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Application Process Design of Digital Quality Monitoring and Traceability System for Fresh Agricultural Products

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Abstract. The quality and safety of fresh agricultural products have become a top priority in the study of agricultural products, and there is a need to shift from the traditional supply chain approach to a digitally enabled smart supply chain, which can realize data collection, monitoring, control, positioning, tracking and supervision of fresh agricultural products in production, processing, transportation, sales, and other aspects, to improve the efficiency of agricultural production, processing, and circulation, while also enhancing consumer satisfaction and government The paper summarizes the quality monitoring of fresh agricultural products. This paper summarizes the main stages of the development of fresh agricultural products' quality monitoring and traceability system and the corresponding traceability technologies and introduces the technical characteristics and application performance of IoT technology, blockchain technology, and their integration respectively. Combining the application characteristics of IoT and blockchain technologies, it summarizes the distribution and management mode of typical product identification such as QR codes and RFID tags in the whole process of the supply chain from four aspects: IoT information collection, real-time monitoring, and early warning, product information traceability, and product quality supervision and proposes a kind of application process of pig supply chain traceability digitalization scheme, taking pig as an example. The research results of this paper have important reference value for the innovative development of a blockchain-enabled supply chain.

Keywords. Fresh produce traceability, smart supply chain, blockchain, Internet of things

1. Introduction

Fresh agricultural products, including vegetables, fruits, meat, poultry, fish, eggs, and milk, are fresh and perishable due to their short life cycle. At present, the value loss rate of fresh agricultural products in China reaches 25-35% [1]; the perishability of fresh agricultural products also increases the difficulty of supply chain management [2]; the quality safety of agricultural products is the foundation of food quality safety, which is related to people's health and life safety, and concerns farmers' income increase and high-quality development of agriculture and rural areas [3]. The traceability information provided by most current traceability systems is very incomplete and in-depth, and cannot match the actual needs of consumers. Although various departments and regions

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have developed targeted traceability platforms for fresh agricultural products, the service areas and service targets of these traceability systems and traceability platforms are too narrow, the sustainable service capacity is weak, and the commercial operation capacity is insufficient to meet the actual needs of safe circulation of fresh agricultural products. The supply chain of fresh agricultural products is a continuous process from farm to table, which usually includes production, processing, distribution, and marketing, and is a typical "post-check commodity". and opportunistic behavior.

The new generation of information technology industries is revolutionizing and reshaping every industry, such as the Internet of Things (IoT), Big Data and Analytics (BDA), Systems Integration (SI), Cloud Computing (CC), Simulation, Autonomous Robotic Systems (ARS), Augmented Reality (AR), Artificial Intelligence (AI), Wireless Sensor Networks (WSN), Cyber-Physical Systems (CPS), Digital Twins (DT) and additive manufacturing (AM) to digitize the industry [4]. Smart technologies provide technical guarantees to meet the safety of fresh agricultural products supply chain, so it is necessary to rely on these technologies to develop a quality monitoring and information traceability system covering many aspects of agricultural products' production, processing, distribution, and consumption[5]. By entering the product traceability code in the system, it is easy and fast to check the details of each process of the product from production to sales, and if quality problems occur, the root cause of the problem can be quickly identified and dealt with in time to prevent the spread of hazards.

2. Review of technical methods and trends

2.1. Development stage of quality monitoring and traceability system

Traceability refers to the organization of traceability to record and locate products through the various stages involved in manufacturing, processing, distribution, and handling feed and food products, from primary production to consumption. It is "the unique and reliable identification of items and/or batches" and represents a technology that makes the fresh produce supply chain more mechanically transparent [6]. Today, consumers increasingly require verifiable evidence of traceability, which has become an important criterion for food quality, safety, and sustainability. Product quality monitoring and tracking systems have been an effective measure for food quality and safety assurance for nearly three decades now.

