the supply chain for eggs produced by a firm based in the Midwest of the United States as an example, this article will discuss in detail how blockchain technology was integrated into the supply chain system from the farm to the customer. Feng [26] constructed a real-time traceable food supply chain traceability system based on HACCP, Blockchain, and IoT technologies. He also proposed a novel idea called BigchainDB to overcome the issue of blockchain scalability. Both of these accomplishments were credited to Feng. For the purpose of tea quality and safety management, Liao and Xu [27] developed a blockchain-based traceability system that is based on intelligent agriculture and wireless sensor networks. They combined this system with food risk assessment and safety traceability technology that is based on hazard factors in order to effectively control product quality and safety. beginning at the level of the blockchain's multi-chain structure. Using the account blockchain (ABC) and the transaction blockchain (TBC) dual-chain architecture, Zhao et al. [13] designed a big data version of a fresh food traceability platform. They analysed user needs from the perspective of information ecology and proposed a risk compensation plan that tracesparticipating entities. A dual blockchain and IPFS system were used in the anti-counterfeiting traceability system (TSPPB) that was built by Liu and colleagues [28]. The TCDBB technology is used to handle the issue of product label copying and spam. The TSPPB employed two sets of blockchains, including public chain and private chain. To the point of enhanced architecture and mechanism. Through an analysis of the technical architecture level, Li et al. [29] proposed the application of blockchain technology to the database layer and communication layer of the blockchain food safety traceability system. They then demonstrated the design of the program's effectiveness using the case of ham sausage. Dwivedi et al. [30] created a pharmaceutical supply chain management system (PSCM) by mixing blockchain technology with conventional medication supply chains. They also suggested a technique that would use smart contract technology to distribute all encryption keys to all users in the system. Many researchers employed both on-chain and off-chain data storage while designing the storage architecture for blockchains in order to limit the amount of stress placed on on-chain storage. Lin et al. [31] developed and implemented a food safety traceability system that was based on blockchain and EPC Information Service (EPCIS). Additionally, they proposed an on-chain and off-chain data storage structure in order to solve the pressure problem that was associated with blockchain data storage. A method of conducting business transactions was proposed by Khaled et al. [32] in which the Ethereum blockchain and a smart contract were used to track and trace soybeans all the way through the agricultural supply chain process. This method was combined with the InterPlanetary File System (IPFS) for storing traceable data in order to cut down on the amount of data that needed to be stored on the chain. Based on blockchain technology, Dong et al. [33] built a reliable traceability prototype system for the whole food supply chain. They also suggested a data storage style of "on-chain + cloud database." As a result, the running costs and overall effectiveness of the blockchain system are ensured. Even while a significant number of researchers have developed a blockchain-based traceability system, the vast majority of those researchers have not taken into account the challenges of effective information storage and the protection of private data.

