

Development of Quality and Safety Traceability of Agricultural Products Based on Internet Plus

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Abstract: Ensuring the quality and safety of agricultural products is a basic requirement for building a moderately prosperous society, and is related to the development of agriculture and the countryside as well as people's health and safety. The Internet Plus initiative has accelerated the building of quality and safety standards and traceability systems for agricultural products. Overall, the quality and safety risks of agricultural products have been effectively controlled. However, there remain many problems, such as ambiguity of power and duties of government oversight, severe segmentation of different regions, poor uniformity in traceability standards, lack of width, depth, and accuracy of traceability information, weak commercial operation capacity, and insufficient sustainability of traceability systems. This study reviews the progress in agricultural product quality and safety with respect to supervision systems, laws, and regulations, standards system construction, and traceability technology/system development in China, analyzes the main problems, and proposes potential solutions to achieve the development objectives for 2025 and 2035. We propose promoting the standardization of information traceability, improving the national traceability system, deepening risk monitoring and warning systems, widening the practical fields and service products, focusing on research on traceability technology, and paying attention to professional training. By these means, we hope that China can realize the long-term goals of building a sustainable traceability system with a positive cycle and modernizing the national management system of agricultural product quality and safety by 2035.

Keywords: Internet Plus; quality safety of agricultural products; traceability system; development suggestions

1 Introduction

The quality and safety of agricultural products is the basis of food quality and safety, which is related to people's health and safety as well as the increase in farmers' income and high-quality development of agriculture and countryside [1,2]. China has attached great importance to the quality and safety of agricultural products over the past two decades. In 2006, the *Law of the People's Republic of China on Agricultural Product Quality Safety*

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was implemented and the *Plan of Constructing National Agricultural Product Quality and Safety Inspection and Testing System (2006–2010)* was issued, marking the beginning of standardized and unified regulation at the national level of agricultural product quality and safety. In 2009, the *Food Safety Law of the People's Republic of China* came into force and put forward stricter regulations on the production, processing, sales, and service of agricultural foods. *The 13th Five-Year Plan of the People's Republic of China*, the *Plan of Health China 2030*, the *National Food Safety Plan for the 13th Five-Year Plan*, and the *National Agricultural Modernization Plan (2016–2020)* further made clear arrangements for work on agricultural product quality and safety. The *Report of the State Council on 2017* proposed a national food safety strategy. In 2019, the *Opinions of the Central Committee of the Communist Party of China and the State Council on Deepening Reform and Strengthening Food Safety* announced the establishment of the most rigorous standards, organized strict supervision, implemented the most severe punishment, and adhered to the most serious accountability to assure food quality and safety.

Since 2015 when the Internet Plus action plan was put forward in the Report of the State Council, Internet Plus Agriculture has made full use of existing Internet resources and has been closely combined with new information technologies, such as big data, cloud computing, Internet of Things, and artificial intelligence (AI). Diverse modern agricultural products, patterns, and business forms based on Internet Plus have developed [3,4]. Constructing a traceability system covering the entire process from farm to table is a core target of Internet Plus Agriculture. Recently, research and practice in China's agricultural product traceability have achieved great progress based on Internet Plus [1,5]. Some scholars have elaborated the concepts of traceability, traceability platform, or system, and proposed the overall framework of forward tracking and reverse traceability of agricultural products in combination with China's status and requirements. Various traceability technologies have been developed, covering the entire supply chain of agricultural products, including integrated identification technologies, intelligent inspection and detection technologies, systematic and refined risk assessment technologies, and precise and directional process control technologies. Additionally, applications of blockchain, big data, and AI technology are also being popularized in agricultural product traceability.

