The Application and Prospects of Blockchain Technology in the Development of National Geographical Indication Agricultural Products

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Abstract. The application of technology to strengthen the protection and development of national geographical indication agricultural products is a trend, and there have been many beneficial explorations. Daxing watermelon is one of the ten national geographical indication agricultural products in Beijing, and the product has been widely recognized. Its rich culture also has great appeal to consumers. However, in recent years, it has still faced the threat of counterfeit and shoddy products, causing losses to farmers and consumers. This study builds a traceability system based on blockchain technology for Daxing watermelon, displaying data on watermelon production, processing, transportation, and transactions, as well as corresponding cultural information to consumers, in order to establish consumer confidence in Daxing watermelon. Based on this, this study also explores the role that blockchain technology can play in protecting and developing Daxing watermelon, pointing out that there is still room for its application in traceability, optimizing the supply chain, reducing farmers' production costs, and cooperating with government regulatory departments.

Keywords: Blockchain technology · National Geographical Indication · Daxing watermelon

1 Introduction

Geographical indication is one of the seven independent intellectual property rights specified in the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) of the World Trade Organization (WTO) [1]. On February 1, 2007, the State Administration for Industry and Commerce of China officially announced the Chinese Geographical Indication, which is a special logo for geographical indication products [2]. On October 16, 2019, in accordance with relevant regulations such as the Trademark Law and the Patent Law, after integrating the management functions of geographical indications, the State Intellectual Property Office registered and filed the new version of the special logo for geographical indication and included it in the official logo protection [3]. In recent

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years, the continuous development of digital technology has provided new technologies and ideas for the protection and development of national geographical indication products. Among them, blockchain technology has played an increasingly important role in the protection of characteristic agricultural products due to its decentralized and anti-tampering characteristics.

Existing research has analyzed the advantages of the "blockchain-based" traceability system by comparing it with the traditional traceability system of agricultural products, promoted the application of blockchain technology in the agricultural product supply chain, and created a smart supply chain, realizing the visual, tangible, and adjustable information supply chain of agricultural products [4]. Due to the impact of counterfeit and shoddy products flooding the market, farmers who grow national geographical indication agricultural products are forced to lower their product prices and compete with them, lacking motivation in building brands and improving planting techniques, leading to the current situation of the development of national geographical indication agricultural products is not optimistic. At the same time, some national standard agricultural products with traceability certification also face the problem of false traceability, making it difficult to gain consumer trust. The shrinkage of brand value and false traceability have become problems faced by national geographical indication agricultural products.

This article analyzes the current situation of the protection of Daxing watermelon, a national geographical indication agricultural product, and the development difficulties it faces. Through an experiment in Nanxiaoying Village, Daxing District, a traceability system based on blockchain technology for agricultural products was built, which not only uploads and stores relevant data in the four links of Daxing watermelon cultivation, storage and processing, transportation, and sales but also adds cultural information behind agricultural products according to the characteristics of national geographical indication agricultural products. Based on this experiment, this study proposes strategies and suggestions for using blockchain technology to empower the protection of national geographical indication agricultural products.

2 Background and Problems

2.1 The Current Situation of GI Products in Beijing

Geographical indications (GI) products are closely related to the natural and human factors of their origin, reflecting the reputation of different geographic regions [5]. Protecting GI products can safeguard the legitimate rights and interests of producers and consumers, and promote sustainable economic and social development in China by utilizing intellectual property rights. In 1999, the General Administration of Quality Supervision, Inspection and Quarantine issued the "Regulations for the Protection of the Geographical Indications of Origin of Products," which outlined the use and management of exclusive logos, [6] and in 2021, it released the "Management Measures for the Construction of Demonstration Zones for the Protection of Geographical Indication Products," further clarifying the institutional framework for protecting GI. As of October 2022, the National Intellectual Property Administration has approved 2,495 GI products, with a direct output value of nearly a trillion yuan [7].

Beijing, with its diverse soil, vegetation, and topography, has nurtured many GI products, including 10 agricultural products. Da Xing watermelon, with its high reputation in Beijing and throughout the country, attracts 200,000 visitors annually to come to Da Xing for sightseeing and watermelon picking [8]. The excellent natural environment, rich planting experience, and abundant historical heritage have created "Da Xing watermelon" as a GI agricultural product. According to the Beijing Municipal Bureau of Statistics, as of December 31, 2021, the area of watermelon planting in the region totaled 144.4 acres, with a cumulative output of 370.5 tons and a cumulative output value of 2.973 million yuan.