The quality monitoring and tracing system of the fresh agricultural products supply chain focus on tracking and recording the data of fresh agricultural products in production, processing, transportation, and sales, and real-time monitoring of the product and environmental status in key stages[7]. Information technology application is an important basis for the development of quality monitoring and tracing system, and the main stages of the current development of quality monitoring and tracing system for fresh agricultural products are summarized in the main line of technology application (as shown in Table 1).

Table 1. Quality control and traceability system development stage and characteristics

Stage	Period	Features
1.0	From the 1990s to around 2007	Information recording
2.0	From 2008-2015	Information integration
3.0	2016 to Present	Intelligent decision-making

1.0 stage in the 1990s - 2007 or so, this stage of relevant laws and regulations were introduced one after another, and its traceability is based on single link information records. For example, having the product certified by a third party or labeling the product according to the reputation of the seller [8]. However, many consumers still doubt the authenticity of such information[9]. In conclusion, this phase is more of a simple, single-link data and information system, and more of a legislative perspective to explain and provide for product traceability [10].

Around 2008-2015 is the 2.0 stage of quality monitoring and traceability system development, which mainly realizes information integration through IoT technology and can achieve quality and safety assurance for a variety of application scenarios. Wolfert et al. in 2017 systematically discussed how agriculture can adopt advanced ICT-enabled big data technologies, such as IoT technologies and cloud computers, to achieve smart agriculture [11]. The development of IoT information technology provides the basis for a comprehensive supply chain quality control and tracking system that integrates total awareness, information transfer, and intelligent management.

From 2016 to the present, the quality control and tracking system have ushered in stage 3.0, which promotes intelligent decision-making and leads to smart innovation through the application of emerging information technology. The development of new-generation information technology provides technical support to solve the problems faced by China's fresh agricultural products supply chain quality monitoring and tracing, and these emerging technologies are interrelated, although each has its focus, and their logical relationships are shown in Figure 1.

(1) The main role of the Internet of Things (IoT) is to actively collect various kinds of information, and the development of mobile networks based on cell phones has turned everyone into an information generator; the application of IoT technology has improved the visualization and transparency of the agricultural supply chain, reduced the uncertainty of the supply chain, and improved the intelligence of the supply chain management [12].

(2) Big data mainly concentrates a large amount of structured and unstructured information, and the data is mainly used to manage supply chain links and to a limited extent for further analysis [13].

(3) With the growth of information volume and complexity of the system requires cloud-based servers for information memory and storage, and in turn, the parallel computing technology of cloud computing technology promotes more efficient and intelligent management of big data processing;

(4) The cultivation of artificial intelligence models also requires the support of a large amount of cloud computing funds, and the wisdom model established can be counter-affected on the Internet of Things, thus realizing more perfect and wiser management of all kinds of foreground technologies of the Internet of Things [14].

(5) Blockchain is an intelligent P2P network. Each block is configured with information such as timestamps, random numbers, difficulty values, and large amounts of transaction data Blockchain technology has great potential to transform supply chain functions, from supply chain sourcing to business process re-engineering to security enhancement [15].

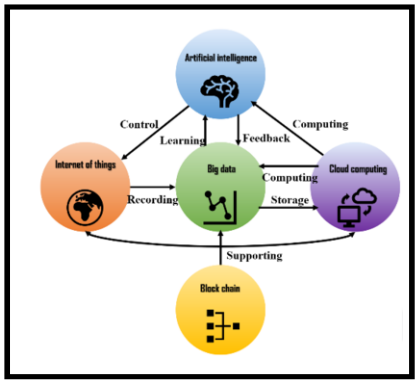

Figure 1. Schematic diagram of the logical relationship of the new generation of information technology

2.2. Digital development trend of quality control and traceability system

Next-generation information technology in the fresh produce supply chain creates important conditions for supply chain intelligence enhancement to address several supply chain challenges related to supply chain transportation safety, environmental impact, food security, and crop loss.

