A Coding Management System for Traceability of Chinese Agricultural Products Based on Blockchain

Li-Xian Jiao[1,5], Yan-Dong Yu[1,5](✉), Yin-Bo Liu[1,5], Da An[1,5], Yu-Ge Yao[1,5], Zhu-qing Lan[2,5], Guo-jie Xie[3,5], Ting Wu[4,5], and Xiao-han Jia[1,5]

[1] Jining Normal University, Inner Mongolia 012000, China
cfssyyd@163.com
[2] Beijing Zhongsheng Huaan Information Technology Co., Ltd., Beijing 100089, China
[3] Zhejiang Key Laboratory of Open Data, Hangzhou 310000, China
[4] Hangzhou Innovation Institute, Beihang University, Hangzhou 310051, China
[5] National Engineering Laboratory for E-Commerce Transaction Technology, Baotou Big Data Research Institute, Inner Mongolia 014014, China

Abstract. In recent years, food safety has become an increasingly serious topic around the world. Problems such as pesticides, heavy metal pollution, and chemical additives in various agricultural products have attracted widespread attention. Therefore, reliable green agricultural products are urgently demanded by consumers. To this end, this paper uses item coding technology and a new generation of information technology such as blockchain to analyze the key data of the entire life cycle of green agricultural products (especially Ulanqab potatoes, oats and other geographical indication products) from growth to harvest to circulation. Blockchain trusted certificate. Through a complete traceability supervision system, product safety and quality will be improved, the market's visibility and recognition of agricultural products in the region will be enhanced, and the "quality and efficiency" of agricultural economic development will be achieved, thereby promoting the construction of smart agricultural big data projects.

Keywords: Food safety · Food traceability · Blockchain · Smart agriculture

1 Introduction

1.1 A Subsection Sample

IN recent years, with the rapid economic development and the continuous improvement of people's living standards, the quality and safety of agricultural products has become increasingly serious and has developed into a worldwide problem. For example, the "mad cow disease" incident in the UK, the "dioxin" incident in Belgium, the "poisonous cucumber" incident in Germany, the "trichloramine" incident in China. These food safety incidents made people feel worried. roughly, the causes of problems can be divided into

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the following categories: 1) Chemical fertilizers, pesticides and other substances are commonly used in some vegetables and fruits; 2) Heavy metal pollution in food; 3) The use of inferior raw materials in food manufacturing and processing it poses a great risk to food safety; 4) Excessive use of food additives and other chemical products in food processing, etc. If these problems with potential safety hazards are not solved in time, they may evolve into food safety accidents that endanger consumers' health and bring irreversible consequences to consumers.

Iit is worth noting that, as a major agricultural country in the world, China's annual demand for fruits and vegetables is about 730 million tons. However, in reality, due to the backward agri-food logistics system, the annual loss rate of agri-food in china is as high as 25%–30%. The advantages of agricultural development gradually decreased. At present, although China's agricultural product supply chain system has developed rapidly in recent years, it is still in its infancy on the whole, and there are still many problems, such as the shortage of modern equipment and funds, the low level of informatization, the chaotic supervision system, and the lack of a traceable system that can be monitored. It is for these reasons that the frequent and large-scale outbreaks of food safety incidents in China make consumers a vulnerable group in the market.

At present, a variety of effective methods or standards for food safety control have been proposed, such as ISO9000 certification, GMP (Good Manufacturing Practice), SSOP (Sanitation Standard Operating Procedure), HACCP (Hazard Analysis and Critical Point Analysis System) and so on. However, these standards are for specific links, and they lack the technical means or specifications to connect the supply chain. When there is a problem in a certain link in the middle, if you want to find the source of the problem or the product information related to the problem, the above methods are not perfect.

Based on the above reasons, the main purpose of this paper is to establish a supply chain traceability system for green agricultural products (especially Ulanqab potatoes, oats and other geographical indication products) based on blockchain technology to help the agricultural product market improve food safety and quality. The rest of the paper is organized as follows. In Sect. 2, we review the relevant literature on the application of blockchain technology in agricultural supply chains in recent years. Section 3 explains the technical background of the method used in this paper. The detailed process of the proposed agricultural product supply chain traceability system is described in Sect. 4. Finally, discussions and future work appear in Sect. 5.