Overall, the quality and safety of agricultural products in China are satisfactory. A traceability system from farm to table has been formed, the inspection and detection ability of key products has steadily increased, and the quality and safety risks have been effectively controlled. It should also be noted that compared with sound regulatory mechanisms, perfect laws and regulations system, standardized testing and certification procedures, and sustainable traceability platforms of developed countries, agricultural product quality and safety in China still faces some challenges [6,7]. At present, global agricultural trade risk is increasing, and the import/export of agricultural products poses potential threats to the international public health system. In response to the changes in international situations, China must accelerate the construction of a modern management system for agricultural product quality and safety, expedite the proceedings of sustainable tracing ecology with a positive cycle for timely early warning and prevention of safety risks, enhance the international competitiveness of China's agricultural products, and reshape the trust system of exported agricultural product quality for the development of smart agriculture.

In this study, we systematically summarize the development of agricultural product traceability in China under the background of Internet Plus, analyze the main problems in the current traceability systems, and finally propose the strategic objectives, key tasks, and suggestions for agricultural product traceability in 2025 and 2035. This study provides a reference for future development of agricultural product quality and safety traceability.

2 Traceability of agricultural products in China

In China, Internet Plus agricultural product traceability has been developed rapidly, which has significantly improved the quality and safety level of agricultural products in China. In the first half of 2019, the national agricultural product quality and safety routine monitoring (risk monitoring) results showed that the overall qualified rate of agricultural products reached 97.2%. The sampling inspection products cover five categories, i.e., vegetables, fruits, tea, livestock/poultry products, and aquatic products, and include 108 varieties. The qualified rates of the five categories were 97.3%, 94.1%, 98.3%, 98.3%, and 95.7%, respectively.

2.1 Supervision system

The State Administration for Market Regulation, Ministry of Commerce, and the Ministry of Agriculture and Rural Affairs are responsible for the supervision of agricultural product quality and safety in China. Multiple departments jointly perform “segmented supervision supplemented by variety supervision,” and have built a

supervision network covering major cities, agricultural production areas, and agricultural products in China [8]. The Ministry of Agriculture and Rural Affairs implements routine monitoring to check agricultural product quality and safety, which places regular sampling inspection of key parameters (e.g., pesticides, veterinary drugs, and antibiotics) of various agricultural products of different types and varieties. The results of routine monitoring, random inspection, and special checking on agricultural product quality are publicly released. Other information on quality and safety accidents associated with their punishments, investigation, verification, and treatments of open reported concerns are regularly disclosed to the public. The Agricultural Product Quality Safety Network, National Agricultural Food Quality Safety Traceability Management Information Platform, and National Agricultural Product Quality and Safety Public Information Platform established and controlled by government departments based on Internet Plus play growing roles in regular supervision of agricultural products.

2.2 Laws and regulations

The laws and regulations on agricultural product quality and safety mainly consist of national laws and regulations, supplementary regulations of local governments, and supporting rules of specific operation departments [9]. The national laws stipulate the basic contents of agricultural product quality and safety, such as standards, place of origin, production, packaging identification, supervision and inspection, and legal responsibility. The *Seed Law of the People's Republic of China*, *Fisheries Law of the People's Republic of China*, and *Law of the People's Republic of China on Animal Disease Prevention* detailed the standards on the supervision, production, and business of specific agricultural products. The *Administrative Measures for Agricultural Product Quality and Safety in Hunan Province* was the first local regulation in this field issued by the provincial government. This file formulated operational plans to improve agricultural product quality, protect food safety and people's health, and promote sustainable agricultural development. The rules and regulations, such as *Management Measures for Livestock and Poultry Identification and Breeding Archives*, *Management Measures for Packaging and Marking of Agricultural Products*, *Management Measures for Safety of Agricultural Production Areas*, and *Management Measures for Soil Environmental Management of Agricultural Land (Trial)* clearly defined the specific measures to ensure agricultural product quality and safety during planting and breeding, feed input, and pesticide use.

