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A Reliable Traceability Model for Grain and Oil Quality Safety Based on Blockchain and Industrial Internet

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Abstract: Gain and oil are important compounds in global food supplies, and ensuring the quality and safety of grains and oil is a critical issue in the food supply chain security. Data traceability is the key factor in quality and safety management. Currently, it is a big challenge to ensure the reliability of data and guarantee the efficient exchange of data in various highly heterogeneous systems. To address this challenge, we develop a reliable traceability model applied to the grain and oil industry. In this paper, we first analyze the characteristics of the whole chain traceability information flow, and then we propose the concept that the connector for blockchain and industrial internet is suitable for data traceability in the grain and oil industry. Based on this concept, a reliable traceability model of grain and oil quality and safety is constructed. Finally, a reliable traceability prototype system for wheat quality and safety was designed, and the system implementation of the model was validated. The overall advantage of the proposed model is that the traceability information is safe and credible, the interaction is concise and efficient, and the security and full-process traceability of cross-chain information interaction are guaranteed. This paper fills the gap in the application of research chain network in the field of grain and oil traceability. Reference to this model can also be used to implement and adjust the traceability system, which is adaptable to stakeholders in the grain and oil industry. The model and techniques in this paper not only demonstrate value in real-world applications but also inspire further research in the field.

Keywords: grain and oil supply chain; blockchain technology; information traceability; trusted identity; food safety

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1. Introduction

Grain and oil are essential sources of nutrition for human beings, and they feed most people in the world. Ensuring the safety of grain, oil, and food supply is of great significance to human life and health and the harmonious development of society [1–3]. The quality and safety of grain and oil have always been one of the most concerned topics for human beings, one of the most important challenges currently faced by grain, oil, and food manufacturing companies is the quick collection and reliable traceability of data generated in each link of the supply chain [4,5]. There are many safety problems in each link of the grain, oil, and food supply chain, such as heavy metal and pesticide residues, mycotoxin pollution, and an unreasonable application of additives [6,7]. As a result, multiple standards and restrictions corresponding to each grain and oil product need to be considered in the process of tracing. Because each grain and oil food product has a different production process, it is urgent to establish a grain and oil quality and safety traceability model that is convenient

for data interaction and can ensure data accuracy interconnection, and integrity of data traceability [8,9].

In terms of food supply chain traceability, current research studies mainly focus on solving the traceability problem in food trading; the role of physical technology, chemical technology, and biotechnology in food traceability was studied, including RFID technology, Internet tag traceability technology, isotope traceability technology, mineral element traceability technology. Some characteristics are discussed, including traceability, traceability in food manufacturing, advantages of chain traceability, and advantages and future trends of internal traceability in the production process, but the traceability process features of the complex supply chain of grain, oil, and food are still not yet solved [10–13]. Nowadays, the application of blockchain technology in the field of traceability of grain and oil quality and safety is increasing. Preliminary research includes the storage structure of the blockchain-based agricultural product traceability system and the index storage and query methods of traceability information; it solves the problem of excessive blockchain data load, ensures the data privacy and security, and improves the reliability and timeliness of traceability information. The fault party of food safety incidents can be quickly identified through the interconnection of all links of food circulation, but the methods are difficult to solve the problem of rapid storage and query of complex data in the grain, oil, and food supply chain from the blockchain [14–17]. Some researchers have applied industrial internet technology to the food industry and related fields and obtained preliminary results. The actual industry requirements in different supply chain scenarios are identified, the application scenarios of the industrial internet are also analyzed, and potential applications are discussed. This research enlightens the future of the application of industrial internet technology in the supply chain and the implementation of industrial internet technology. The progress of these research studies is connecting devices and systems, bringing together disparate data called digital threads, and improving operational visibility, productivity, quality, and sustainability in the food industry. There are still many unsolved challenges, including the performance and practical application scenarios of the industrial internet [18–20].

The above research [10–17] can effectively solve some problems faced by the current grain and oil quality and safety traceability. By applying blockchain technology, a decentralized, data tamper-proof, safe and reliable grain and oil quality safety traceability system is constructed. It can effectively improve the traceability and security of the grain and oil supply chain and improve the transparency of the grain and oil supply chain [21,22]. However, the use of blockchain technology alone for tracing data interaction and storage in each link of the supply chain cannot solve the problems of existing blockchain data storage pressure and low query efficiency. The substantial increase in grain and oil enterprises has led to huge growth in the data stored on the blockchain in all aspects of the supply chain, which has brought great pressure to the traceability system [23,24]. Industrial internet technology has been applied in various industries; excellent performance has been achieved in data collection and sharing [25,26]. However, some scholars have begun to explore technologies based on blockchain and the industrial internet, which provide safe and reliable data sharing and data traceability services for enterprises within an industry and across multiple industries [27,28]. However, with the increase in users, the number of identification codes has also exploded. There is no effective method to solve how to ensure the accuracy of the identification codes. The previous research [18–20] is still in the application-oriented mode; the specific key technology research has not been fully discovered, and the specific and effective way to solve the chain-network integration is still underlying.

The contributions of this paper can be summarized as five key aspects: (i) This study studies a lot of related research on blockchain technology and industrial internet technology for grain and oil quality and safety traceability applications and analyzes the role of blockchain technology and industrial internet technology in the whole chain of traceability. (ii) This study discusses in detail the advantages and disadvantages of each link in the whole chain in the traceability process of grain and oil quality and safety, as

well as the opportunities and challenges in the traceability process. (iii) The study also introduces the application of blockchain technology and industrial internet technology in the fields related to grain and oil quality and safety traceability, such as quality supervision, quality traceability, traceability data processing, and the construction of the whole chain. (iv) The research also specifically considers the problems and deficiencies in the application of blockchain technology and industrial internet technology to the traceability of grain and oil quality and safety, and discusses issues that need to be addressed in depth in the next step. (v) Finally, the research focuses on the integration of blockchain technology and industrial internet technology in the traceability of grain and oil quality and safety, proposed the concept of the connector for blockchain and industrial internet. Based on the concept, a grain and oil quality safety traceability model that combines blockchain identification and resolution of the industrial internet is proposed. Based on the model, a wheat quality and safety traceability system is proposed. The contribution of this research is not limited to the creation of a traceability model for the grain and oil industry but may also provide new thoughts for the traceability process in other industries in the future.

The rest of this study is organized as follows. Section 2 is a literature review, Section 3 proposes the research on the circulation characteristics of the whole chain of grain and oil quality and safety, Section 4 introduces the traceability model and prototype system design, Section 5 is model and system analysis, and Section 6 is the conclusion and discussion of this paper.

2. Related Work

Agricultural information modernization is a new generation of information technology combining artificial intelligence, mobile communication, the Internet of Things, blockchain, etc. Through continuous intersection and integration of information technology with traditional agriculture, it can promote the healthy development of the grain and oil industry and ensure the quality and safety of grain [29,30]. The blockchain was first proposed by Satoshi Nakamoto. It is formed by linking blocks to each other according to certain rules; each block consists of a block header and a block body. Blockchain technology includes distributed data storage, consensus mechanism, point-to-point transmission and encryption algorithms, etc. The blockchain can be considered a decentralized public ledger and a distributed storage database. A consensus algorithm, hash encryption, and other techniques of blockchain lead to its specific characteristics, such as decentralized, information transparent, tamper-proof, traceable, etc. These characteristics made it possible to clearly record the traceable data in the whole process of grain and oil on the chain, and it can improve the integrity and accuracy of such traceable data [31–34]. The industrial internet is the cornerstone of the fourth industrial revolution and arises wide interest. It involves the rise of a large number of key technologies, such as big data, cloud computing, artificial intelligence, etc. Among them, the identification and resolution system of the industrial internet is to give each entity or virtual object a unique identity code by means of a barcode, two-dimensional code, radio frequency identification tag, etc., while carrying relevant data information. Novel infrastructures enable localization, connection, and dialogue of physical and virtual objects [35,36]. By accessing the identification and resolution of the industrial internet, enterprises can link through all elements from the human, machine, materials, method, and link. It can also connect upstream and downstream enterprises and small and medium-sized enterprises can also connect to form a platform. It provides a digital base for the creation and promotion of business scenarios based on interconnected data. Our literature review uses the Web of Science database to search the keywords such as "Blockchain", "Blockchain + Traceability", "Blockchain + Food", and "Blockchain + Supply chain". The results are listed in Table 1a. Industrial Internet technology was proposed in 2012, but most research about it began in 2018. We also found the articles using the keywords "Industrial internet", "Industrial internet + Blockchain" and "Industrial internet + Food" and "Industrial internet + Supply chain" from the Web of Science database. The results are listed in Table 1b. It can be clearly seen that scholars from various countries have paid a lot

of focus to the research on blockchain, especially in the past three years, during which an increase in research on the application of blockchain technology in the fields of grain and oil, traceability, supply chain, and other fields was also increasing. The data suggested that the research situation in this area is promising; blockchain technology has promoted the development of these fields. Additionally, research on the industrial internet has gradually emerged in recent years. Especially in the past three years, scholars from various countries have also conducted in-depth research on it and achieved good results. However, for indexes "Industrial internet + Blockchain", "Industrial internet + Food", and "Industrial internet + Food", the number of publications related to "Internet + Supply chain" is small. It can be seen that research in these fields is still in its infancy, and no in-depth research has been carried out. This indicates that research on the key technologies of the industrial internet has not been in-depth.

Table 1. Number of publications with different keywords from web of science database, table (a) is about blockchain, and table (b) is about industrial internet.