2 Related Work

In recent years, agri-food supply chains have been extensively studied. For example, Li et al. developed a dynamic programming model for perishable food supply chains. This method attempts to minimize the loss of agricultural products and maximize the profits of the members of the agricultural supply chain by means of the real-time product quality information of the RFID system. In order to improve the delivery system of perishable products, Wang et al. proposed a rule-based decision support system for real-time monitoring and online decision-making during the distribution of agricultural products. The system includes radio frequency identification (RFID), a sensor network and a decision rule base.

As research progresses, food traceability management has been gaining attention, as traceable food can ensure food safety for consumers. Li et al. proposed a new product tracking model and traceability method based on radio frequency identification (RFID) semantic events for the needs of product tracking and tracing in the supply chain. At the same time, they define five types of RFID business events and extensible Markup Language elements to describe the logistics status of products. In addition, the method is applied to the winery management system to improve the anti-counterfeiting and anti-change performance of products, as well as inventory management. Interest in blockchain technology has surged, especially as it is being applied to agriculture. Tian F proposes an agricultural product supply chain tracking system that utilizes RFID and blockchain technologies. By collecting, transmitting, and sharing real data on agricultural products in production, processing, warehousing, distribution, and sales, the authors bring the traceability of trusted information into the entire agricultural supply chain to ensure food safety. Kamath R looked at the case of Walmart, which used blockchain technology to address food safety issues in the supply chain in response to food contamination scandals around the world. This case study highlights the implementation of blockchain solutions in the global food ecosystem to improve safety and reduce waste. Ciccio C D et al. leveraged new opportunities to run business processes in a supply chain environment on a blockchain infrastructure to provide full traceability to their runtime formulation. Their approach retrieves information only from transactions written on-chain to track the execution of process instances. They present their findings through a realized software prototype and report challenging context of the pharmaceutical supply chain through a case study. A fully decentralized, blockchain-based traceability solution for agrofood supply chain management, called agriculture, for management, is proposed by Caro et al. the solution enables seamless integration of IoT devices that produce and consume digital data along the supply chain. They define the classic farm-to-fork case, in a given vertical, in order to effectively evaluate AgriBlockIoT. Finally, they evaluated and compared the performance of the two deployments, including latency, CPU, and network usage.

Food safety issues have attracted an increasing attention from society. In order to effectively detect and prevent food safety problems and hold them accountable, it is essential to establish a reliable traceability system. Accurately recording, sharing and tracing specific data throughout the food supply chain, including production, processing, warehousing, transportation and retailing, is one of the government's key responsibilities. Lin Q et al. proposed a food safety traceability system based on blockchain and EPC information services, and developed a prototype system. At the same time, they proposed a management framework for on-chain and off-chain data, and the data explosion problem of the IoT blockchain can be alleviated through the traceability system. In addition, enterprise-level smart contracts are designed to prevent data tampering and sensitive information leakage during information interaction between participants. The final results demonstrate the effectiveness of the method. Yuan H et al. analyzed the process of supply chain management information system and the key technologies of blockchain, and proposed a supply chain management information system collaboration mechanism from the perspective of blockchain, including process and consensus collaborative management mechanism, optimized transactions process management and blockchain system consensus, accounting, etc. On this basis, the platform architecture

of the supply chain management information system under the collaborative mechanism is designed, which provides a reference path for the performance improvement and platform architecture design of the blockchain-based data transaction system. To address the problem of no access to blockchain data when private keys are lost, Ra et al. have proposed that public blockchain users can use the wallet program to recover their keys. And there are requirements on the server, which should simply recover and store the key and be resistant to malicious attacks. A password-protected secret sharing (PPSS) key recovery system is proposed by the authors, protected by a secure password from a malicious key storage server from a permissioned blockchain PBC. The reconfiguration of long-standing blockchains and byzantine fault-tolerant (BFT) systems poses fundamental security challenges. In the case of state-of-the-art proof-of-stake (PoS) blockchains, stake reconfiguration enables so-called remote attacks, which can lead to forks. Also, often BFT-based permissioned blockchain systems are reconfigured internally, making them vulnerable to similar "i'm still working here" attacks. To this end, Steinhoff S et al. proposed BMS (Blockchain/BFT Membership Service) to provide secure and dynamic reconfiguration services for BFT and blockchain systems, preventing remote and similar attacks.