III PROPOSED SYSTEM

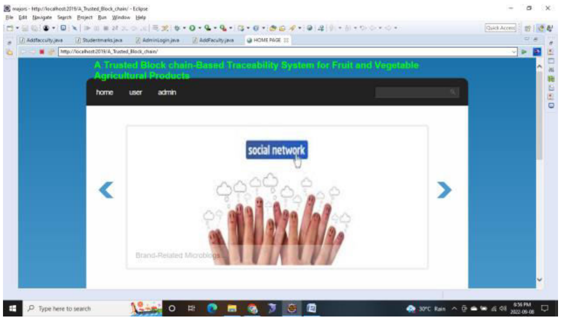
How often does the data included in the whole supply chain contain information on the product's traceability, but it also includes confidential data, the likes of which can only be seen by relevant firms, such as transaction information. Data privacy is a critical concern for businesses that are in direct competition with one another. This study designs a data flow for the preservation of traceable information and privacy that encrypts private information using smart contracts and then uploads it to a blockchain along with the hash value of public information. As can be seen in Figure 3, the Cipher Block Chaining (CBC) mode of the Advanced Encryption Standard (AES) encryption algorithm is used to encrypt sensitive information such as transaction data. The essential Key1 is chosen at random by the smart contract, which then proceeds to produce encrypted ciphertext and upload it to the blockchain. The Elliptic Curves Cryptography (ECC) was utilised to encrypt the Key1 in this study so that the Key1 would be protected from unauthorised access. The decrypted Public Key was required to provide permission to the viewing node. The combination of the Encrypted Key1 and the Public Key of the authorised viewing node makes up a key-value pair that is kept in the global state of the smart contract and is also recorded to the blockchain. When the relevant enterprise nodes view the private data stored on the blockchain, the current node's private key is used to decrypt the encrypted version of Key1 stored on the blockchain in order to obtain the original version of Key1. The original version of Key1 is then used to decrypt the private information in order to view it. In its most basic form, smart contracts are time-driven and stately computer programmes that are implemented on shared distributed databases [35]. When certain trigger circumstances are satisfied, it is able to be automatically performed, and the behaviour of individual nodes may be sent and validated in an informationized fashion. In Hyperledger Fabric, smart contracts are referred to as Chaincode. This significantly minimises the amount of human involvement required, which in turn assures the decentralisation of blockchain technology as well as the immutability of data. Members of the Alliance chain that are also members of the Consortium negotiate to take part in bookkeeping and create incentive schemes depending on the requirements of the company. The agricultural goods traceability system based on blockchain that was built in this study maintains traceability data of fruit and vegetable products at every stage of their life cycle, including production, processing, transportation, and sales. The purpose of this study is to develop a reputation-based smart contract with the intention of encouraging members of the alliance to input traceability data. Following the successful uploading of traceability data by the node that satisfies the criteria, the contract logic that increases the reputation value of the node will be activated. The user-friendly interface of the smart contract is detailed in Table 2. Figure 4 depicts the flow chart of the blockchain-based traceability system for agricultural goods, including fruits and vegetables. The information on the traceability may either be manually input or acquired by a device connected to the Internet of Things. Users contribute to the system by entering traceability information on manufacturing, processing, logistics, and sales. Following the system-based categorization, the information about the traceability is then separated into private information and public information. After going through the CBC encryption process, the secret information is then posted to the blockchain, while the public information is kept in the local database. The hashing of the public information is performed using the SHA256 technique. The acquired hash value is then saved in the blockchain system, and the block number is the value that is returned. The public information record that corresponds to the database is given the most recent version of the block number. In the event that the information on agricultural goods has to be altered, the hash value of the publicly available information will need to be rebuilt into the blockchain in order to bring the block number up to date. By scanning the QR code, customers can access the database and obtain public information as well as the block number. They can then hash the public information that they have obtained and check whether or not it is consistent with the hash value that is stored on the blockchain through the block number. This will allow customers to determine whether or not the product traceability information has been tampered with. This study has continued the complete test of the system's performance by varying the transmit rate in order to examine the system's throughput as well as the network's latency. The Hyperledger Caliper open-source blockchain performance assessment tool is employed. This tool enables users to run performance tests on the blockchain network by using preset use cases and get a set of performance test results. Among the performance metrics that are now supported are things like transaction success rate, transaction throughput, transaction delay, resource usage, and so on.

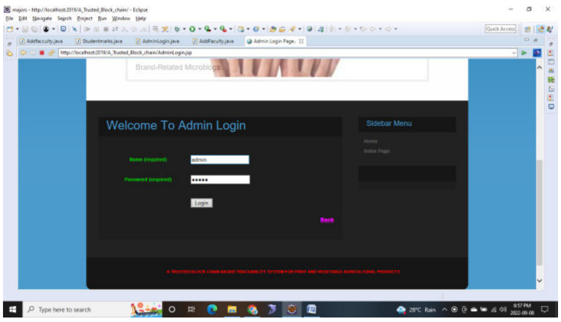
The performance of the system is primarily represented in two aspects: transaction delay and transaction throughput under varying transmit rates. [Case in point] The term "transaction latency" refers to the amount of time it takes for a single user to get a response to a request that they have sent. This time frame also includes "query latency" and "write latency." The terms query throughput and write throughput are both included in the definition of transaction throughput, which describes the amount of data that is successfully sent in one second. In this study, both the transaction latency and the transaction throughput of the system were measured. Figure 7 depicts the results of the read request tests that were conducted. Figure 7(a) demonstrates that a linear relationship exists between the transmit rate of the read request and the read throughput in situations in which the send rate of the read request is lower than 250 tps. [Citation needed]