2.3 Standard system

The standard system of agricultural product quality and safety takes national standards and industrial standards as the core, and local standards, enterprise standards, and group standards as supplements [10]. The national standards, such as *General Rules for Quality and Safety Traceability of Agricultural Products*, *General Specification for Food Traceability*, *Code and Identification of Food Traceability Information*, *Rules for Information Collection and Quality Control of Agricultural Products Market*, and industrial standards, for instance, the *National Construction Specification of Meat and Vegetable Traceability System (Trial)*, created prerequisites for the construction of traceability systems. The regulations, for example, *Administrative Measures for Agricultural Standardization*, *Approval Specification for Agricultural Standard*, *Guideline for Risk Assessment of Food Pesticide Residues*, *Guideline for Maximum Limits of Food Pesticides Residue*, *Construction Guideline for Traceability Management Platform of Key Agricultural Products (Trial)*, provided a solid foundation for the standardization of the traceability system. In addition, by referring to the international standards and taking into account the actual situation in China, GS1 China formulated a series of standard specification and application guidelines of typical products, such as the *Guideline for Tracking and Traceability of Beef Products*, *Guideline for Tracking and Tracing of Fruits and Vegetables*, and *Practical Scheme for Tracking and Traceability System of Beef Quality*.

2.4 Traceability platforms

To cope with international trade environment changes and domestic agricultural product quality and safety, China has implemented the construction of the Internet Plus agricultural traceability system since 2003 [11]. At present, traceability systems have been widely applied to the supervision of agricultural products such as meat, vegetables, fruits, and grains. The Ministry of Commerce established a three-level traceability management platform at the national, provincial, and municipal levels, and deployed subsystems in slaughtering, wholesale, retail, supermarket sales, and group consumption. The traceability information covers the entire agricultural

production chain, making the source and destination of agricultural products traceable and the whereabouts and accountability of quality and safety verifiable. Since 2012, the central management department has deployed agricultural product traceability systems in eighteen provinces. Provinces such as Beijing, Tianjin, Shanghai, Zhejiang, Jiangsu, and Sichuan also established their own local traceability systems, which were connected with the national management platform to form a unified tracking network covering both urban and rural regions. In addition, leading agricultural enterprises such as GuangMing and China Oil & Foodstuffs Corporation are also starting to establish traceability platforms for agricultural raw materials and products.

2.5 Traceability technology

With the rapid development of Internet Plus Agriculture, agricultural product traceability technology has matured in China. The supervision of agricultural production areas has basically formed an integrated system consisting of satellites in outer space, unmanned aerial vehicles in the sky, and sensors on the ground. Inspection and detection technology tends to be miniaturized and intelligent, including various microelectronics and mechanical systems, nanotechnology, sensor technology, on-site rapid detection technology, remote data transmission, and processing technology. Risk assessment technology has become systematic and refined, such as omics technology, computational molecular biology, data mining, and machine learning. Process control technology has become precise and directional, which realizes precise control of the pollution path and process of key hazard factors relating to agricultural product quality and safety. The traceability identification technology is integrated and interconnected, for which the Internet of Things is widely used in agricultural production. Two-dimensional codes are used as the ID cards of agricultural products in traceability systems. The data-sharing platform and cloud computing system form a digital anti-counterfeiting system. In addition, blockchain along with its distributed, traceable, unforgeable, asymmetric encryption, and self-maintenance characteristics, has gradually been applied to agricultural product traceability, contributing to the construction of a modern agricultural system that is trustworthy and secure.

3 Problems of agricultural product traceability

3.1 Supervision of agricultural product traceability is seriously divided

In China, there are serious divisions among different departments or regions in the quality and safety management of agricultural products. Management involves diverse departments, such as agriculture, quality inspection, industry, commerce, and health. Each department is the regulatory body of a certain sub-process related to agricultural products. It seems that multiple departments work together for joint management; however, it easily leads to the situation of “multiple management, but no one in charge” and “segment management.” The presence of divisions also leads to the repeated construction of traceability systems with the same functions, resulting in “isolated traceability islands.” Although traceability systems have been fully deployed at all levels of supervision and all steps related to agricultural products, these systems are usually in various forms and lack cross-system consistency, compatibility, and interchangeability. Local governments are required to take overall responsibility for food quality and safety within their territory, so they have also established local traceability systems to strengthen the management of agricultural product quality and safety [12]. However, faced with large numbers of agricultural products from external regions or foreign countries, it is difficult for local governments to achieve effective management and supervision of the entire process.