Among these previous studies, the method of applying blockchain technology to achieve the traceability of different product information has received the most attention. However, few researchers have considered the importance of government regulators in product traceability mechanisms, especially for Chinese agriculture.

3 Technical Background

This section will precise discuss the key techniques covered in this paper.

3.1 The Blockchain Technology

The essence of blockchain is a technical solution for a reliable database, which is centrally maintained in a decentralized and trustless manner. This technical solution can use cryptography to create blocks through any number of nodes in the system. It's just like the name says: a blockchain. Each block contains data for all transactions in the system over a period of time, and it can create a digital format print that verifies the validity of the information and connects to the next block. There may be a large number of such blocks in the blockchain. The blocks are linked to each other in a linear (chain-like) time order, with each block containing the hash of the previous block.

Blockchain technology is a reliable database model composed of technologies such as a comprehensive consensus mechanism, cryptography principles, and smart contracts. It has security features such as decentralization, non-tampering, and traceability. It can eliminate the interference of human factors and realize the openness of the circulation process. It is transparent and targeted to solve various trust problems existing in the current traceability system, which is very suitable for the traceability of agricultural product quality. Therefore, the application of blockchain technology to the agricultural product quality traceability system mainly has the advantages of information security, information sharing, and information traceability. Applying blockchain technology to

agricultural product quality traceability can give full play to the advantages of the technology, promote the stable operation of the agricultural product quality traceability system, effectively prevent human tampering and network attacks, and effectively solve the current problems in the system.

Blockchain technology combined with the Internet of Things can provide greater transparency and efficient supply chains. At present, many blockchain architectures suitable for the Internet of Things have been proposed. Based on blockchain technology, a general, scalable, and easy-to-manage IoT distributed access control system architecture is implemented. The blockchain is used to store and distribute access control information. The management center node connects multiple constraint networks to the blockchain network, solves the access expansion problem of billions of restricted devices on the Internet of Things, and effectively improves the ability to handle load. Some scholars have proposed a multi-layer secure IoT network model based on blockchain technology. By dividing the IoT into a multi-level decentralized network, and adopting blockchain technology at all levels of the network, it reduces the cost of blockchain, while retaining the high security and credibility of the blockchain.

The integration of blockchain and network improves the reliability, security and transparency of the system, but with the rapid increase in the number of IoT devices, data transmission and data calculation, the system has an increasing requirement for transmission bandwidth, calculation and response speed. As the future progresses, the scalability, storage capacity, and security issues of the system need to be further improved.

3.2 Item Coding Technology

Under normal circumstances, the so-called item code is mainly used in the creation of the relationship between an item object and a code, and when the item object is represented by a code, the code is called an identification code, and if a code is representing a certain type of item, the code is called a classification code, and if the code has a unique attribute to a certain item, the type of code is called an attribute code. In practical application, relevant units and personnel need to strengthen strict control over the application of item coding to avoid the occurrence of certain undesirable problems, and provide sufficient foundation and guarantee for the improvement of the overall economic level of the country and society.

With the emergence and popularization and application of item coding, all walks of life in China have conducted in-depth research on it. In order to meet the development needs of all walks of life, the number of coding types is also increasing. After investigating a large number of item codes, it is found that in the process of general classification of products, it is mainly based on United Nations statistics, allocating enough professional managers, and providing them with goods, services and economic activities. At the same time, with the application of the CPC, a scientific and reasonable comparison between international statistics and economics can also be made. In addition, in order to ensure the level and quality of item coding, the relevant departments have also formulated the "Commodity Name and Coding Coordination System" for establishing a commodity classification and coding system to manage import and export.