- **Big data-improve quality and safety early warning capability**

Big data aggregates massive data, and the highly virtual nature of big data processing facilitates the use and control of product traceability data across industries and environments, providing more accurate and comprehensive traceability data for product safety early warning, thus transforming "post-event recovery" into "pre-event prevention".

- **Internet of Things - Promote the reform of supply chain wisdom**

The supply chain of fresh agricultural products has a long cycle, involves multiple links, and requires the collaboration of multiple parties. Internet of things mainly refers to the use of RFID technology, infrared sensors, intelligent sensing, biometric network, pervasive computing, and ubiquitous Internet, through the network of information exchange and communication between people and objects, thus achieving a network of positioning, identification, tracking, and management of goods.

- **Blockchain - Enhancing the credibility of the whole traceability**

Blockchain is a ledger of accounts and transactions written and stored by all participants. It is an immutable means of storing information that is accepted by all participants [16].

2.3. Research on traceability technology based on a blockchain + IoT digital platform

Domestic fresh agricultural suppliers are generally characterized by extended supply chain strips, discrete products, and heterogeneous data from multiple sources, which cannot meet consumers' demand for food quality and safety information traceability. To truly solve the supervision of fresh agricultural products, it is necessary to implement a traceability system with the help of modern information technology [17].

The traceability system relying on the Internet of Things effectively solves the problem of product quality and safety in the supply chain of agricultural products. However, because the information of traceability has the problem of insecurity and the

possibility of data tampering, it cannot solve the problem of information asymmetry. Therefore, the use of IoT and blockchain technology can achieve full data transparency, which can not only reduce the asymmetry between enterprises and users, improve the supervision and management of agriculture by relevant government agencies, but also remove counterfeit and shoddy products to purify the market, thus further improving and perfecting the national quality control system of the fresh agriculture [18]. To conclude blockchain combined with other advanced technologies, such as the Internet of Things, can realize automatic real-time uploading of data to the blockchain without human intervention [19].

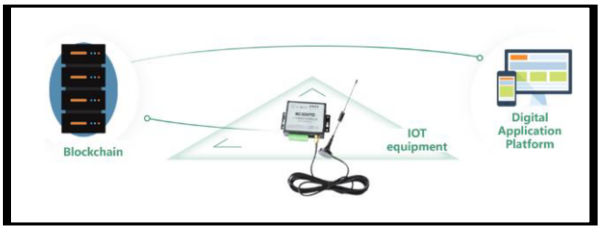

Figure 2. Blockchain + IoT-based digital platform diagram

3. Information collection and application process of quality monitoring and traceability system - taking raw pork as an example

3.1. Traditional pork supply chain security risks

The traditional fresh produce supply chain faces many challenges such as financing risk, counterparty risk, and lack of consumer trust. Under the traditional conditions, a pig from the farmer to the factory, then to the storage center, and finally to the retailer, a series of processes are faced with huge potential information dangers, including uncontrollable reasons caused by tampering, misinformation and collusion, environmental pollution caused by poison, pests, bacteria and viruses, including temperature, humidity and expiration dates caused by spoilage, etc., all of the above dangers can cause certain The above-mentioned risks can cause certain losses, liabilities and economic and social impacts, as shown in Figure 3.

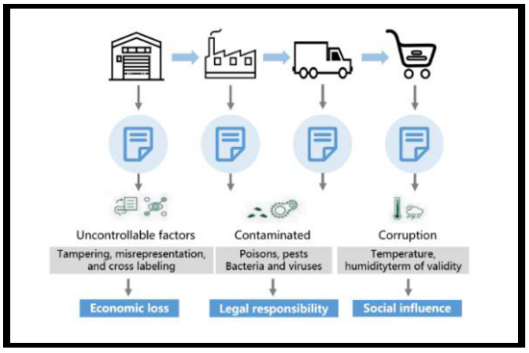

Figure 3. Data risk of the pork supply chain under traditional conditions

3.2. Digital supply chain platform information collection tools

The information collection of the fresh agricultural products supply chain is an important foundation to realize traceability, and the correctness and continuity of information collection in each link is the key to the detection and management of the fresh agricultural products supply chain.