(**a**)							
Key Word	**2014**	**2016**	**2018**	**2019**	**2020**	**2021**	**January–June 2022**
Blockchain	1	0	2134	5948	10,228	11,284	3092
Blockchain + Traceability	0	1	81	245	526	728	266
Blockchain + Food	0	1	43	89	163	205	66
Blockchain + Supply chain.	0	1	133	304	549	720	243
(**b**)							
Key Word	**2008**	**2016**	**2018**	**2019**	**2020**	**2021**	**January–June 2022**
Industrial internet	30	177	419	509	761	1411	662
Industrial internet + Blockchain	0	0	1	0	1	1	1
Industrial internet + Food	0	1	2	2	5	5	3
Industrial internet + Supply chain	0	1	7	9	9	20	10

In the research on the reliable traceability model of grain and oil quality and safety based on the connector for blockchain and industrial internet, the top priority is to study the key technologies involved. Such key technologies include blockchain technology and industrial internet technology, as well as related fields of grain and oil quality and safety. This section shows the research on the application of blockchain technology and industrial internet technology in the fields of supply chain, traceability, and food in recent years.

The latest research related to the use of blockchain in agricultural products and grain, oil, and food in recent years is shown in Table 2.

The first category is research on grain, oil, and food supply chain based on blockchain technology. In literature [37], the author proposes to establish a game theory model to study the operational decision-making and blockchain adoption strategies of the food supply chain, thereby reducing the health and safety problems of consumers due to products. In the literature [38], the author proposes a blockchain-based food supply chain traceability modeling and a food traceability use case scenario to deal with the complexity of the network and its fragmentation, hindering sound traceability mechanism development issues. In the literature [39], the author analyzes the characteristics of information flow in the rice supply chain. Based on a multi-party hybrid encryption algorithm and consensus algorithm, the author proposed a multi-blockchain rice-refined supervision model. It involves the transmission, use, storage, and consensus mechanism of rice data. Based on the model, it built a prototype system based on the model and refined the supervision system of the supply chain. In the literature [40], the authors propose a sustainable blockchain framework for the halal food supply chain, discussing supply chain integration and food regulations as key enablers for the success of blockchain technology in the halal food

supply chain. In the literature [41], the authors examine the behaviors and organizations that influence the adoption of blockchain technology in supply chain management and confirm the core arguments of behavioral reasoning theory and technology organization and environmental theory. Articulates new factors influencing blockchain adoption in supply chains. In the literature [42], the author proposes a simulation of the Parmigiano Reggiano supply chain based on blockchain technology and uses blockchain technology to promote the implementation of RFID and IoT technology in Vendor Managed Inventory in order to gain a time advantage in supply chain operations.

Table 2. Literature review of different categories.

Category	Main Content	References	Problem
Research on the supply chain of grain, oil, and food based on blockchain technology	Study the role of blockchain technology in the supply chain	[37–42]	These studies involve the practical application of blockchain technology in agriculture and grain, oil, and food supply chains. However, the research of blockchain in supply chain still faces many challenges, such as the game theory model proposed in literature [37], the retrospective model proposed in literature [38], and the sustainability framework proposed in literature [40]. Although it has promoted the development of the supply chain to a certain extent, it is necessary to improve the existing blockchain, In order to improve the applicability of blockchain in the supply chain, benefits for traditional agriculture and food supply chains.
Research on traceability of grain, oil, and food based on blockchain technology	Research the existing traceability methods based on blockchain technology, how to collect and store data in the traceability process, and the advantages and disadvantages of various methods.	[43–48]	These research efforts were analyzed quantitatively and qualitatively through a large number of studies. Such as, literature [43] proposes an architectural design framework for traceability systems, and literature [45] proposed a traceability system. It has a positive effect on traceability. However, the supply chain of the grain and oil industry is complex. There is still room for improvement in the traceability efficiency and data interaction efficiency of blockchain in the field of grain, oil, and food, and many challenges to truly apply blockchain technology to the traceability of grain and oil quality and safety on a large scale.
Research on the integration of industrial Internet technology based on blockchain technology	Quickly find the data that needs to be traced during the traceability process	[49–52]	These research works integrate the application of blockchain technology and industrial internet technology. Such as, literature [49] proposes to apply blockchain and federated learning to industrial internet, and literature [52] proposes a trusted industrial data management scheme based on industrial internet editable blockchain and a consensus-based collaborative optimization method for manufacturing services. These studies have played a positive role in fusion applications. However, the integration of applications in the traceability of grain and oil quality and safety has not been realized. It cannot provide reference and learning for traceability.

The second is the research on the traceability of grain, oil, and food based on blockchain technology. In the literature [43], the author proposed the architecture design framework and applicability application analysis flow chart of the blockchain-based food traceabil-

ity system, analyzed the role of traceability in food quality and safety management, and discussed the benefits and challenges of blockchain-based sustainable traceability management. In the literature [44], the author summarizes the implementation of blockchain technology in the Canadian food and agriculture industry. It describes how the supply chain traceability information based on blockchain has more advantages than its current use in food safety and product recall. The adoption of blockchain technology in agriculture will reach critical mass earlier. In the literature [45], the author proposed a trusted agricultural product traceability system based on the Ethereum blockchain, considering the dual storage model of "blockchain + IPFS". To achieve efficient information query, a data privacy protection solution based on some cryptographic primitives and Merkle Tree is also proposed. In the literature [46], the author establishes the causal relationship between blockchain and agricultural supply chain and uses the combined approach of interpretive structural modeling and decision-making test and evaluation laboratory to derive its framework in India's agricultural supply chain from promoting the application of blockchain. In the literature [47], the author proposed the idea of combining blockchain technology with agricultural traceability systems. Using qualitative research methods and case analysis methods through in-depth research and analysis of representative blockchain application cases in the field of agricultural traceability. In the literature [48], the author proposes a storage structure of a blockchain-based agricultural product traceability system. This method uses "on-chain and off-chain" data storage technology. It solves the problem of excessive blockchain data storage load, ensures the privacy and security of data, and improves the reliability and timeliness of traceability information.

The last category is research on the integration of industrial internet technology based on blockchain technology. Due to the professionalism of the industry, higher requirements are placed on the latency, security, and stability of the resolution service. It puts forward higher requirements for the delay, security, and stability of parsing services. Because the traditional domain name systems are single identification subjects and have weak awareness of security protection, they cannot meet the requirements of the industrial internet. In the literature [49], the author proposes a new framework for applying blockchain and federated learning technology to the identification research of the industrial internet. It has laid a solid foundation for the future development of the industrial internet. In the literature [50], the author proposes a trustworthy industrial data management scheme based on redactable blockchain in the industrial internet. A double-blockchain architecture is established to separate trapdoor management transactions. It can effectively deal with malicious behaviors and has an acceptable overhead. In the literature [51], the author proposed a digital twin and blockchain-enhanced manufacturing service collaboration mechanism for the Industrial Internet platform. It enhanced manufacturing service management, challenges, and future work to implement digital twin and blockchain-enhanced manufacturing service management for industrial internet platforms are discussed. In the literature [52], based on the establishment of the underlying data and network layer of the blockchain, the author proposed the collaboration optimization of manufacturing services based on consensus. The providers are selected with a higher satisfaction degree of consumers.

It can be found from the review that the control method of the currently established traceability system is too centralized. As a result, consumers have low awareness of the traceability system, which leads to doubts regarding the authenticity and reliability of the provided information. It affects the effectiveness of the implementation of the traceability system. The tracing process of the traditional traceability system cannot cover the entire chain; information traceability can only be limited to one or several links. It is difficult to achieve information sharing and mutual trust between different subjects in the production, processing, and transportation of grain, oil, and food. Due to the information isolation of different circulation links, the authenticity and reliability of the data cannot be guaranteed. At present, food safety traceability system based on blockchains plays the role of data storage and data tamper-proof in the research on the traceability of grain and oil quality

and safety. Most of these kinds of systems are still in the theoretical analysis stage or have a small number of implementations. Therefore, it is necessary to establish an advanced food traceability system for the whole chain of grain, oil, and food.

Starting from our previous research, this study first classified and analyzed the design and key information of the whole chain of grain and oil quality and safety. The block data structure of the traceability data of grain and oil quality and safety in the blockchain is designed, and the identification and resolution system of the industrial internet of the grain and oil industry is designed. The concept of connector for blockchain and industrial internet is proposed, and it is applied to the traceability of grain and oil quality and safety. The research proposed in this article can improve the collection efficiency and accuracy of grain and oil quality and safety traceability data. It can solve existing problems such as difficulty in traceability and low efficiency of grain and oil quality and safety.

3. The Design of the Whole Chain and Key Information Analysis of Grain and Oil Quality Safety

It is vital to keep the integrity of each link in the whole chain of grain and oil quality. In the process of tracing grain and oil quality and safety information, if the chain integrity cannot be guaranteed, it will be impossible to query traceability data. In this way, it is impossible to reduce the impact of the safety incident or find its original cause. The security of the whole chain is important to the traceability of grain and oil quality safety. The whole chain consists of six major links: plant, purchase, storage, process, transport, and sale. Although most steps are similar across different grain and oil industries, specific details may be different.

Due to the complex links in the whole chain of grain and oil quality and safety, each link is necessary to record more information than other products, and the information data corresponding to each link are different, especially in the production and sales links. The data, which are collected, recorded, and uploaded, are massive, so all the key information needs to be sorted and classified before they are uploaded to the chain. Taking wheat as an example, the classification of key information is shown in Table 3, including the information that needs to be traced across the six links of the whole chain from planting to sales. The information on each link is further divided into basic information, hazard information, environmental monitoring information, and transaction information. All the key information on wheat quality and safety is basically covered by the four categories of records and price information. By utilizing these data, when quality and safety problem occurs, it is possible to quickly locate the problematic enterprises in the corresponding small links through data related to the problems, and the reason for the problem can be found. The above method plays a crucial role in quickly solving the grain and oil quality and safety problems.