Due to technical barriers and other reasons, there are many standards for item coding and identification, a lack of uniformity, and there are very few open coding systems,

among which the GS1 system is the most widely used. The China Article Numbering Center uses the GS1 system, which originated in the United States and provides accurate codes for identifying goods, services, assets and locations worldwide. These codes can be represented by barcode symbols for electronic reading required for business processes. The system overcomes the limitations of manufacturers and organizations using their coding systems or some special coding systems, and improves trade efficiency and responsiveness to customers. The GS1 system uses the Global Trade Item Code, which is also the most widely used identification code in the coding system.

4 Detailed Description of System Functions

The item coding management system realizes one item, one code, one person, one code, corresponding to the information collection of the whole process of planting from the sowing period to the fertilization period to the final harvest period of the relevant agricultural products planted by the farmer and the farmer, and realizes the coding of agricultural products set up. In terms of product coding, the information coding of geographic location, farmer and crops are set in the system, and a batch-to-coding method is adopted for crops. In the system, set up coding packages corresponding to countries, provinces, cities, farmers, agricultural products, etc., and input the information of farmers and agricultural products to generate corresponding codes for easy traceability.

4.1 System Implementation Functions and Requirements

The functional structure diagram of the item code management system is shown in Fig. 1.

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The information collection of the planting process realizes the registration of seed/seedling information, the information registration of the seeds/seedlings purchased by the farmer, and the registration of the fertilizer information used. Planting information registration realizes the registration of planting data in the growth process of farmland/greenhouse, sowing, watering, fertilization, loosening, insecticide, weeding, etc., including the registration of time, category, quantity, etc. Harvest information registration realizes the registration of the quantity and time of harvesting batches of agricultural products during the harvest period.

The farmer management realizes the farmer's real-name authentication and information maintenance, and sets the farmer's code rules and checks the types of agricultural products grown by the farmer.

4.2 Detailed Description of Functional Requirements

The system involves the following roles: 1) Farmer: Responsible for the analysis of the farm's business decisions, the management of all the farm personnel, and the tracking and management of the entire process of planting products on the farm. 2) Growers:

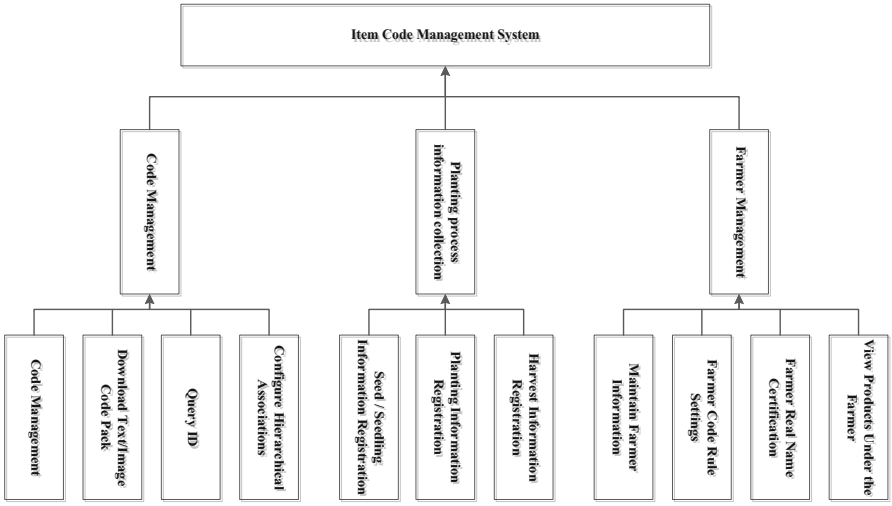

Fig. 1. Functional structure diagram of the management system

responsible for the selection, planting, irrigation and fertilization of agricultural products. 3) System administrator: responsible for system coding rule management, farm/farmer management and information maintenance, basic data maintenance (seed/seedling information registration, statistics) 4) Ordinary users: Ordinary users can log in to the system, scan the code to identify the product through the "traceability interface", and display information such as planting, fertilization, pest control, and harvesting of the product. A detailed introduction is given below.