3.2 Traceability standards are not well organized and unified

The development of traceability standards for agricultural product quality and safety started late in China. Subject to the industrial development level and the national overall deployments in the traceability industry, the application scope and depth of existing standards are far behind those of other developed countries. The current standard system is unsound because standards are formulated by multiple departments and lack communication among vertical levels. Various departments, industries, and commercial companies independently built traceability systems for special agricultural products; however, these systems do not fully follow relevant standards and specifications issued by the National Standardization Administration Committee or use completely different coding rules and standards. Such a phenomenon seriously affects the interconnection and sharing of traceability information among different systems and results in a large waste of social resources [13]. Additionally, some basic concepts, such as agricultural products and traceability, still exist in the definition of connotation and extension in

different laws, regulations, and standards. Different experts and departments did not reach a consensus on the concept of traceability. For instance, some industrial departments regard the certification of various qualifications as the quality and safety traceability, and even directly name authentication or anti-counterfeiting systems as traceability systems.

3.3 Traceability information lacks width, depth and precision

At present, the traceability information provided by most traceability systems is extremely incomplete and lacks depth, exhibiting superficial and broken states, which cannot match the actual needs of consumers. Ordinary traceability systems only achieve origin traceability and logistics traceability, but cannot meet the requirements of environment monitoring, process monitoring, and product processing monitoring. Due to the supervision division among multiple departments, the traceability systems are unable or have no right to achieve comprehensive and accurate traceability of the entire process relating to agricultural production. The high price of various environmental sensors or equipment hinders their application in agricultural product traceability. For example, the Internet of Things remains in the demonstration pilot project of facility agriculture or smart agriculture, which has not been widely popularized; the traceability information of a large number of agricultural products is difficult to collect and cannot be updated in real time.

3.4 Operational capability of current traceability system is limited

Almost all departments and regions have developed agricultural product traceability systems for specific targets. However, the narrow service scopes and objects, poor sustainability, and insufficient commercial operability make it difficult for these systems and platforms to meet the real needs of agricultural product traceability. Socialized external traceability systems are organized and coordinated by competent authorities, constructed and implemented by the affiliated institutions they belong to, and operated daily by pure technical companies. This mode of one-way investment and construction makes it difficult to form a positive ecosystem for agricultural product traceability. The neglect of profitability reduces the enthusiasm of enterprises to participate in the construction of traceability systems, thus ultimately leading to the unsustainability of traceability projects.

3.5 Sustainable traceability with positive cycles have not been established

Consumers' willingness and ability to pay for traceability services critically determine whether a traceability system can be sustainable. According to the experiences in China and abroad, consumers have a higher willingness to pay for agricultural products with quality safety labels and animal welfare assurance information. Consumers can only have a rough knowledge of the quality and safety level of agricultural products based on their experiences under the conditions of information asymmetry and purchase products according to the expected prices. This leads to a decrease in the sales volumes of agricultural products above the average quality and safety level and potential risks of being withdrawn from the market for these products, which further causes a decline in the quality and safety level of agricultural products retained in the market [14]. This kind of abnormal reverse elimination leads to market price distortion and makes the agricultural product market a "market for lemons," which seriously hinders the establishment of sustainable traceability with positive cycles.

4 Strategic objectives in 2025 and 2035

In the future, agricultural product quality and safety traceability should fully adapt to the development level of a well-off society by strengthening the support of the basic conditions for agricultural modernization, breaking through critical hardware and software technology hurdles in product traceability, establishing a healthy market mechanism, and fostering a sustainable business ecosystem.