Table 3. Classification of key information in wheat supply chain.

The Whole Chain of Wheat	Classification of Key Data Information			
	Basic Information	**Hazard Information**	**Environmental Monitoring Information**	**Transaction History and Price Information**
Plant	Basic information of growers; name of planting base; address of planting base; water quality of irrigation water; wheat species; planting time; planting method; nursery time.	Mycotoxins: Zearalenone, Aflatoxins. Heavy metals: lead, cadmium, zinc, chromium, copper. Pesticide residues: imidacloprid, triazolone.	Environmental real-time humidity; environmental real-time light intensity; soil moisture content; soil type, climate, and rainfall.	Planting cost; harvested quantity; wheat yield; wheat flow.

Table 3. *Cont.*

The Whole Chain of Wheat		Classification of Key Data Information			
		Basic Information	**Hazard Information**	**Environmental Monitoring Information**	**Transaction History and Price Information**
Purchase and storage	Purchase	Grower information; pesticide sampling record at the time of purchase; wheat origin information; purchase time; wheat type.	Mycotoxins: DON, Trichothecenes, Zearalenone, Aflatoxins, fumonisins, Ochratoxins, Aspergillus versicolor. Pests: wheat moth, corn weevil, grain beetle.	Ambient temperature, humidity; oxygen concentration; carbon dioxide concentration; formaldehyde; VOC; wheat moisture content.	Information of growers; purchase price; costs of drying, cleaning, storage, etc.; sales price.
	Impurity removal	Types of impurities (scab grains, imperfect grains, stones, other impurities); impurity content; impurity removal rate.			
	Storage	Inventory number; warehouse address, size, storage warehouse environment; product origin; product quantity.			
Process	Tempering	Selection of wheat moistening method; water temperature; watering times; wheat moistening time; wheat moistening machine equipment information.	Mycotoxins: Aflatoxins, Zearalenone. Heavy Metal: Lead, Cadmium, Mercury, Zinc, Chromium, Copper. other hazards	Ambient real-time temperature; ambient real-time humidity.	Inventory number; warehouse address, size, storage warehouse environment; product origin; product quantity. Selection of wheat moistening method; water temperature; watering times; wheat moistening time; wheat moistening machine equipment information. Grinding method; number of passes of skin grinding system and contact length of grinding roller.
	Grinding	Grinding method; number of passes of skin grinding system and contact length of grinding roller; information of grinding machine and equipment.			
	Flour blending	The physical and chemical indicators of the powder; the color, odor, and impurities of the powder; the sanitary environment of the powder; the content of mycotoxins.			
	Package	Brand name; packaging source and raw materials; processing personnel information; packaging time; product packaging number.			
Warehousing		Warehousing company name; warehousing company address; corporate legal person information; inventory number; product source; product quantity; warehousing time; delivery time.	Mycotoxins: trichothecenes, zearalenone, etc.	Ambient temperature, humidity, oxygen concentration, carbon dioxide concentration, formaldehyde, TVOC.	Storage cost; storage price.

Table 3. *Cont.*

The Whole Chain of Wheat	Classification of Key Data Information			
	Basic Information	**Hazard Information**	**Environmental Monitoring Information**	**Transaction History and Price Information**
Transportation	Name of logistics company; address of logistics company; license information; contact information of person in charge; means of transportation; place of departure; departure time; destination;	Fungi and toxins; physical impurities (gravel, etc.), such as aflatoxins, etc.	The ambient temperature in the car, the ambient humidity in the car, and the oxygen/carbon dioxide concentration in the car.	The process of logistics; logistics costs.
Sales	Business name; shop address; shop owner information; product name; product quantity; purchase time.	Hazardous substances in transport vehicles; residues of chemical additives; physical impurities.	Sales environment photo.	Purchase price; sale price.

4. The Reliable Traceability Model for Grain and Oil Quality and Safety

The previous section discussed the production process and key data of the grain and oil quality safety chain. This study designed the blockchain traceability data structure, as well as the identification and resolution system of the industrial internet based on the whole chain of grain and oil quality and safety. To better solve the problems that exist in the traceability process of grain and oil quality and safety, the design of a reliable traceability model of grain and oil quality and safety is carried out.

4.1. Design of Connector for Blockchain and Industrial Internet

Grain and oil need to go through multiple complex links, from planting and processing to the final consumer. Problems in any link of the whole chain of grain, oil, and food will end up hurting the health of consumers. Therefore, the traceability of grain and oil products is very important; the accuracy of data in the tracing process will ultimately affect the accuracy and efficiency of the result. In the past, the traceability data collection from each link of the whole grain and oil chain, which is based on blockchain, can improve the accuracy of the data, but it cannot guarantee the comprehensive and quick collection of the data. This study divides the data into two types: dynamic factors of production traceability data and static factors of production traceability data. Dynamic factors of production include crops in the planting process, grain in the procurement and storage process, raw materials in the process, storage process, and finished grain and oil products in the transportation process. Static factors of production include equipment and tools in the planting process, all machines in the process, and warehouses in the warehousing process, as well as the transportation vehicle information in the transportation link and various sensors in each link. Integrating blockchain technology and industrial internet technology can ensure the quality and safety of grain and oil. The research on chain traceability can provide a solution for the comprehensive, fast, and accurate collection and storage of traceability data. Therefore, this paper deeply studies blockchain technology and industrial internet technology and proposes the concept of a connector for blockchain and industrial internet in the model of grain and oil quality and safety. On this basis, this paper designed the application scenario of the connector for blockchain and industrial internet. Based on this, design its principle.

4.1.1. Structure Design of Traceable Block for Grain and Oil Quality and Safety

Cryptographic algorithms are effective ways to achieve traceability data security, such as RSA, ECC, MD5, SHA-1, 3DES, AES, etc., are widely used in the security field. We select the SM3 algorithm in this model; SM3 is a cryptographic hash algorithm. It is an improved algorithm based on SHA-256 and adopts the Merkle–Damgard structure. The traceability information generated by each link of the supply chain can be converted into a 256-bit hash value. A small change in the traceability number will lead to a huge change in the hash value. In the traceability model, it can be used for encryption/decryption operations of traceability data to ensure the confidentiality of traceability data. Algorithm 1 is specific data upload based on the SM3 algorithm.

Algorithm 1: Data Upload

Message population:
If input (Data)//input data
Return
$Data_p$ = Data + "1" + K-bit"0" + 64-bit//K is the minimum nonnegative solution of the equation l + 1 + k = 448 mod 512
Iteration
for i = 0 to n − 1
H(i + 1) = CF($H^{(i)}$, $B^{(i)}$)//$H^{(i+1)}$ is the link variable, and $H^{(n)}$ is the hash value; CF (.,.) is the compression function
end
Message orchestration:
//When the message is filled, the message block $B_{(i)}$ is divided into 16 or 32-bit words $W_0, W_1, \ldots, W_{15}$
for j = 16 to 67
$W_j \leftarrow P1(W_j - 16 \oplus W_j - 9 \oplus (W_j - 3 <<< 15)) \oplus (W_j - 18 <<< 7) \oplus W_j - 6$
end
for j = 0 to 63
$W'_j \leftarrow W_j \oplus W_j + 4$
end
Compression function:
//Input link variable $H^{(i)}$ and message word $B^{(i)}$, A, B, C, D, E, F, G, H are word registers: A, B, C, D, E, E, G, H ← $H^{(i)}$
for t = 0 **to** 63
SS1 ← ((A <<< 12) + E + (T_j <<< (j mod 32))) <<< 7
SS2 ← SS1⊕(A <<< 12)
TT1 ← FF_j(A,B,C) + D + SS2 + W'_j
TT2 ← GG_j(E,F,G) + H + SS1 + W_j
D ← C
C ← B <<< 9
B ← A
A ← TT1
H ← G
G ← F <<< 19
F ← E
E ← P0(TT2)
end
$H^{(i+1)}$ = ABCDEFGH⊕$H^{(i)}$
Output: return $H^{(i+1)}$

Taking the storage link in the whole wheat chain as an example, the corresponding block is designed in Figure 1. The block header includes the generation time of the current block, the parent block hash, the Merkle root, etc. The block body contains hash values for both dynamic and static production factors and industrial internet identity data.

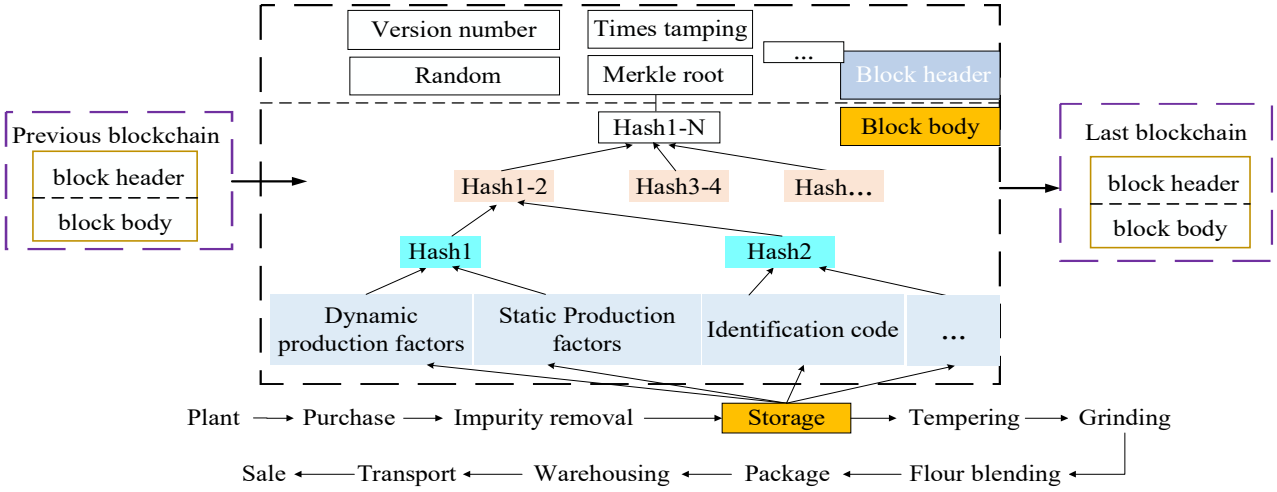


Figure 1. Wheat traceability blockchain structure.