(1) Farmer Functional Requirements

Farmer management realizes the farmer's real-name authentication and information maintenance, sets the farmer's rules, checks the types of agricultural products grown by the farmer, and collects planting process information. Among them, the maintenance of the farmer information realizes the addition of the basic information of the farmer. The real-name authentication of the farmer realizes the setting and maintenance of the basic information of the farmer's personnel. The farmer coding rule setting realizes the setting and viewing of the basic codes of the farmer's personnel, regions, and commodities.

The information collection of the planting process realizes the registration of seed/seedling information, the information registration of the seeds/seedlings purchased by the farmer, and the registration of the fertilizer information used. Planting information registration realizes the registration of planting data in the growth process of farmland/greenhouse, sowing, watering, fertilization, loosening, insecticide, weeding, etc., including the registration of time, category, quantity, etc. Harvest information registration realizes the registration of the quantity and time of harvesting batches of agricultural products during the harvest period.

The detailed management introduction is given below: 1) Base information management: Click on the plot data in the system to view the information about the crop

growing plot, which can include the plot name, province, person in charge, contact number, area (mu), floor plan and other information. 2) Land preparation information: record the land preparation time, land preparation method, person in charge and other information. 3) Seedling management: Seedlings and seedlings mainly involve information on the sources of seeds produced by plants, breeding methods and sources of seedlings produced by animals. The main information includes the following: seed name, seed source, seed status, breeding method, whether it is genetic engineering, whether it has undergone chemical and radiation treatment. 4) Fertilization management: Fertilizer is an important part of agricultural production. Fertilizer management mainly collects fertilizer-related information, including fertilizer type, fertilization time, fertilized crops, fertilization amount, fertilization person and other information. 5) Irrigation management: Water is an important factor in the process of plant growth. Irrigation is one of the important processes in the planting process of agricultural products, providing sufficient water for plants. The information collected during plant irrigation includes date, duration, and person in charge, irrigation period, irrigation method, and etc. 6) Flower and fruit management: Flower and fruit management is a commonly used fruit tree management method in the growth process of fruit trees. The management measures for fruit tree flowers and fruits ensure high yield, stable yield and high quality of fruit trees, such as thinning flowers and fruits, fruit coloring, etc. Information on flowers and fruits can be collected, including specific measures, time, operators, etc. 7) Pruning and pruning: During the growth of fruit trees, pruning is performed in order to increase product yield or maintain tree shape, such as topping and topping of cotton. Collect pruning information, such as pruning date, operator, pruning method, and pruning area. 8) Pest control: Information on pest control mainly involves disease control measures for plant production and animal production, as well as drug use and management information, including the name of pests and diseases, time of occurrence, control methods, control measures, and whether chemical products are used. 9) Picking management: Picking management is mainly to determine the picking time, quantity, method (manual or mechanical) and other information in the picking process, so as to ensure that the picking information of the product can be queried in the process of product traceability. Figure 2 shows the commodity viewing interface under the farmer.

(2) Growers' Functional Requirements

The role of the grower is the role of the actual operation of the product seedlings. After the seedlings are sown, fertilized, pest and disease control, and the agricultural products are harvested, they need to log in to the system and record and register the specific operations so that people in need can view them. The role of the grower needs to log in to the system and bind it to operate. After actually operating the agricultural products at different stages in reality, enter the "scan code operation interface" to record the operation behavior.