Table 2. Quality control and traceability system development stage and characteristics

Links	Production	Processing	Logistics	Sales
Information collection	Breeding place Breeding time Breeding environment Growth state Material record Vaccine record Quality inspection report	Processing unit Processing environment Packaging materials Packaging equipment Shelf life Quality inspection report	Product temperature Humidity Residue of preservative Environmental conditions Transportation route Transportation company information Warehousing records	Product price Sales unit Storage time Storage environment and Sales time

Taking RFID pig electronic ear tag and two-dimensional code as information carriers, it establishes electronic identity files for each pig, realizes the whole process information record and management of feed, breeding, epidemic prevention, treatment, and sales, establishes perfect production files for breeding enterprises, collects basic data for pig product traceability, realizes information management of upstream and downstream enterprises in the supply chain, and also provides government supervisory departments with pig supply chain Real-time supervision and traceability of key links in the supply chain [20].

1) **Identification**. By equipping the newborn piglets with RFID electronic ear tags, the identity profile information is created for each piglet. The ear tag is associated with the pig's unique ID number and contains all the information about the individual during the growth process.

2) **Data collection**. In monitoring and guiding the various aspects of feeding, the breeder holds the RFID reader or collection device, reads the pig identification, and enters the relevant information, including the epidemic, feeding input supply, testing and other data from production to slaughter, and uses the information guidance system to input the collected information into the system, and if problems are found, every detail of the feeding process can be tracked, even down to each pig, to timely To develop measures.

3) **Marking conversion**. When the pig passes the inspection and is sent to the slaughterhouse, the RFID system will be entered into the slaughterhouse, the slaughterer, the date of slaughter, etc., and will be transferred to the system. After the pigs are slaughtered, they are processed into partial cuts and divided according to different parts such as heads and feet. Next, the RFID of the pig is converted into a 2D code. First of all, they are in each part of the pig attached to the exclusive two-dimensional code mark (large label), each part of the cut out of the size of the piece of meat, and then separately attached to the small label. The size of the marker is the data recorded on the pig RFID ear tag.

4) **Real-time monitoring of storage**. In the transportation and storage process, the QR code on the package is associated with the sensor device, real-time monitoring of environmental temperature and humidity, gas concentration, and other changes, and data recorded into the QR code.

5) **Full record of the sales process**. In the circulation process, it may pass through several intermediate links such as wholesalers, distributors, and retailers, and each participating entity needs to enter the relevant information of that node into the QR code, such as enterprise qualification, arrival time, etc.

6) **Consumer traceability**. After the pig is on the shelves, the public can check the "past life" of the pig through the QR code on the pig's bag, so that they can know which pig they are buying, which part of the pig, which kinds of pigs and the growth conditions, health condition, slaughter date, transportation time, etc.

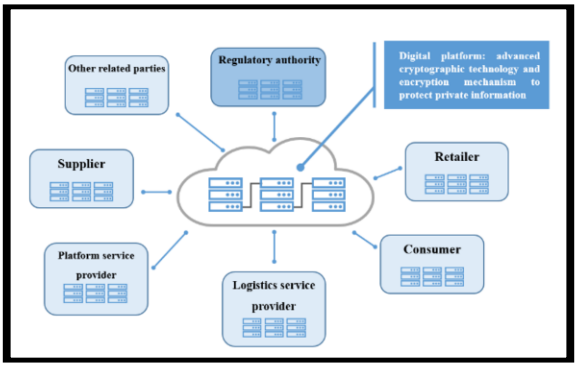

Figure 4. Flow chart of pork food supply chain management based on blockchain

The high difficulty of monitoring and traceability is a pain point in the supply chain of meat products, and a digital platform that combines blockchain and IoT allows for the timely sharing of information on key points in the meat handling chain in supply chain management. These include meat origin, slaughter date, quality, transportation environment, food safety, and organic product certification through blockchain, IoT, and wireless sensor networks, which can effectively enhance consumer trust [21].