The design of this grain and oil quality and safety traceability block provides data storage and data query functions for the connector of blockchain and industrial internet, ensures the tamper-proof of the traceability data, and makes the grain and oil quality and safety traceability data more credible and secure.

4.1.2. Identification and Resolution System of Industrial Internet Design

The grain and oil quality and safety credible identification aims to connect the main data of enterprises from all links of the whole chain of grain and oil quality and safety. Getting through the barriers of data interoperability in all links of the supply chain is the key foundation to improving the quality and efficiency of traceability. In this study, the identification and resolution system of the industrial internet of the grain and oil industry is designed based on the basic identification and resolution system of industrial internet analysis, as shown in Figure 2. The model includes a root node of identification and resolution, national top-level node of identification and resolution, second-level node of identification and resolution of grain and oil, and an enterprise node. The national top-level node of identification and resolution is the core foundation of the industrial internet identification system. The second-level node of identification and resolution, which is designed in combination with the characteristics of the grain and oil industry, includes rice nodes, wheat nodes, corn nodes, and other grain and oil-type nodes. It is the intermediate link of the industrial internet identification and analysis system, and it is also an important hub for connecting national top nodes and enterprise nodes, and the key link of the identification and resolution system of the industrial internet system. The enterprise nodes, consisting of the six links of the whole chain, are respectively connected to the corresponding secondary nodes. This structure allows the seamless transmission of data and information between enterprises and systems and enables the management and sharing of identification data in the identification analysis system.

The design of the identification and resolution system of industrial internet in the grain and oil industry provides the connector for blockchain and industrial internet with functions such as collection and storage of heterogeneous data. Such design ensures rapid, accurate, and comprehensive collection of traceability data of grain, oil, and food products in all links of the whole chain. During the tracing process, it can enable more accurate, rapid, and comprehensive access to the required traceability data in the traceability process of grain and oil quality and safety.

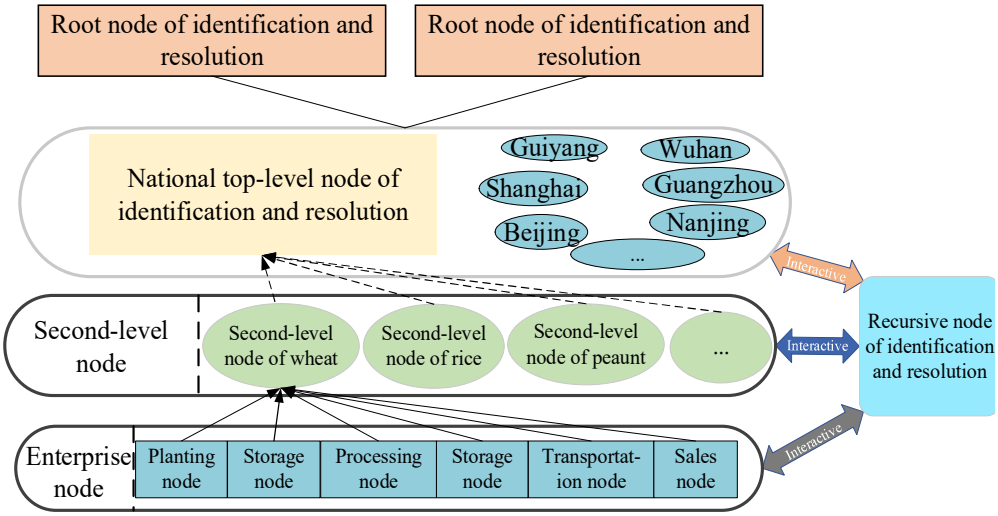


Figure 2. Identification system scheme of grain and oil.

4.1.3. Application Scenario Design of the Connector for Blockchain and Industrial Internet

The connector for blockchain and industrial internet is designed to connect the blockchain system and the identification and resolution system of the industrial internet. The connector for blockchain and industrial internet is deployed in the blockchain nodes of grain and oil enterprises, and it will break through the data interaction barriers between blockchain technology and industrial internet technology. There are different blockchains used by different enterprises in each link of the whole chain, so the application scenarios are designed based on the type of user. The application scenarios of the connector for blockchain and industrial internet are shown in Figure 3, including three application scenarios: off-chain, single-chain, and cross-chain, 1 represents the information interaction process of Scenario 1, 2 represents the information interaction process of Scenario 2, 3 represents the information interaction process of Scenario 3.

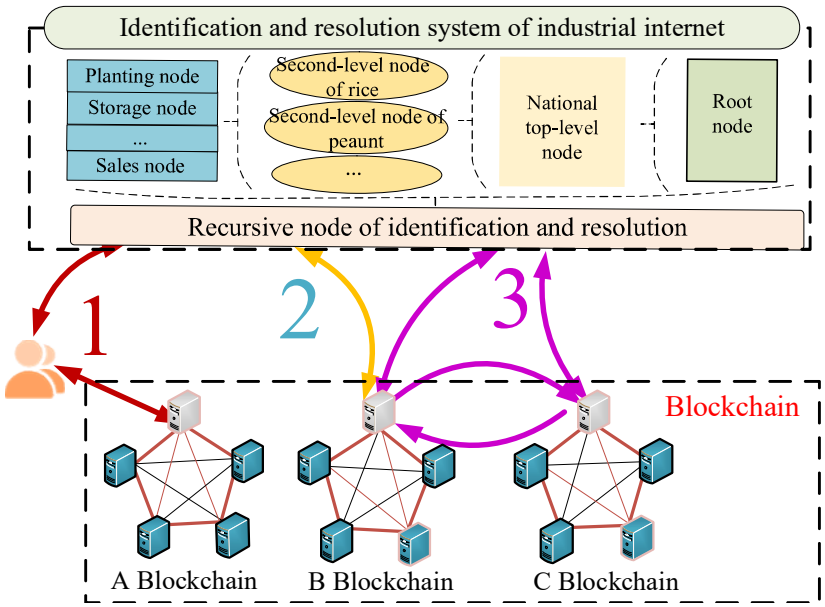


Figure 3. Application scenario 1, 2, 3 of the connector for blockchain and industrial internet.

Scenario 1: Off-chain user data access. The users are not in any blockchain system, such as consumers and regulatory authorities. The user scans the dynamic factor of the production identification code. The traceability information corresponding to the identification code can be parsed by the user from the identification and resolution system

of the industrial internet. Tracing data can also be obtained in the blockchain where the data are located. The two methods can verify each other, and they can ensure the accuracy of the traceability data.

Scenario 2: User data access within a single chain. The data of dynamic factors of production and static factors of production are stored in the same blockchain. When a company that holds static factors of production in a certain link scans the product's dynamic production factor identification and determines the data stored on the same blockchain. At this time, the user will store and query data in the blockchain system.

Scenario 3: Cross-chain user data access. The data of dynamic factors of production and static factors of production are stored in different blockchains. When a company that holds static factors of production in a certain link scans the product's dynamic production factor identification, it is determined that the data are stored on different blockchains. Due to the cross-chain data interaction, cross-chain data processing needs to be coordinated through the connector for blockchain and industrial internet nodes of the two blockchain systems.

4.1.4. Principle Design of the Connector for Blockchain and Industrial Internet

According to the above application scenario of the connector for blockchain and industrial internet, the principle of the connector for blockchain and industrial internet is designed in Figure 4. The connector for blockchain and industrial internet connects the blockchain system and the identification and resolution system of industrial internet, and it is deployed in the blockchain node of grain and oil enterprises. Using the PBFT consensus mechanism, the connector can deploy smart contracts on the blockchain node to interact with data in the chain and interact with the identification and resolution system of the industrial internet through the API interface. When user needs to register or parse an identification code, the connector will deploy the smart contract and access the API interface to register and analyze the identification code through the blockchain system. In the connector, three types of API interfaces are designed for interaction with the analysis system: the off-chain user interface, the cross-chain user interface, and the identification resolution interface. Three types of smart contracts are designed for in-chain data processing: data upload smart contracts, data query smart contracts, and information exchange smart contracts with the identification and resolution system of the industrial internet.

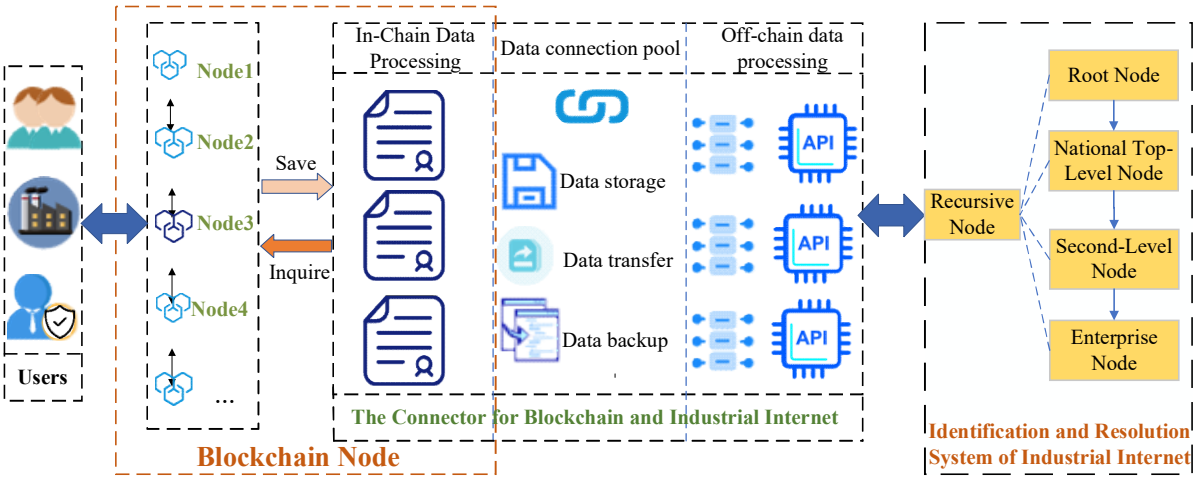


Figure 4. Architecture diagram of connector for blockchain and industrial internet.