The detailed discussion is as follows: 1) The sowing record information includes: crop code, variety name, sowing method, sowing plot number, and input of sowing method information. 2) The fertilization record information includes: crop code, fertilization time, fertilization amount, fertilizer number, fertilizer type, and the input of operator information. 3) Pest control information includes: crop

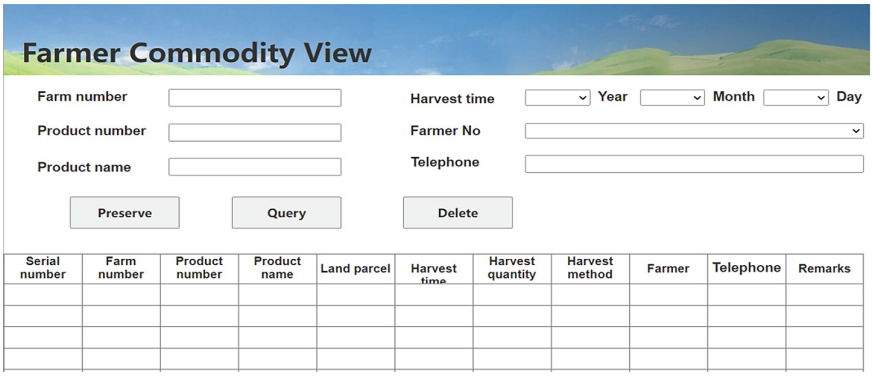

Fig. 2. The farmer's commodity viewing interface

code, time, name of pests and diseases, control methods, control measures, whether drugs are used, drug number, quantity used, and input of operator information. 4) Harvest record information includes: crop code, crop name, farm, plot, harvest time, harvest batch, and harvest method. Figure 3 shows the summary page of planting process information collection.

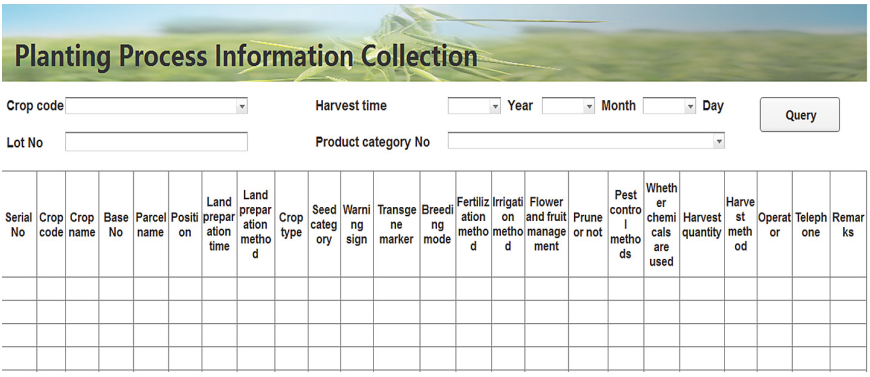

Fig. 3. Summary of planting process information collection.

(3) Administrator Functional Requirements

The general administrator role mainly has three functions: 1) The source code traceability management function can realize source code traceability type management and source code traceability group management. The traceable source code type management function can add, modify and delete different types of traceable source code according to user needs; the traceable source code group management function can check the coding rules, names, number of operations and creation time. 2) The traceability process management function can realize the management of information such as adding and modifying the traceability process. 3) Rights management functions are divided into role management and user management. The role

management implements the addition, deletion, modification and query of roles, and displays the operation times, status and creation time of different roles. User management realizes user additions, deletions, changes, and permissions allocation.

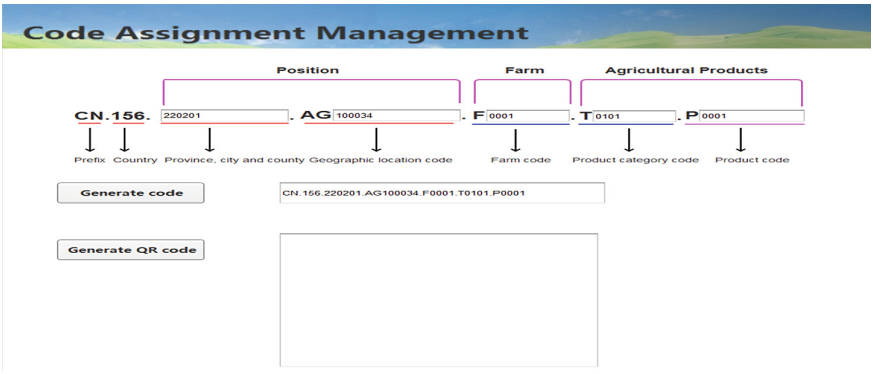

Fig. 4. Assignment management interface.