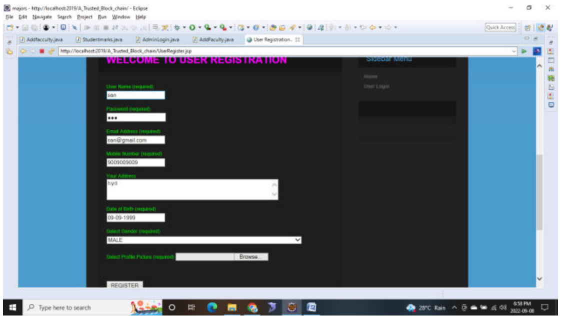
When the transmit rate goes over 250 tps, the read throughput of the system hits its maximum capacity and becomes saturated. The read latency of the system is measured by gradually raising the transmit rate from 0 tps to 400 tps over the course of 60 seconds, with each increase representing an increase of 50 tps. The results of the transaction latency test performed on the read request are shown in Figure 7. (b). According to the findings, there is not much of an impact that the transmit rate has on the read latency of the system, and the average reaction time of the system remains unchanged at 0.02 seconds. Figure 8 illustrates the results of the tests conducted on the input request. Figure 8(a) reveals that the transmit rate of the input request is directly connected to the input throughput when the send rate of the input request is less than 125 tps. This is the case when the throughput of the input request is being measured.

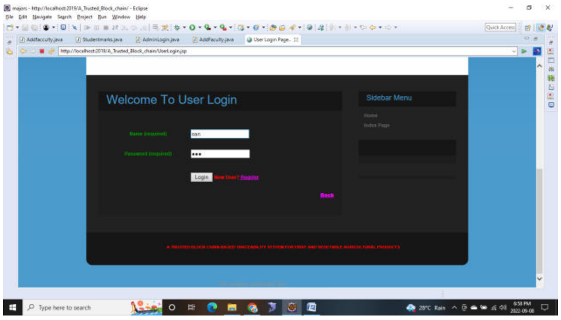
When the transmit rate is more than 125 tps, the system's input throughput hits its maximum capacity, which is known as saturation. The input latency of the system is measured by gradually raising the transmitting rate from 0 tps to 200 tps over the course of 60 seconds, with each increase representing an increase of 50 tps. Figure 8(b) demonstrates that there is no clear correlation between the send rate and the input latency of the system. Additionally, the system has always been maintained at a low input latency of approximately 0.12 seconds, which has resulted in an average response time of approximately 0.12 seconds. In conclusion, the fruit and vegetable agricultural goods traceability system based on blockchain technology that is suggested in this study is a system with low-latency and high-throughput that fulfils real production requirements.

IV RESULTS









V CONCLUSION

In this work, we created and built a system for the traceability of agricultural items such as fruits and vegetables, basing it on the non-tampering and traceable qualities of blockchain. Additionally, we examined the architecture of the system's storing and query capabilities. An on-chain and off-chain data storage method that uses "database + blockchain" has been proposed as a solution to the issues of high data load pressure and poor private security posed by the growing data in the blockchain traceability system. These issues are caused by the exponential growth of the data.

The information that is exposed publicly to customers is saved in the supply chain to the local database; the hash value of this information, computed using the SHA256 technique, was then uploaded to the blockchain system.