The connector for blockchain and industrial internet is deployed in the blockchain nodes of grain and oil enterprises in order to connect the traceability data of dynamic factors of production and static factors of production. The connector for the blockchain and the identification and resolution system of the industrial internet allows information exchange between them. The application of blockchain in the traceability of grain and oil

quality and safety promotes the development of the identification and resolution system of the industrial internet. Due to the trusted and non-tamper characteristics of blockchain technology, the system can fully connect, share and link traceability data. Therefore, the data related to the whole chain can be fully transparent and fully traceable in the tracing process, thereby improving the efficiency of collaboration.

4.2. Traceability Model Design

At present, due to regional and subject differences, there are still many problems that need to be solved urgently. In particular, reliable and efficient data exchange between heterogeneous systems cannot be guaranteed. After analyzing the characteristics of the whole chain of grain and oil quality and safety, completing the construction of the block data structure of grain and oil quality and safety trusted traceability and the identification and resolution system of industrial internet of the grain and oil industry, the reliable traceability model of grain and oil quality and safety was designed. The model includes the whole chain of grain and oil quality and safety nodes, grain and oil enterprises blockchain nodes, and industrial internet identification resolution system nodes. The overall structure is shown in Figure 5.

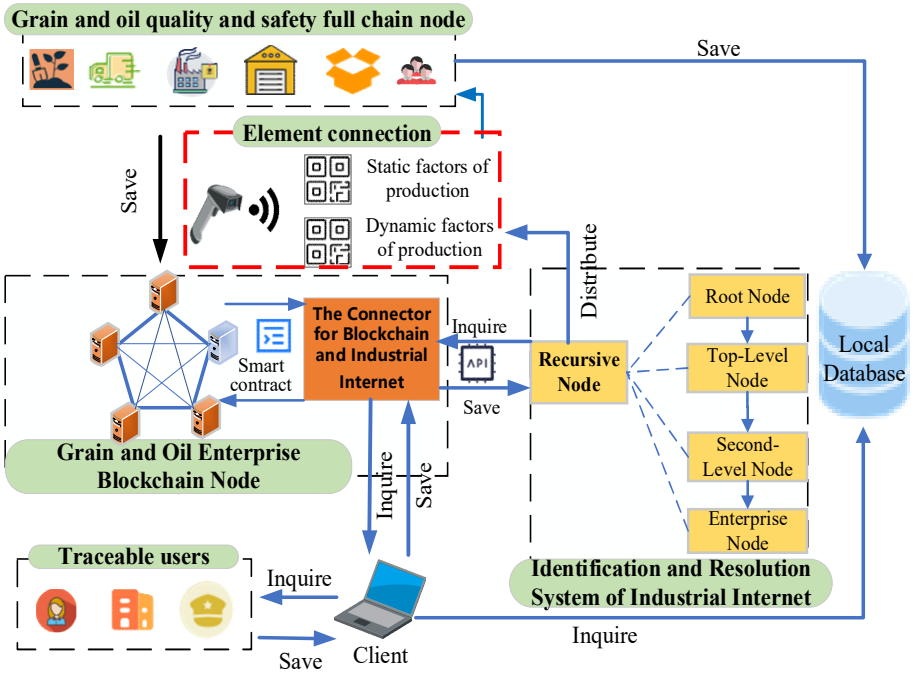


Figure 5. Reliable traceability model of grain and oil quality and safety based on blockchain and identification analysis.

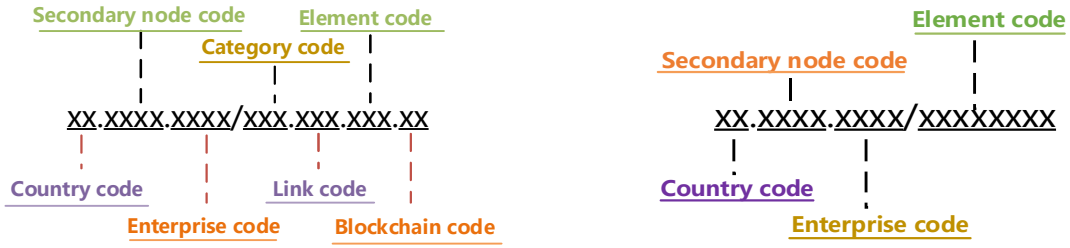
In this model, blockchain technology and identifier resolution technology are integrated. For enterprises in different links of the whole chain of grain and oil quality and safety traceability system, a whole-chain node of grain and oil quality and safety has been established. Blockchain technology has been used to establish a grain and oil enterprise blockchain node corresponding to the whole chain of grain and oil quality and safety. The identification resolution technology is used to establish the identification and resolution system of industrial internet nodes. Through connecting equipment, the dynamic factors of production and static factors of production of each link of the whole grain and oil chain are connected. In order to integrate the blockchain system and the identification and resolution system of the industrial internet, the connector for blockchain and industrial internet is designed in credible data sharing in three application scenarios: out-chain, single chain, and cross-chain. The functions of the model include data uploading and classified storage, identification registration and analysis, data query, etc. In the current traceability system,

it can effectively solve the difficulties in traceability, namely the low efficiency of traceability data collection, the inability to obtain comprehensive data, the inaccuracy of data, and regional problems. By resolving the problem of information interaction between the blockchain system and the identification and resolution system of the industrial internet, the model provides a feasible solution for truly realizing the whole chain traceability of grain and oil quality and safety.

4.3. Trusted Traceability Information Flow

4.3.1. Design of Identification Code

The identification and resolution system of the industrial internet adopts a hierarchical identification scheme. Each identification code consists of two parts: prefix and suffix. The prefix is the naming authority, and the suffix is the unique local name under the naming authority. The two are separated by "/" character. The naming authority is the creator and manager of the handle identification. It consists of multiple non-empty sub-naming authorities. The sub-naming authorities' codes are separated by "." to form a tree-like hierarchical structure. The suffix is defined by the naming authority. To ensure that the suffix is globally unique in the system, the naming authority needs to ensure the uniqueness within its local namespace. Under normal circumstances, if the enterprise does not specify a suffix, it will be randomly assigned one by the top node of the country; the enterprise can also develop corresponding suffix generation rules according to its own business needs. According to the characteristics of the grain and oil industry, combing the needs of traceability business, the industrial internet identification coding rules of dynamic production factor coding and static production factor coding are designed as shown in Figure 6, including country code, secondary node code, enterprise code and category code, link code, element code, blockchain code. Among them, the prefix of country code, secondary node code, and enterprise code is automatically allocated by the identification and resolution system of the industrial internet; it cannot be modified. The suffix of categories and elements codes is important information of the whole grain and oil chain data, and the blockchain code help identify and locate the blockchain where the element is located, then determines the block where the data are located.



(**a**) (**b**)

Figure 6. (**a**) Static factor of production identification code. (**b**) Dynamic factors of production identification code.

It can be seen from the above figure that the coding format of static factors of production is different from the coding format of dynamic factors of production. This different design is based on their specific usage scenarios. The identification of static factors of production will inevitably change along with the changes in the entire chain. The dynamic factors of the production code do not need to be changed, and only the traceability information of the identification codes needs to be updated in real-time. The traceability information contained in the identifications of dynamic factors of production is updated by connecting the identifications of static factors of production to the traceability information contained in the identifications of dynamic factors of production. As a result, there is no need to modify the shape and format of the dynamic production code; the traceability data

can be collected more accurately and quickly, which improves the efficiency of traceability of grain and oil quality and safety, making the tracing process more secure and reliable.

4.3.2. The Flow of Traceability Data

In the traditional blockchain system, all the basic data of enterprises are stored in the blockchain, which will cause problems such as high cost, heavy load, access difficulty, inefficiency, and waste of resources. Therefore, enterprises generally upload the summary of data and the hash value of complete information. When the enterprises upload data, the data uploaded by each node are stored in the enterprise's blockchain node, and a large amount of basic product data is stored in the enterprise's local database to ensure data security and completeness. Although this method ensures the accuracy of the traceability data of the blockchain system, it cannot solve the problems of rapid collection, uploading, and storage of traceability data. The traceability data flow model of this study, as shown in Figure 7, can perfectly solve these problems.