3.3. Traceability platform application process analysis

IoT information collection, real-time monitoring and early warning, product information traceability, and product quality supervision are the core services of the integrated service platform for quality monitoring and traceability of fresh agricultural products supply chain, information collection mainly relies on product identification, and the completion of information collection is the basis of the following three steps.

- **Real-time monitoring and early warning process**

Traceability tags (such as QR codes, RFID electronic tags, etc.) are installed on the container trucks configured with refrigerated containers to track and record the loading and unloading of raw pork in real-time. When each overall packing box is encapsulated into the refrigerated container, establish the correlation between raw agricultural products packing box ID and refrigerated container ID. When the refrigerated container is placed into the container truck, the association relationship between the refrigerated container ID and the container truck ID is established. Once there is a dangerous state, the vehicle monitoring system quickly receives the danger control signal from the monitoring platform and makes an alarm, and the staff receives the alarm information and immediately takes targeted safety measures such as cooling or heating to determine the safety of the storage environment during the transportation of agricultural products.

- **Product information traceability process**

The integrated service platform of quality monitoring and traceability based on a blockchain + IOT big data mainly provides services to users through Web terminal and mobile app terminal. After the traceability file of fresh agricultural products is established, merchants and consumers can check all traceability information in the file of fresh agricultural products in two ways: the platform website and cell phone mobile terminal. The website platform and cell phone mobile terminal can query the product information that consumers need to trace by keywords on the product information retrieval page. When the keywords are entered, the platform will call the platform application product query interface to display the relevant batch information queried by consumers, to enter the traceability file of the product to view all traceability information of the product. Consumers can also enter the traceability code on the product label on the product information retrieval page to trace all the information about this agricultural product.

- **Product Quality Supervision Process**

The fresh agricultural products quality supervision platform consists of a traceability supervision platform, circulation tracing platform, and information public platform, which provide information supervision services for the government, enterprises, and the market public respectively; the supply chain node enterprises such as farmers, processing plants, transporters, and sellers upload the relevant information of fresh agricultural products supply chain to the blockchain through the system, and at the same time can supervise the upstream and downstream nodes of the supply chain; the platform uses big data technology to analyze and organize the received information and provide it to relevant government regulatory departments, as well as for consumers and node enterprises to check.

4. Conclusion

As one of the seven strategic emerging industries, the new generation information technology industry can not only form an emerging growth point with a certain scale, but also build a key foundation for the transformation of traditional industries. This paper firstly compares the development of traceability system and interprets the inner connection and technical characteristics of new generation information technology. Through overview and analysis, the development history of the traceability system from 1.0 to 3.0 is proposed, and the trend of intelligent enhancement of the traceability system is analyzed. Based on blockchain technology, a digital traceability scheme for pig supply chain is proposed to realize data collection, monitoring, control, tracking and supervision of pig production, processing, transportation and sales, and to guarantee the quality and safety of pigs from farm to table.

This paper makes full use of the new generation of information technology such as blockchain to promote the transformation and development of traditional industries such as agriculture and logistics. By building a fresh agricultural products supply chain under the blockchain+Internet of Things environment, creating a fresh agricultural products quality monitoring and traceability system integrating technology integration, hardware equipment, software function modules and operation mode, and implementing whole-process monitoring and information tracing for the product supply chain, it can effectively improve the overall quality of fresh agricultural products, construct a fresh agricultural products safety from source to table and from online to offline for consumers It can effectively improve the overall quality of fresh agricultural products and build a

safe chain of fresh agricultural products from source to table and from online to offline for consumers to ensure quality and safety of fresh agricultural products. In the future, under the environment of supply-side reform, improving the quality, safety and efficient supply level of agricultural products will be the goal of scholars' continuous exploration and optimization.

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