By 2025, traceability, standard, and policy systems based on risk analysis and supply chain management have to be formed and agricultural product traceability resources and information of all regions and departments must be fully connected. The width, depth, and precision of the traceability information should be enhanced and a national unified agricultural product traceability platform linking the whole country, including all departments as well as the upstream and downstream of the agricultural market, must be developed. Referring to international standards, a distinctive system of traceability standards and specifications that conform to China's economic development should also be constructed in the next five years. Innovation of the traceability mechanism and management

system, linkage strategy between agricultural production and market access, and response mechanisms to quality and safety accidents are expected to be introduced in this stage.

By 2035, a sustainable traceability ecology of agricultural product quality and safety will be developed, and modernization of agricultural management systems should be achieved to safeguard agricultural product quality and safety. With breakthroughs in application bottlenecks of new information technologies, such as the mobile Internet of Things, big data, cloud computing, 5G, blockchain, and AI in agriculture, it will be possible to realize all-round, comprehensive, and accurate traceability of agricultural products, including planting, breeding, production, processing, logistics, wholesale, retail, and other sub-processes. This stage is also expected to see the innovation of operation and service mechanism of agricultural product traceability, a completely open and sharing state of diverse traceability information, and the formation of a sustainable traceability ecosystem.

5 Suggestions for traceability development

5.1 Promote the construction of unified traceability standards

First, national laws and regulations should be issued to clarify the object, information, process, subject, legal responsibility, and other contents of agricultural product quality and safety traceability to ensure related works are under the protection of laws. Second, multiple supervision departments should coordinate their respective responsibilities and take efforts to interconnect the existing traceability platforms and systems, thus finally forming a national unified traceability system with hierarchical supervision, internal communications, and integrated external services. Moreover, it is highly required to build a fully open, shared and general intelligent national traceability platform based on the Internet Plus application, whose key technical standards such as coding and identification, information collection, platform operation, and data exchange are all under a standardized framework.

5.2 Research and develop key traceability technologies

It is suggested to establish a special project for research and development of key traceability technologies relating to agricultural product traceability, aiming to accelerate the implementation of frontier technologies in this field and provide feedback power for the application of traceability information. This project should focus on the following three aspects: (1) agricultural remote sensing and environment detection, which targets the development of low-cost, low-energy, and long-life agricultural environmental sensing devices and portable equipment for origin traceability to serve the field agriculture, facility agriculture, intelligent animal husbandry, and breeding industries; (2) agricultural big data technology, which focuses on breaking through the technical difficulties in storage, exchange, and retrieval of massive heterogeneous traceability data from multiple sources and exploring the market mechanism of big data sharing and exchanges; and (3) a new-generation intelligent traceability system based on blockchain, AI, and other frontier technologies, which aims at reducing human participation in quality supervision, thus reconstructing a trustworthy agricultural system.

5.3 Enrich innovative Internet Plus applications

Efforts should be taken to build an Internet Plus agricultural industrial park and demonstration project with the aim of exploring the approach to achieve the last kilometer in technology application. Such a project is regarded as an experimental bed of new technology and new equipment before popularizing the application. Herein, we suggest two main demonstration projects: (1) traceability demonstration of animal husbandry and breeding products. This work can start from representative products and undertaken by large-scale, well-experienced enterprises. The main directions of such projects include collecting, processing, and analyzing observational data on animals' living environments, growth, and processing, connecting animal husbandry and breeding databases with a government traceability platform and mainstream e-commerce system, and supporting the quality assessment, safety traceability, marketing positioning, yield regulation, and production regulation of animal husbandry and breeding products; (2) demonstration project of blockchain application in quality traceability. This project can be undertaken by scientific research institutions with practical experience in agricultural traceability or agricultural entity enterprises with a scientific research foundation. The focus can be researching the key technologies of agricultural blockchain to untie the constraints of core underlying technologies, such as throughput, latency, capacity, bandwidth, data encryption, and security, and applications of blockchain in the agricultural Internet of Things, big data, quality and safety traceability, rural finance, insurance, industrial supply chain, and

other scenarios in view of its decentralization and unforgeable characteristics.