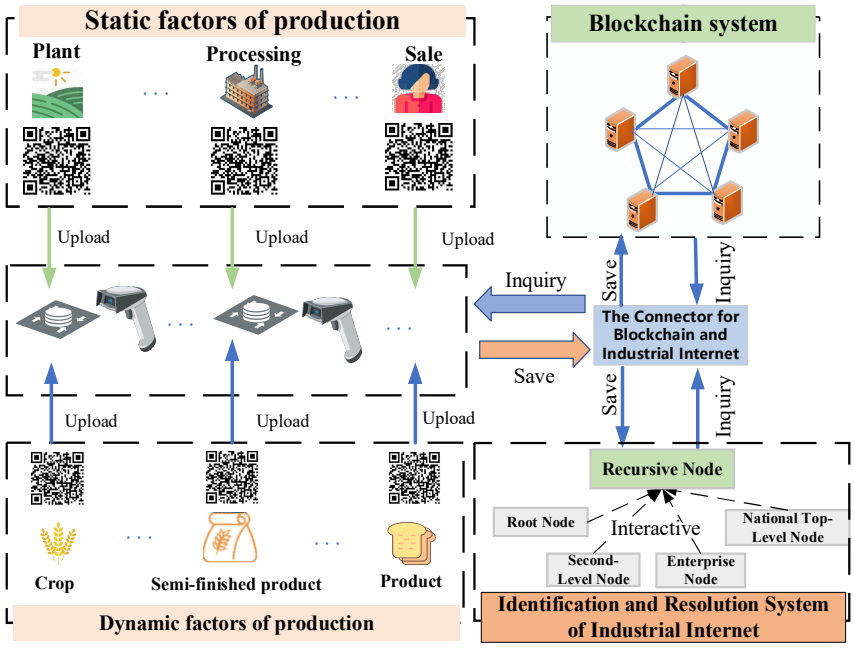


Figure 7. Traceability data flow model.

The flow model of traceability data has four main parts:

The first part includes the quality information and environmental information of the products in each link of the supply chain. In terms of traceability information flow, the production factors are divided into two categories: static factors of production and dynamic factors of production. Crops in the planting link, grain in the purchase and storage link, raw materials in the processing link, storage link, and finished grain and oil products in the transportation link are the dynamic factors of production; equipment and tools in planting, all machines in processing, warehouses in warehousing, and information on vehicles in transportation, as well as various information in each link such as sensors, are static factors of production. Static and dynamic factors of production will be given different identification codes to distinguish them.

In the second part, the identification of static factors of production and dynamic factors of production is connected, the data exchange mechanism based on the cross-judgment of time and space, and the connection tool of each link will match with the static factors of production of this link first. When the dynamic production factor of a link reaches this link, there is an intersection of time and space with the static factors of production of this link; the connecting equipment connects the traceability data of static factors of production with

dynamic factors of production and achieves the goal of quickly and accurately collecting traceability data.

The third part is the identification and resolution system of the industrial internet. After the connection tool connects the dynamic factors of production and the static factors of production, the traceability data of grain and oil starts from the planting link, and the identification begins by recording relevant information during planting. After all the information in this link is collected, dynamic factors of production enter the next link. The dynamic factors of production and the static factors of production are bound in a new link through the code-scanning device. The information on the static factors of production and all actual time information is measured; it will be updated to the information contained in the dynamic production factor identifiers.

The fourth part is the blockchain platform. Through the connector for blockchain and industrial internet, the identification and resolution system of industrial internet collects traceability data and stores them on the blockchain platform through smart contracts. The platform can ensure that the traceability data cannot be tampered with and also provides users with a product information query interface.

The working steps of traceability information flow are as follows:

In the first step, after the dynamic factors of production reach a certain link, the identification link tool, which has been matched with the static factors of production, reads the identification code of the dynamic production elements to ensure whether the identification can be analyzed by the identification and resolution system of the industrial internet. In the second step, the identification linking tool identifies whether the identification is parsed for the first time in this link. If it has not been parsed by the identification linking tool in this link, it will link the dynamic factors of production with the static factors of production. If it is not the first time, it will not be connected again. In addition, the linking tool in the previous link cannot link the identification of the dynamic production factor, and the link of the identification of the dynamic production factor is determined by the last link. With this limit, the traceability identification of the grain, oil, or food would not be affected by the packaging form, which reduces the cost of identification. The third step is to transfer the traceability information from the static factors of production collected by the identification and resolution system of the industrial internet to the blockchain system through the connector for blockchain and industrial internet. First, the smart contract verifies the data type and the link and then processes the data. This verification process will help ensure the integrity and accuracy of the uploaded data and the correct format. After verification, the data are uploaded to the blockchain. The identification and resolution system of industrial internet updates the real-time identification of dynamic factors of production once upload happens.

This model realized a property where the information contained in the blockchain, in this model, the identification changes with the quality of the grain and oil products themselves in the whole chain process. Enterprises are not allowed to automatically enter information, such as the purchase price, sales price, etc., that need manual input. This model realized real-time and accurate data and information recording for each link in the production chain from farm to processing factory and then to the consumers, therefore, ensuring the traceability of grain and oil quality and security. Each link of the grain and food chain is linked to the identification, which ensures that traceability data are never tampered with. Improved data flow efficiency of the system also solves the security concerns of grain and oil enterprises regarding data upload while providing a convent means for data access.

5. Results and Analysis

5.1. Model Analysis

5.1.1. Operation Process Analysis

The safety traceability model is built based on the concept of the connector for blockchain and industrial internet. The operation process is shown in Figure 8. The operation process is divided into three parts according to the application scenarios of

the connector for blockchain and industrial internet, chain users, single-chain users, and cross-chain users.

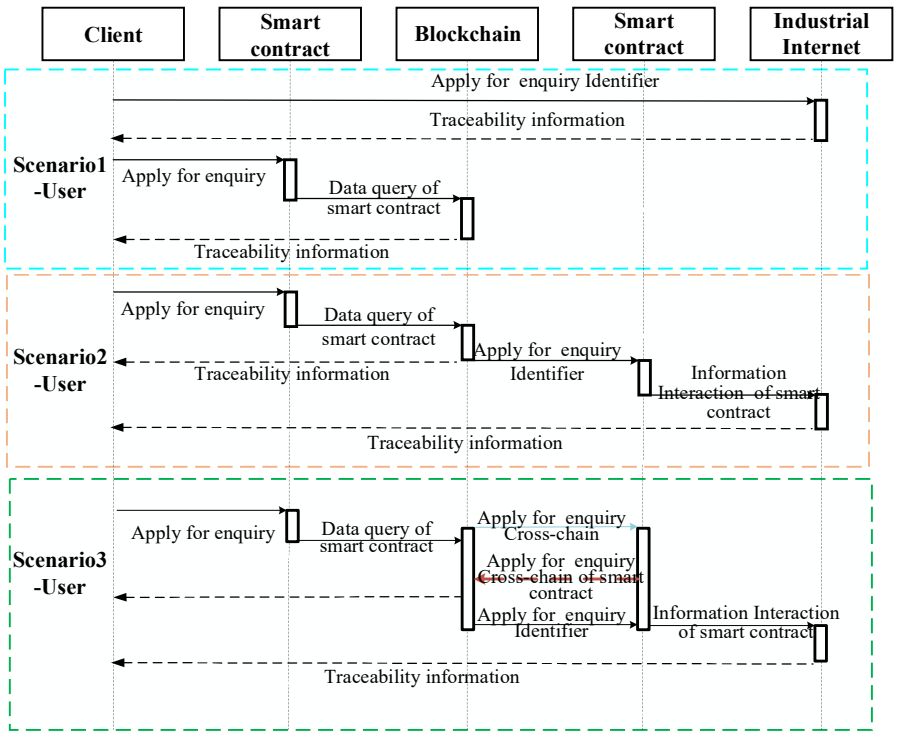


Figure 8. Model running process.

The traceability of grain and oil quality and safety begins with the user querying data. Taking the user in scenario 3 as an example, the main process flow is as follows: First, the user scans the identification code on the client or directly sends an application for querying traceability data. The enterprise grants some permissions to its query and queries through the query smart contract. If the data are not found on this blockchain, these data are queried through the cross-chain smart contract deployed on the connector for blockchain and industrial internet and transmitted to the client. At the same time, the connector for blockchain and industrial internet will also call the information exchange smart contract to query the data of the identification in the identification and resolution system of industrial internet and transmit information to the client. By verifying whether the traceability data are the same, it can determine whether the traceability data have been tampered with and how they have been tampered with. If it is tampered with, the user will obtain the data, and it will be fed back to the regulatory authorities.

The grain and oil quality and safety traceability model, due to the use of the concept of the connector for blockchain and industrial internet, the traceability data can be obtained quickly and accurately. Solve the problems of inaccurate traceability data, low data security, and low traceability efficiency.

5.1.2. Efficiency Analysis

A comparison between our proposed model and other popular blockchain-based track-and-trace system approaches is shown in Table 4. It is clear from the comparison our proposed system has a high-security level and relatively low cost, which allows convenient data entry.

It can be seen from this table that the traditional traceability method is relatively low in data security, data accuracy, and transmission efficiency. The application of blockchain technology in the traceability system can solve the problems of data security and accuracy but cannot solve the problem of traceability data transmission efficiency. Methods such as blockchain + QR code and blockchain + radio frequency identification can improve the

transmission efficiency of traceability data to a certain extent, but they cannot meet the current traceability requirements. The blockchain technology in the system targeted by this research can allow enterprises in all links of the chain to store traceability data in a decentralized manner. Industrial internet technology enables enterprises in various links to adopt different types of information systems or different types of data formats. Relevant personnel can connect to the industrial internet identification analysis platform, and those who need to assign and analyze the identification and need the entire chain of products can download it from the blockchain platform and the industrial internet platform. With the help of blockchain and industrial internet identification analysis, the whole chain of grain and oil quality and safety can be more transparent and can be easily traced, which can perfectly solve the problems of data security, accuracy, and transmission efficiency.

Table 4. Traceability system comparison.