(4) System Administrator Functional Requirements

System administrators need to maintain the bottom layer of the system, and manage and maintain coding rules, farm/master information and basic data. The system administrator has three modules: coding management, farm/master management, and basic data management. The coding management module mainly completes the functions of coding rule setting, code assignment management and coding analysis. Coding rule setting mainly completes the design and definition of different types of coding rules. Code assignment management is a summary of different types of code sets. Different data combinations can generate different codes and QR codes, as shown in the Fig. 4 shown. The code analysis uses the "code analysis interface" (as shown in the Fig. 5) to scan and identify the QR code, and displays the code through the "code analysis result interface" (as shown in the Fig. 6), and parses the code in the form of text.

The farm/master management module mainly completes the maintenance and statistics of farm information and farmer information data. The farm information maintenance function realizes the maintenance of farm information data, mainly including the modification and deletion of the farm name, farm number, farm owner name, contact address, planting crop types and planting area information; the farm information list is a list display module for farm information. The farm information in the system can be displayed more intuitively and quickly; the farmer's real-name authentication function is to record the farmer's personal information, mainly including the farmer's name, contact information, contact address, ID number and other information.

The basic data management module realizes the management and maintenance of basic data. It mainly includes the management and maintenance of seed/seedling information, land identification information, drug information, and fertilizer information. The seed/seedling information registration interface can add, delete, and

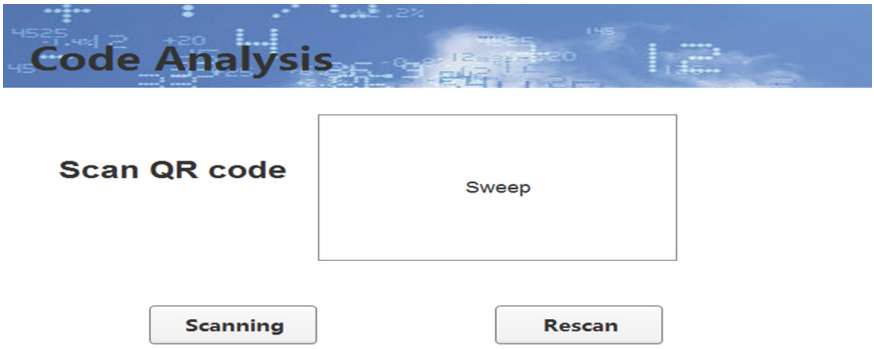

Fig. 5. Code analysis interface.

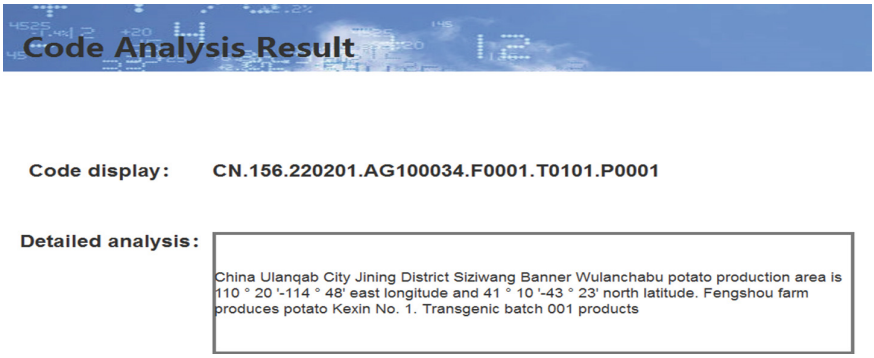

Fig. 6. Code analysis result interface.

modify information such as product type number, seed number, seed category number, etc. The seed/seedling information statistics interface is a list display module for seed/seedling information, and you can also directly query certain information through this module. Specific seed/seedling information; the land information registration interface can add, delete, or modify information such as land number, plot name, province, city, etc. The land information statistics interface is a list display module for land information, and you can also use this module Directly query a specific land information; the drug information registration interface can add, delete, or modify information such as drug number, drug name, functional category, and technical registration. The drug information statistics interface is a list display module for drug information, which can also be Directly query a specific drug information; the fertilizer information registration interface can add, delete, or modify information such as fertilizer number, fertilizer name, nutrient type, and character. The fertilizer information statistics interface is a list display module for fertilizer information, and you can directly Inquire about a specific fertilizer information.