5.4 Strengthen risk monitoring, assessment, and early warning

The agricultural product traceability platform should have the ability of big data mining and intelligent analysis for the purpose of discovering the potential risks of agricultural product quality and safety or locking in key suspicious targets of quality accidents, thus achieving the goal of precise supervision. A risk assessment of agricultural product quality and safety needs to be conducted to identify the key nodes and technical procedures of the agricultural production control so that targeted measures can be taken to prevent potential quality and safety risks. It is also necessary to formulate and revise the emergency plan for agricultural product quality and safety, which must clarify the task division, optimize emergency procedures, and establish an emergency mechanism with the features of rapid response, smooth information channels, coordination of the top and bottom, and cross-regional linkage [15]. Establishing a sound rumor control scheme is necessary to properly deal with false information and rumors on quality and safety accidents and timely elimination of rumors through popular science activities. The participation of WeChat, Weibo, QQ, newspapers, books, and other media is helpful for performing standardized and diversified risk communications and popular science publicity, thus improving the public's awareness and ability to make a rational and scientific judgment on sensitive issues of agricultural product quality and safety.

5.5 Broaden practices on quality and safety traceability

Traceability platforms sponsored by different industrial associations and local standardization committees usually focus on specialized categories (e.g., bee products and teas), special links (e.g., circulation), or specific regions (or provinces and cities). The service areas and objects of these traceability platforms and systems are too narrow to obtain sustainable service ability and advanced commercial operation. Therefore, it is suggested to construct Internet Plus based agricultural product traceability systems with broadened practical fields and service objects, which not only provide services for food crops, fruits, vegetables, pigs, beef, and other main table foods, but also wildlife products, medicinal agricultural products, and livestock feed crops. Supervision is not only limited to circulation, but also focuses on breeding, livestock slaughtering, agricultural product processing, cold chain transportation, marketing, and other aspects of the entire industrial chain.

5.6 Concentrate on professional personnel training

At present, the majority of agricultural practitioners in China are still at a relatively low education level and have a poor mastery of information technology and professional knowledge. Their initiative and ability to accept new knowledge and new technology must necessarily be improved in the age of information. With the rapid development of modern agricultural systems (e.g., smart agriculture), the agricultural product quality and safety traceability urgently requires high-quality talent with solid professional knowledge, strong learning ability, and outstanding innovative thinking [16]. Policies should be formulated at the national level to guide institutions, colleges, and universities to actively cultivate practical talents for modern agriculture. Another choice is to establish special funds to encourage those who master modern agricultural technology to participate in agricultural and rural construction, or work in agricultural posts such as agricultural product traceability. The government is recommended to establish a professional training system, which is responsible for teaching farmers new skills, thus forming a professional team for agricultural development. Meanwhile, permanent financial support is needed to ensure the daily operation of the training system.

5.7 Introduce social forces to supervise agricultural product quality and safety

Social forces play a crucial role in ensuring the quality and safety of agricultural products; hence, it is of great importance to fully mobilize the enthusiasm of social forces, implement socialized labor, and form a healthy state of agricultural product quality and safety management. The first is to establish an information platform for social supervision of agricultural product quality and safety, smooth the complaint channels (e.g., complaint hotlines), and improve the reward system of public tip-offs. Only in this way can social forces be encouraged and mobilized to participate in the collaborative governance of agricultural product quality. The second is to take advantage of the supervisory functions of social media to effectively expose quality and safety incidents involving agricultural

products. The establishment of the “yellow list” and “black list” to disclose the illegal information of illegal producers and operators is conducive to creating a good social credit environment. Finally, third-party organizations or institutions are encouraged to participate in quality and safety management and play a decisive role in resource allocation and safety supervision through market mechanisms.

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