2.2 Problems in the Process of Implementing National Geographical Indication Protection for Daxing Watermelon

2.2.1 Difficulties in Timely Collection and Tracking of Production Chain Information

Taking the national geographical indication agricultural product Daxing watermelon as an example, farmers still use manual methods to collect and record data on the production cycle, pesticide application records, planting dates, harvest dates, soil acidity, and other data related to Daxing watermelon. In addition, there are many intermediate links in processing, circulation, and distribution, and the information generated is difficult to collect, record, and track accurately and timely. The phenomenon of unclear or falsified product traceability information is likely to occur. Therefore, the traceability and real-time monitoring of information in the supply chain of national geographical indication agricultural products are particularly important. However, under the current technological background, the fragmentation of data in the agricultural product supply chain makes it difficult to be regulated and easily tampered with, and it is difficult to achieve the full traceability chain.

2.2.2 Information Asymmetry in the National Standard Agricultural Product Supply Chain

The current agricultural product supply chain of Daxing watermelon requires the commodity to go through transportation, processing, and distribution through wholesale markets, distributors, processors, and shopping malls before it can reach consumers. The circulation process is long and generates a lot of information. The upstream and downstream industrial chains of Daxing watermelon are difficult to share information, and there is information asymmetry among the various parties in the agricultural product supply chain. This ultimately leads to producers being unable to obtain higher profits through planting Daxing watermelon with national geographical indication certification under the influence of middlemen seeking excessive profits and improper competition methods. Consumers also pay higher transaction prices and cannot confirm the authenticity of the national standard certified Daxing watermelon they purchase.

2.2.3 Counterfeit National Standard Agricultural Products Enter the Market at Zero Cost

Most national geographical indication agricultural products currently do not use two-dimensional codes for traceability and anti-counterfeiting, but traditional anti-counterfeiting methods cannot fundamentally solve the problem of counterfeiting by copying and transferring anti-counterfeiting marks, making it difficult for consumers to distinguish the authenticity of two-dimensional codes. Some unscrupulous businesses falsify traceability information to save costs and seek excessive profits, reducing the overall social trustworthiness of the industry. Counterfeit national standard agricultural products entering the market at zero cost not only confuses the market and harms the interests of suppliers and consumers, but also damages the brand value of the national geographical indication product itself, affecting product sales and reputation. Although the General Administration of Quality Supervision, Inspection and Quarantine and the Ministry of Agriculture have issued relevant regulations and management measures, emphasizing the crackdown on counterfeiting and infringement of national geographical indications, they have not been able to effectively curb the proliferation of counterfeit goods.

2.2.4 Multiple Regulatory Bodies Lead to a Vacuum or Conflict in the Regulation of National Standards

Although multiple rounds of administrative institutional reforms have been carried out, the administrative regulatory power of national geographical indications still needs to be integrated and coordinated. The collective trademark and certification trademark of national geographical indications are managed by the Trademark Office of the State Intellectual Property Office, and the national geographical indication products are managed by the Intellectual Property Protection Department of the State Intellectual Property Office. There is a lack of effective communication and cooperation mechanisms among different regulatory bodies, and the quality standards for geographical indication products in different regions are also different. Therefore, there is a vacuum or conflict in the administrative regulation of national geographical indications.

3 The Application of Blockchain Technology in the Protection of Daxing Watermelon

Compared to traditional traceability technologies, blockchain has the advantages of decentralization, immutability, traceability, anonymity and confidentiality, and openness, which has broad prospects for application in the field of agricultural traceability and anti-counterfeiting. In this project, blockchain technology is used to build a traceability model for Daxing Watermelon, by uploading key data such as watermelon planting, storage and processing, transportation, and sales to the blockchain.

3.1 Daxing Watermelon Multi-chain Traceability Model

In order to enable data to freely flow between different public blockchains and achieve a more decentralized design, this research constructs a blockchain multi-chain architecture

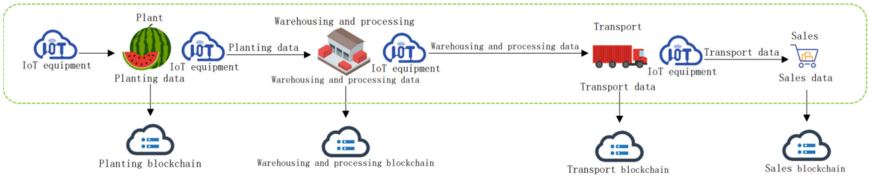

Fig. 1. Multi-Chain Traceability Architecture for Daxing Watermelon on Blockchain

based on consortium chain channel technology, as shown in Fig. 1. It focuses on the four supply chain stages of Daxing watermelon cultivation, storage and processing, circulation, and sales. For each stage, a separate traceability chain is established, and different companies in different stages can initiate traceability data on-chain requests as nodes. These companies are located in different public blockchains, and the isolation storage of traceability data ensures the security of the data.