Method	Security	Accuracy	Transmission Efficiency
Traditional method	low	low	low
Blockchain	high	high	low
Blockchain + QR code	high	high	mid
Blockchain + RFID	high	high	mid
Industrial internet	low	mid	high
This research (Blockchain + Industrial internet)	high	high	high

5.1.3. Scalable Analytics

The research on the traceability model of grain and oil quality and safety based on the identification and analysis of blockchain and industrial internet shows that the traceability model has good scalability. Its traceability function can be applied not only to the traceability of wheat quality and safety but also to the traceability of most grain and oil quality and safety links. In terms of data traceability, it can be used as a reference for other industries, such as steel manufacturing, industrial manufacturing, etc. Specifically, the research on the integration of chain and network based on blockchain technology and industrial internet identification analysis technology has designed a system that can handle the safe and comprehensive collection of traceability data, data classification storage, and data tamper-proof realized the safe storage and transmission of traceability data. Such a model is not only applicable to the whole chain of grain and oil quality and safety but also can provide a reference for the whole chain data traceability of other industries to better ensure product quality and safety.

5.2. Prototype System Design and Verification

A prototype system is designed to verify the traceability model and reflect the feasibility of the traceability model. The traceability model is more intuitively and effectively compared with the traditional traceability model through the traceability system. The traceability system mainly verifies the data accuracy, data interaction efficiency, and timeliness of the traceability model. Taking wheat, a typical grain and oil product, as an example, a quality safety traceability system was constructed.

The system mainly serves three groups of users: consumers, regulatory authorities, and enterprises. The different needs of these users should be fully considered when designing the system functions. The government supervision departments manage the identity authentication of enterprises in all links of the whole chain, supervise and ensure the accuracy of traceability information, and verify whether the information has been tampered with. This means the supervision department has the right to all the query and management functionalities. Enterprises record the circulation and sales information of wheat in all links of the whole chain on the platform and also query information of other companies, realizing the information exchange among enterprises. However, some information cannot be shared completely due to competition among enterprises, so the

system will grant different access rights to enterprises. Consumers hope to ensure food safety by querying the source, hazards, and other basic information of their products through the traceability system. The system can ensure the authenticity and reliability of the information and that there are no quality and safety problems in all links of the whole chain of wheat.

5.2.1. System Architecture Design

Combined with the different needs of enterprises, users, and regulatory authorities in all links of the whole chain of grain and oil quality and safety, relying on the grain and oil quality and safety credit traceability model, a grain and oil quality and safety trusted traceability system architecture was built. The overall architecture of the system is shown in Figure 9. The system architecture mainly includes five layers: data layer, network layer, consensus layer, contract layer, and application layer.

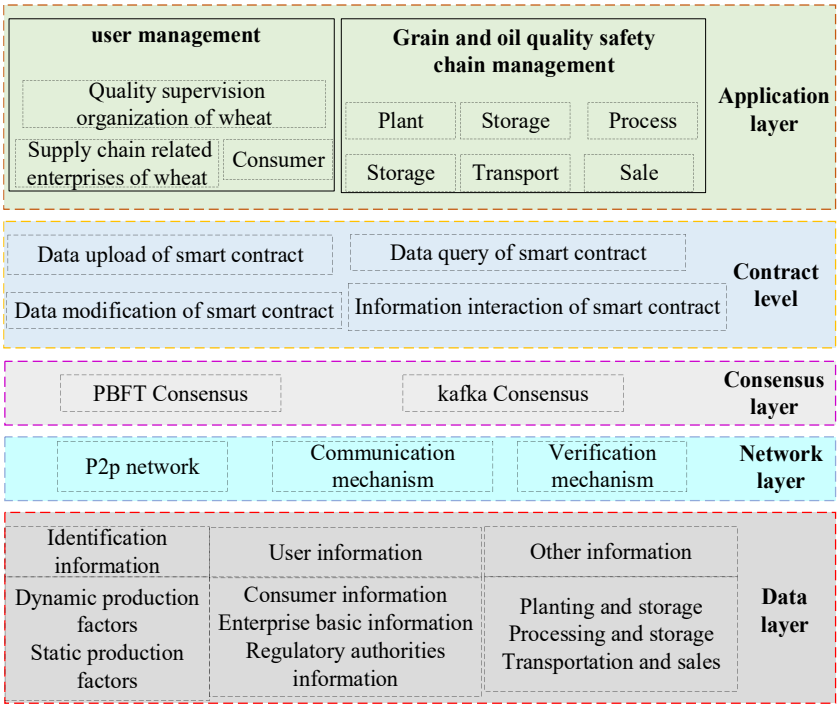


Figure 9. Traceability system architecture.

The data layer includes identification information, user information, whole chain information on grain and oil quality and safety, transaction information, etc. The network layer defines the establishment method of the nodes of the blockchain system and consortium blockchain system built by planting, purchasing and storage, processing, warehousing, logistics, sales companies, regulatory authorities, and other related institutions. The consensus layer selects an appropriate algorithm, establishes a consensus mechanism, and applies a practical Byzantine Fault Tolerance (PBFT) algorithm that meets the requirements to ensure the validity of the quality and safety data of each grain and oil. The contract layer encapsulates the smart contract script code, trigger conditions, and response operations deployed by the system. The application layer includes various enterprise clients, as well as clients for traceability queries by users and regulatory authorities.

5.2.2. System Development

1. Platform selection. Hyperledger fabric is a distributed ledger platform created by the Linux Foundation. Different from traditional blockchain development platforms, Fabric is a consortium chain system with node authority management. Users need to be authenticated before any data can be accessed. Fabric assigns access rights

according to different business and user categories and implements data isolation to protect data security. Fabric supports multiple consensus algorithms such as Solo consensus, Kafka consensus, and PBFT. Therefore, Fabric is chosen as the development platform.

2. Development environment deployment. The virtual machine of the ubuntu system, a Linux system, is installed, and the fabric is installed in it. Details of the computer configuration are shown in Table 5.

Table 5. Computer configuration parameters.

Computer Configuration	Parameter
CPU	Inter (R)Xeon(R)Gold 6230 CPU @ 210 GHz
GPU	Matrox G200e(Emulex) WDDM 2.0
Memory	64 G
Hard disk	20 TB
System	Ubuntu16.1.0
System of package	Ubuntu-20.04.2.0-desktop-amd64.iso

5.2.3. System Case Analysis

The realization of the wheat quality and safety traceability system is divided into four parts: client, server, blockchain network, and identification and resolution of the industrial internet. When the system user uploads the traceability data of each link of the whole chain through the client app or web interface, it will send an upload or query request to the server, and the server assigns the corresponding traceability data upload or query authority according to the user's identity. The purpose of this system design is to collect and store the traceability data of all links of the whole wheat chain by blockchain technology and industrial internet identification analysis technology for users. The local database, blockchain, and industrial internet identification analysis system provide data storage services, thereby improving the security and accuracy of traceability data. The operation process of the wheat quality and safety traceability system is shown in Figure 10.

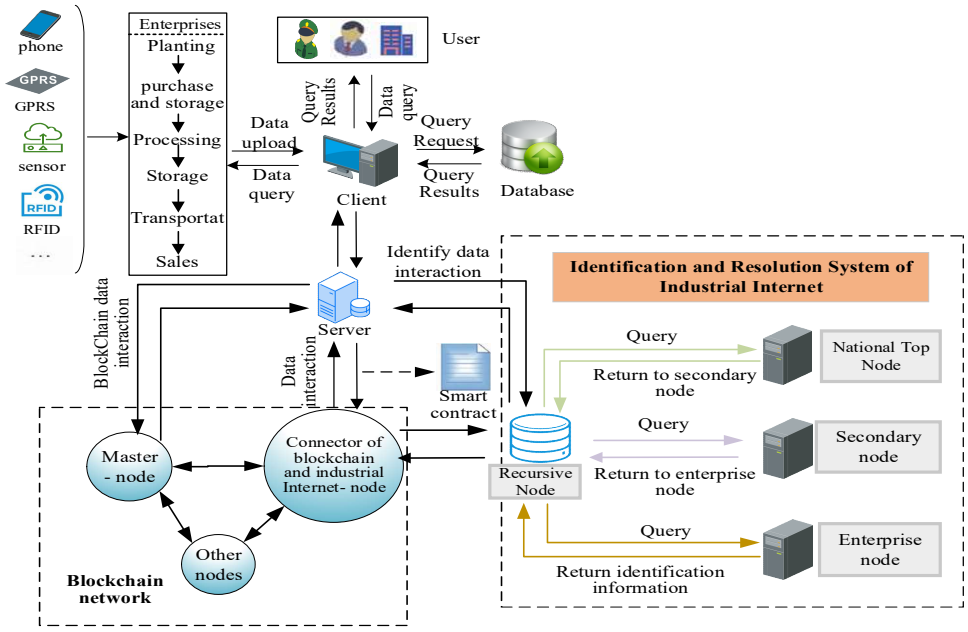
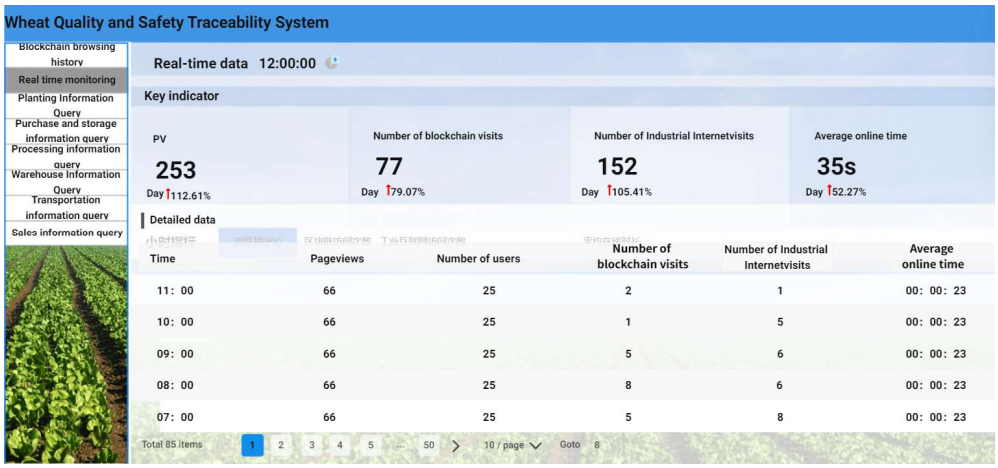


Figure 10. The operation process of the wheat quality and safety traceability system.