(5) Code Management

Coding management implements coding application management and review and release management. Coding application management includes manual application and automatic application. The main function of manual code management to realize the manual application code is that when the user is familiar with the code, the user can directly fill in the content of the first seven digits of the code, and the system automatically extracts the company code from the registration form. After the code is obtained, the system will automatically parse the obtained code, so that the user can know whether the code he entered meets the code he needs. When saving the code, the system will also prompt whether to fill in the attributes of the code. After entering the seven-digit code (only seven digits are allowed in the input box), you must press the Enter key to end, so as to trigger the operation of the system. After getting the code, the user is not allowed to modify it. If you want to modify it, you must click the clear button and then re-fill it. Users can only fill in the codes assigned to their own rules. If they are not within the scope of their own rules, the system will pop up a dialog box indicating that the applied codes exceed the assigned rules. If the entered code does not conform to the encoding rules, a dialog box will pop up to prompt the user that the entered code is incorrect and the code cannot be parsed correctly. Please re-enter a new code. Figure 7 shows the interface of encoding rule setting. Automatic code generation management requires selecting code rules, filling in the corresponding code information, and the system automatically obtains the number corresponding to the code package, thereby generating a new code.

Code review enables code managers to manage the codes that designers have submitted for applications, including review and release. First, make a logical judgment on the coding that has been applied for. The logical judgment is only to judge whether the coding conforms to the rules according to the coding rules. For the coding that conforms to the coding rules through logical judgment, the system will fill in "Y" in the column of "Pass", otherwise Is empty. For codes that conform to the coding rules and the coding administrator thinks that they cannot be applied for, the system will pop up a dialog box to ask for the reason for not applying, and the

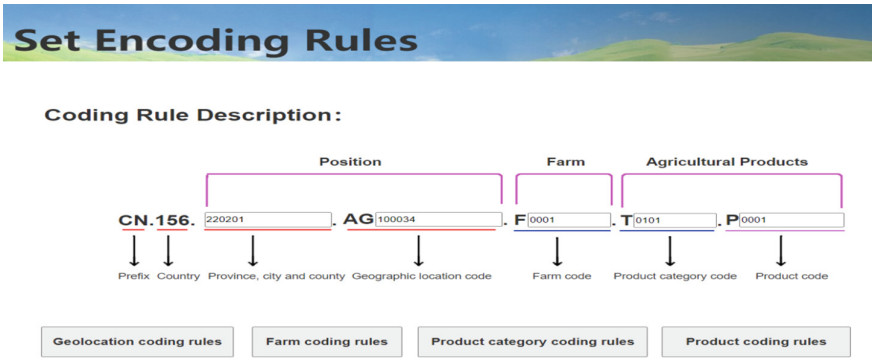

Fig. 7. Setting of encoding rules.

system will automatically return the codes to the applicant for processing. If there is no problem with the coding, right-click and click to go to the review status in the pop-up menu, then these codes have passed the review and are waiting to be published. For a code that has been released, the system does not allow deletion of the code, but can only be abolished.

5 Conclusion

This paper shows that blockchain technology can help us build a verified and trusted environment for transparent and more sustainable food production and distribution that integrates key stakeholders into the supply chain. However, there are still many problems and challenges. Therefore, the government is advised to lead by example and promote the digitalization of public administration. In the future, more enabling technologies in the agri-food chain should be encouraged and popularized so that the agri-food supply chain remains sustainable and well-competitive.

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