The traceability ledger of Daxing watermelon on blockchain is jointly backed up by multiple enterprise nodes within the traceability chain, including both public and private traceability data. The data on the chain is operated or updated through verification by smart contracts. Public traceability data can be directly transmitted through smart contracts, while private traceability data can be shared through decryption smart contracts with the authorization of the data-owning enterprise's key, reducing the risk of privacy traceability data leakage.

3.2 Data Storage Model for Daxing Watermelon Traceability

Traceability for Daxing watermelon involves multiple stages. At each stage, IoT devices such as temperature and humidity sensors, BeiDou positioning equipment, oxygen concentration sensors, cameras, etc. are used to collect real-time data generated during the product cultivation, processing and other processes. Not all data can be made public, such as commercial privacy data like transaction prices that are unrelated to product quality. In this case, data tampering prevention is achieved through blockchain technology while ensuring the security of private data. This serves as the basis for authorized access to upstream and downstream private data and regulatory control by relevant authorities. Table 1 shows the details.

Enterprise nodes submit traceability data in the form of key-value pairs. Creating a database key-value index is used instead of traversing queries to reduce data query time costs. Data on-chain transaction requests are constructed by enterprise nodes as transaction endorsement proposals, which are then sorted by the Kafka cluster for consensus and a new block is generated. The current transaction hash value and block height of the on-chain request are returned. Table 2 provides detailed information.

This study is based on the research of key on-chain data for each link in the supply chain and designs a traceability data storage model for Daxing watermelon. By recording data in a forward sequence according to the order of data acquisition, the traceability system can record data from the four links of watermelon planting, storage and processing, transportation, and sales. When different supply chain nodes submit requests

Table 1. Key Traceability Data for Daxing Watermelon

Public data	Privacy data
Commodity name, source of seedlings, production cycle, fertilization records, application records, responsible farmer information, planting time, fruit setting time, harvest date, soil pH, and agricultural product testing report	Seed price, Harvesting cost management cost, shipping price
Dealer entity, acquisition batch, acquisition quantity, acquisition time, acquisition vehicle number, processing batch, responsible person, processing time, storage temperature and humidity, and storage time	Processing costs, acquisition costs, warehousing costs
Logistics enterprise, transportation batch, transportation vehicle number, transportation principal	-
Sales enterprise, purchase time, sales location	Purchase quantity, purchase price, sales price

Table 2. Upload blockchain data

Open traceability data	Privacy traceability data	Transaction hash	block height
Purchase order number: 133239541| Item number: 104067| Trade name: Anxin Direct Picking Panggezhuang Watermelon 6–7 kg/ Case Raw Material - Beijing	Receiving time: 2022-07-14| Received quantity: 94| Unit price including tax: 58.0| Unit price excluding tax: 53.211| Payment for goods including tax: 5452	38883953d5cf1c31 0806759c3ghcbcg8 jbc35dbf348c9d6gf 601c375b334g3d6	688

to upload data or information, the data or information will be divided into public traceability data or commercial privacy data through smart contracts. Public traceability data will be directly uploaded to the chain for storage, while privacy traceability data will be encrypted using the symmetric encryption algorithm AES and then uploaded to the chain as ciphertext to ensure the security and invisibility of the privacy data.

3.3 Smart Contracts and Traceability Data Query

To meet the traceability needs of consumers for public traceability data and the shared needs of farmers, upstream and downstream enterprises, and regulatory authorities for privacy traceability data, this system designs a public traceability data on-chain contract for public traceability data and a privacy traceability data encryption on-chain contract for ciphertext and data key for privacy traceability data. These smart contracts can ensure that the blockchain ledger is successfully executed with public traceability data and

encrypted privacy data, and returns the hash value, block height, data hash value, etc. of the current request data on-chain transaction on the chain, providing transparent access rights to public traceability data for consumers, and authorized queries for privacy data for farmers, enterprises, and regulatory authorities in the public chain.

In addition to the traceability multi-chain architecture, this system also builds a "Culture" section in the traceability mini-program interface scanned by consumers, which is used to promote national geographical indication brands. Consumers can use this system to achieve full-process traceability of the purchased Daxing watermelon supply chain, confirm the authenticity of the purchased national geographical indication products, and help maintain the reputation and brand value of national geographical indication products.

4 Using Blockchain Technology to Empower the Protection of DaXing Watermelon

Blockchain technology can be applied to all aspects of the production and sale of DaXing watermelon, a national geographical indication agricultural product. By integrating blockchain with traditional agriculture, we can base our recommendations on the reality of China, consumer needs, and the supply-side reform of agriculture. This will help safeguard the reasonable interests of producers and operators, protect the rights of consumers, preserve the value of national geographical indication agricultural products, and provide replicable and scalable demonstration experience for regional specialty agricultural products.