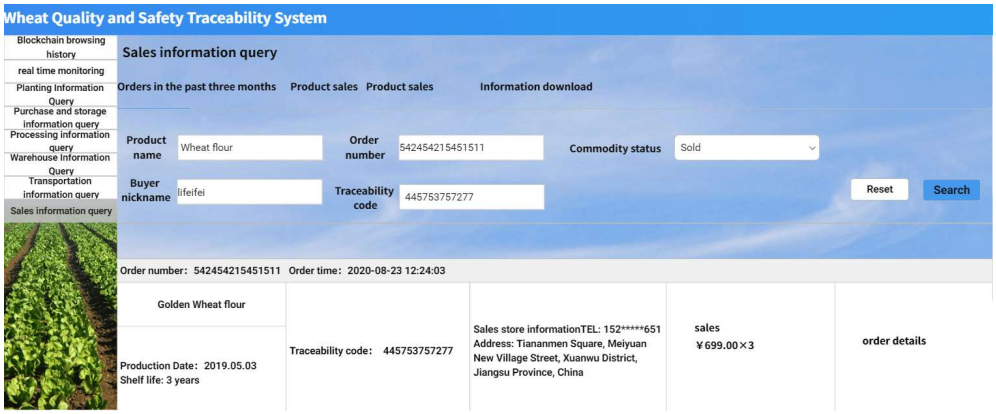
Through the research and field inspection of a flour factory in Beijing, the data of each link of the whole chain were obtained to analyze and verify the grain and oil traceability system based on blockchain and industrial internet identification technology to ensure the

practicability of the system. This flour mill has a complete chain. It includes six major links from planting to sales; including planting, purchasing and storage, processing, warehousing, logistics, and sales, involving planting, acquisition, impurity removal, storage, wheat conditioning, milling, flour blending, and packaging, there are eleven small links of storage, transportation, and sales.

However, due to the poor supervision and control of the factory, different problems occurred in all links, from warehousing to sales. Traditional data storage methods lead to data loss and data tampering. Therefore, the flour quality of the flour mill cannot be guaranteed. Once a safety accident occurs, it cannot be located to a specific link, nor can it be accurately identified as the responsible subject, and the loss caused cannot be compensated. This study builds a traceability system based on the grain and oil quality and safety traceability model of blockchain and identification analysis technology. Part of the system interface is shown in Figure 11.



(**a**)



(**b**)

Figure 11. System interface diagram. (**a**) interface diagram of real time monitoring; (**b**) interface diagram of the selling information.

With this prototype system, after the wheat flour is sold, the quality supervision department may randomly check if the batch of flour has quality problems or if the products that have not been sampled are bought by consumers. When consumers experience safety or health problem due to the product, they can follow instructions on the logo on the grain and oil product packaging to obtain traceability data. The traceability code corresponding to the identification can quickly and accurately find the key data information of the whole chain where the problem occurs. This allows finding the cause of the problem as soon as

possible and recalling the food with the problem while also making it possible to identify related people and hold them responsible for the safety problem. The data can also be used to identify links where the problem occurs and therefore allow focused monitoring of them. Therefore, the wheat quality and safety trusted traceability system can supervise all links of the whole chain of the flour mill, ensure the quality and safety of the flour produced by the flour mill and be responsible to consumers to avoid the recurrence of safety accidents.

5.2.4. Comparative Analysis of Traceability Systems

Compared with the traditional traceability system, the existing blockchain traceability system, and the industrial internet platform, the grain and oil quality and safety traceability system designed in this study has further improvements in the security of traceability data, traceability interaction efficiency, and traceability timeliness. As shown in Table 6, the traceability system can better serve the functionality of grain and oil quality and safety traceability and solve the problems of low tracing efficiency and inaccurate and incomplete traceability data.

Table 6. Comparative analysis of traceability systems.

System	Data Security	Data Interaction Efficiency	Traceability	References
Traditional traceability system	low	low	low	[3–5]
Existing blockchain traceability system	high	mid	mid	[14–17]
Existing industrial internet platforms	low	high	low	[18–20]
The traceability system of this study	high	high	high	

Compared with the traditional traceability system, the traceability system proposed in this paper has the following advantages:

1. Data tamper resistance: The data of the traditional traceability system is stored in the local database of the central enterprise, and the enterprise may tamper with or delete the data for its benefit. Hash encryption makes it difficult to tamper with the data. When the traceability data are deleted or artificially tampered with, the hash value changes accordingly, and other users on the blockchain will know that the data have been tampered with. Therefore, once the data are uploaded to the blockchain, they cannot be tampered with, thus ensuring the authenticity and credibility of the grain and oil traceability data information in the circulation process.
2. Data traceability: The significance of grain and oil traceability lies in the fact that after the grain and oil have been traded in multiple links, consumers and regulatory authorities can still obtain accurate and fast traceability information of grain and oil in all links of the whole chain. Because the data structure of the blockchain can store the information of each link in the whole chain of grain and oil quality and safety. If there is a quality and safety problem in the product, all processes and the data information stored in each link can be traced, which can solve the problem of data traceability.
3. Data sharing: The blockchain is decentralized, and nodes in the network equally send and receive messages to maintain the ledger together. Each node has a ledger, and problems on either side will not affect the process. Therefore, users in the whole chain of grain and oil quality and safety can realize information sharing, thereby solving the problem of information sharing difficulties and information islands.

Compared with the existing blockchain traceability system, the advantages of the traceability system proposed in this study are:

1. Improve the efficiency of traceability data collection. The existing blockchain traceability system focuses on data tracking and traceability and cannot solve the problem of data collection efficiency on the chain. If the data cannot be quickly and accurately uploaded to the chain, it will cause problems for enterprises in all links of the chain when they are querying and using the data, leading to immeasurable losses. As a module of the traceability system, the grain and oil quality and safety traceability

model based on the connector for blockchain and industrial internet proposed in this paper can improve the efficiency of uploading traceability data to the blockchain system, improve the efficiency of enterprises in all links of the traceability chain, which not only saves time but also saves costs.

2. Improve the traceability identification and improve the overall performance of the traceability system. By using the industrial internet identification analysis technology in the traceability system, the system migrated the problems of inconsistent identification, poor scalability, and high identification analysis complexity of enterprises in all links of the whole chain, which improves the traceability efficiency after problems arise, therefore helps in solving quality and safety problems faster.
3. In this study, a complete grain and oil quality and safety traceability system was constructed. The proposed grain and oil quality and safety traceability system includes all links in the supply chain, according to the data security requirements of the whole chain of grain and oil quality and safety chain participants (including enterprises, individuals, and regulatory authorities). According to the actual needs of the management mechanism, a wheat quality and safety traceability system was constructed and realized. It can not only strengthen the privacy protection, data security, and data reliability of the wheat quality and safety tracking and traceability process but also improve the system scalability and traceability efficiency while protecting the commercial interests of all parties involved.

6. Conclusions and Discussion

First, research on the characteristics of information flow in the whole chain was carried out. The whole chain of grain and oil quality and safety was constructed, and we also built a classification table of key information. Secondly, we integrated blockchain technology and the identification and resolution system of the industrial internet and proposed the concept and architecture of a connector for blockchain and the identification and resolution system of the industrial internet. Based on this, the traceability model of grain and oil quality and safety was constructed. At last, based on the Hyperledger fabric platform, a wheat quality and safety trusted traceability prototype system was established to verify the system implementation and case analysis of the model. This study has symbolic significance for the model construction of grain and oil quality and safety traceability. Because more and more consumers want to find complete and correct information about the goods they buy, more traceability work is focused on products in the food industry. The use of blockchain technology and the identification and resolution system of industrial internet technology ensures the accuracy and completeness of traceability data and reduces the involvement of external intermediate links. This study realizes the data link network coordination in the process of grain and oil quality and safety traceability, ensures the reliability of data, reduces the risk of human tampering, and greatly improves the quality and safety of grain and oil, production efficiency, and economic benefits. It plays a certain role in improving the quality and safety of grain and oil. This research can have some implications for grain and oil companies and regulators. In addition, the model framework, while conceptual, can help managers plan their implementation with the insights provided, providing actionable solutions for accelerating the digitalization of the grain, oil, and food industry.

However, we need further theoretical, practical, and quantitative indicators to study the practical benefits of applying blockchain technology and industrial internet technology to the process of grain and oil quality and safety traceability. First, the technical implementation cost, hardware facility management cost, and technical personnel cost involved in the model should be quantified, and the influence of these factors on the model should be evaluated to ensure the smooth deployment of the model. In addition, it is necessary to affect the implementation of the blockchain and identification and resolution system of the industrial internet in terms of data throughput, processing business ability, and traceability efficiency. Finally, it is necessary to consider the processing business capabilities of the

model in different business scenarios and under different conditions in order to better understand the real advantages and challenges of these solutions.

In the follow-up research, consideration will be given to the development of a consensus mechanism that is more suitable for grain and oil quality and safety traceability models and the development of smart contracts suitable for chain network connectors. In this study, the dynamic production factors and static production factors were unsuccessfully matched in the data traceability process, resulting in the traceability data being unable to upload to the blockchain and the industrial internet identification and resolution system. The limitations of this study in the data traceability process that cannot verify whether the matching data are completely uploaded include the unsuccessful matching of dynamic production factors and static production factors. How to flexibly endow the identification and resolution system of industrial internet coding to the production factors, make the transmission and reading of traceability process data more concise and faster, protect the data easily, and the intelligent analysis of on-chain traceability data will be the focus on in the next stage.

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