The CBC encryption technique is used to encrypt private information, and then that information is saved on the blockchain so that it may be shared with appropriate businesses. The method of storage that is proposed in this paper combines the actual situation, taking into account the need for encryption of corporate private information as well as the need for public supervision of supply chain public information, and reducing the pressure of data load that is placed on the supply chain. Realization of the relationship between the blockchain and the database is made possible by the saving of the block number of the publicly available information on the database. By scanning the QR code, the consumer is able to receive public information from the database. The system then checks the information using the associated block number that is kept in the database to verify whether or not the product information has been altered. With the advancement of blockchain technology, the multi-chain architecture is the direction in which future development should go in order to satisfy genuine business requirements. In the course of our future study, we want to investigate the technology that enables cross-chain communication across numerous chains as well as a novel kind of consensus mechanism that is suited to traceability.

REFERENCES

[1] NBSC National Bureau of Statistics of China. (2019). National Data. [Online]. Available: https://data.stats.gov.cn/

[2] G. Francois, V. Fabrice, and M. Didier, ‘‘Traceability of fruits and vegetables,’’ Phytochemistry, vol. 173, May 2020, Art. no. 112291, doi: 10.1016/j.phytochem.2020.112291.

[3] J. Hu, X. Zhang, L. M. Moga, and M. Neculita, ‘‘Modeling and implementation of the vegetable supply chain traceability system,’’ Food Control, vol. 30, no. 1, pp. 341–353, Mar. 2013, doi: 10.1016/j. foodcont.2012.06.037.

[4] W. Li, S. M. Pires, Z. Liu, X. Ma, J. Liang, Y. Jiang, J. Chen, J. Liang, S. Wang, L. Wang, Y. Wang, C. Meng, X. Huo, Z. Lan, S. Lai, C. Liu, H. Han, J. Liu, P. Fu, and Y. Guo, ‘‘Surveillance of foodborne disease outbreaks in China, 2003–2017,’’ Food Control, vol. 118, Dec. 2020, Art. no. 107359, doi: 10.1016/j.foodcont.2020. 107359.

[5] A. N. Desai, A. Anyoha, L. C. Madoff, and B. Lassmann, ‘‘Changing epidemiology of listeria monocytogenes outbreaks, sporadic cases, and recalls globally: A review of ProMED reports from 1996 to 2018,’’ Int. J. Infectious Diseases, vol. 84, pp. 48–53, Jul. 2019, doi: 10.1016/j.ijid.2019.04.021.

[6] P. Luber, ‘‘The case of the European escherichia coli outbreak from sprouts,’’ in Global Safety of Fresh Produce. Amsterdam, The Netherlands: Elsevier, 2014, pp. 356–366.

[7] Regulation 178/2002 of the European Parliament and of the Council of 28 January 2002 Laying Down the General Principles and Requirements of Food Law, Establishing the European Food Safety Authority and Laying Down Procedures in Matters of Food Safety, Eur. Commission, Brussels, Belgium, 2002.

[8] Food Safety Law of the People’s Republic of China, Order No. 21 of the President of the People’s Republic of China C.F.R., Standing Committee NPC, Beijing, China, 2009.

[9] M. M. Aung and Y. S. Chang, ‘‘Traceability in a food supply chain: Safety and quality perspectives,’’ Food Control, vol. 39, pp. 172–184, May 2014, doi: 10.1016/j.foodcont.2013.11.007.

[10] X. Yang, J. Qian, C. Sun, and Z. Ji, ‘‘Key technologies for establishment agricultural products and food quality safety traceability systems,’’ Trans. Chin. Soc. Agricult. Machinery, vol. 45, no. 11, pp. 212–222, 2014, doi: 10.6041./j.issn.1000-1298.2014.11.033.

[11] Y. Zhang, W. Wang, L. Yan, B. Glamuzina, and X. Zhang, ‘‘Development and evaluation of an intelligent traceability system for waterless live fish transportation,’’ Food Control, vol. 95, pp. 283–297, Jan. 2019, doi: 10.1016/j.foodcont.2018.08.018.

[12] F. Casino, V. Kanakaris, T. K. Dasaklis, S. Moschuris, and N. P. Rachaniotis, ''Modeling food supply chain traceability based on blockchain technology,'' IFAC-PapersOnLine, vol. 52, no. 13, pp. 2728–2733, 2019, doi: 10.1016/j.ifacol.2019.11.620.