5 Using Blockchain Technology to Achieve Traceability in the Production Chain

The production chain of national standard agricultural products, such as DaXing watermelon, involves a wide range of data information, including the production cycle, pesticide records, planting and harvesting dates, soil acidity and alkalinity, storage temperature, storage humidity, storage time, transportation trips, purchase time, purchase quantity, purchase price, sales price, and so on. The full-process data of the four stages of planting, storage and processing, circulation, and sales together ensure the authenticity of the origin of the geographical indication agricultural products. By applying blockchain technology, the data of the four stages of planting, storage and processing, circulation, and sales of geographical indication agricultural products will be permanently recorded and cannot be tampered with. It can be traced at any time, solving the problem of data fraud in the traceability of geographical indication agricultural products. At the same time, if quality and safety issues arise, the responsible party can be identified through the traceability data chain. This highlights the brand value of national standard agricultural products while also increasing their added value.

5.1 Blockchain Technology Optimizes the Supply Chain of Daxing Watermelon

In recent years, the strong development of Internet technology has led to more convenient and reliable e-commerce transaction methods, which in turn has promoted the frequency of inter-regional agricultural product trade. In addition, the gradual improvement of the agricultural product logistics system has greatly increased the proportion of remote consumers buying Daxing watermelon. In the current supply chain of fresh agricultural products, there are still information barriers between various transactional parties, and a reliable traceability mechanism has not been established, resulting in damage to the reasonable interests of producers and operators. In the context of big data, the best logistics arrangements and logistics data for Daxing watermelon can be scientifically formulated, and the decentralization and anti-tampering properties of blockchain can be used to ensure the authenticity and transparency of transaction information between various links, thereby solving the problem of information asymmetry caused by cold chain transportation of Daxing watermelon, building a reliable traceability system, reducing the generation of some invalid information, optimizing the supply chain of Daxing watermelon on e-commerce platforms, and improving the overall efficiency of traceability.

5.2 Blockchain Technology Authenticate Daxing Watermelon

The application of blockchain technology to high-value-added products is becoming more and more common. Yang Yunyong and others from Guizhou Maotai Distillery [9] used a secure RFID product and an alliance chain model with authentication nodes to embed tags in the chip of each bottle of liquor, recording product raw materials, batch numbers, and bottle ID information, and added a anti-counterfeiting app. Users can use NFC phones to authenticate the authenticity and view data information of various links of the product. The national geographical indication agricultural product, Daxing watermelon, can be combined with packaging by applying blockchain technology, referring to and learning from other traceability and anti-counterfeiting cases, strengthening the application of NFC, electronic radiation technology (RFID), quantum cloud codes and other technologies, building a blockchain platform, continuously improving the collection of agricultural information, and combining the advantages of blockchain technology in processing and storing data, interconnecting systems, information security, and privacy protection. Good design of the core technology of blockchain traceability, and provide secure and reliable technical support for the blockchain-driven anti-counterfeiting traceability of Daxing watermelon.

5.3 Blockchain Technology Using in Government Supervision System

The distributed ledger technology of blockchain enables self-verification, transmission, and management of information. In the case of national geographical indication agricultural products, supply chain information and logistics information of DaXing watermelon can be viewed by participants of the distributed ledger at any time. With the help of blockchain technology, the supply and demand sides of national standard agricultural products such as DaXing watermelon can promptly grasp the supply and demand quantity of agricultural products, adjust business strategies in a timely manner through

information sharing, and avoid problems such as agricultural products being unsold or supply exceeding demand due to information asymmetry.

Related regulatory agencies can also integrate data from all departments involved in the entire industry chain, such as planting, logistics, sales, soil and water, and meteorology, to establish a blockchain monitoring service platform that can provide data integration, information collection, technical support, and other services for different user groups. The platform can also undertake various standard formulation, contract execution, and data usage, allowing professional associations, enterprises, and government agencies involved in the DaXing watermelon industry chain to collaborate on monitoring, solve the problem of counterfeiting in agricultural product circulation, and maintain a sound market environment.

6 Conclusion

In the implementation of national geographic indication protection for Daxing watermelon, there are problems such as difficulty in timely collection and tracking of production chain information, information asymmetry in the supply chain, difficulty in achieving traceability art and anti-counterfeiting, and multiple regulatory authorities leading to regulatory vacuum or conflicts. However, blockchain technology, through decentralization, open sharing, and smcontract mechanisms, completes data transmission and sharing, bringing new opportunities for the protection of national geographic indication agricultural products. To enable blockchain to empower the protection of national geographic indication agricultural products, we should seize the opportunity of applying blockchain technology to the supply chain of national standard agricultural products, strengthen government guidance, promote the standardization of national geographic indication agricultural product supply chains, do a good job in the core technology design of blockchain traceability, innovate the industry regulatory system, build a blockchain monitoring platform, tap into the greater application value of blockchain technology, and provide new ideas and directions for digital rural construction.

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