[13] L. Zhao, X. Bi, and A. Zhao, ''Frame reconstruction of mobile traceability information system for fresh foods based on blockchain,'' Food Sci., vol. 41, no. 3, pp. 314–321, 2020, doi: 10.7506/spkx1002-6630-20181119- 217.

[14] K. Demestichas, N. Peppes, T. Alexakis, and E. Adamopoulou, ''Blockchain in agriculture traceability systems: A review,'' Appl. Sci., vol. 10, no. 12, p. 4113, Jun. 2020, doi: 10.3390/ app10124113.

[15] X. Yang, M. Wang, D. Xu, N. Luo, and C. Sun, ''Data storage and query method of agricultural products traceability information based on blockchain,'' Trans. Chin. Soc. Agricult. Eng., vol. 35, no. 22, pp. 323–330, 2019, doi: 10.11975/j.issn.1002-6819.2019.22.038.

[16] H. Yu, B. Chen, D. Xu, X. Yang, and C. Sun, ''Modeling of rice supply chain traceability information protection based on block chain,'' Trans. Chin. Soc. Agricult. Machinery, vol. 51, no. 8, pp. 328–335, 2020, doi: 10.6041./j.issn.1000-1298.2020.08.036.

[17] P. Zhu, J. Hu, Y. Zhang, and X. Li, ''A blockchain based solution for medication anti-counterfeiting and traceability,'' IEEE Access, vol. 8, pp. 184256–184272, 2020, doi: 10.1109/ACCESS.2020.3029196.

[18] Y. Lu, ''Blockchain and the related issues: A review of current research topics,'' J. Manage. Anal., vol. 5, no. 4, pp. 231–255, Oct. 2018, doi: 10.1080/23270012.2018.1516523.

[19] K. Christidis and M. Devetsikiotis, ''Blockchains and smart contracts for the Internet of Things,'' IEEE Access, vol. 4, pp. 2292–2303, 2016, doi: 10.1109/ACCESS.2016.2566339.

[20] Y. Lu, ''The blockchain: State-of-the-art and research challenges,'' J. Ind. Inf. Integr., vol. 15, pp. 80–90, Sep. 2019, doi: 10.1016/j.jii.2019. 04.002.

[21] Z. Zheng, S. Xie, H. Dai, X. Chen, and H. Wang, ''An overview of blockchain technology: Architecture, consensus, and future trends,'' in Proc. IEEE Int. Congr. Big Data (BigData Congress), Jun. 2017, pp. 557–564.

[22] X. Li, F. Lv, F. Xiang, Z. Sun, and Z. Sun, ''Research on key technologies of logistics information traceability model based on consortium chain,'' IEEE Access, vol. 8, pp. 69754–69762, 2020, doi: 10.1109/ACCESS.2020.2986220. [23] P. Olsen and M. Borit, ''How to define traceability,'' Trends Food Sci. Technol., vol. 29, no. 2, pp. 142–150, Feb. 2013, doi: 10.1016/j.tifs.2012.10.003.

[24] J.-P. Qian, X.-T. Yang, X.-M. Wu, L. Zhao, B.-L. Fan, and B. Xing, ''A traceability system incorporating 2D barcode and RFID technology for wheat flour mills,'' Comput. Electron. Agricult., vol. 89, pp. 76–85, Nov. 2012, doi: 10.1016/j.compag.2012.08.004.

[25] D. Bumblauskas, A. Mann, B. Dugan, and J. Rittmer, ''A blockchain use case in food distribution: Do you know where your food has been?'' Int. J. Inf. Manage., vol. 52, Jun. 2020, Art. no. 102008, doi: 10.1016/j.ijinfomgt.2019.09.004.

[26] T. Feng, ''A supply chain traceability system for food safety based on HACCP, blockchain & Internet of Things,'' in Proc. Int. Conf. Service Syst. Service Manage., Dalian, China, 2017, pp. 1–6.