

# Research on Quality and Safety Supervision of Fresh Agricultural Products Supply Chain in Hainan Province under the Digital Economy

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**Abstract:** With the rapid development of the digital economy, the quality and safety supervision of the fresh agricultural products supply chain in Hainan Province faces new opportunities and challenges. This paper aims to explore the issues of quality and safety supervision of the fresh agricultural products supply chain in Hainan Province under the digital economy and propose corresponding solutions. Firstly, it analyzes the impact of the digital economy on the fresh agricultural products supply chain, discussing the advantages of information transparency, data-driven decision-making, and intelligent supervision. Secondly, it evaluates the current situation and existing problems of the fresh agricultural products supply chain in Hainan Province. Finally, based on the development trend of the digital economy, strategies such as constructing a digital supervision platform, promoting standardization, enhancing technological innovation, improving the quality of supervision personnel, and strengthening public participation are proposed to enhance the quality and safety level of fresh agricultural products in Hainan Province and promote the modernization of agriculture.

**Keywords:** Hainan, fresh agricultural products, supply chain, digital economy, quality safety, supervision

## 1. Introduction

Hainan, as a significant agricultural production base in China, possesses unique natural conditions and geographical advantages, yielding a large quantity of high-quality fresh agricultural products such as tropical fruits, vegetables, and seafood. The quality and safety of the fresh agricultural products supply chain in Hainan directly impact consumer health and the stability of the agricultural market. However, with the increasing consumer demand and market expansion, the supply chain of fresh agricultural products in Hainan faces challenges including increased complexity, information asymmetry, and frequent quality safety incidents. Traditional regulatory methods struggle to comprehensively cover and effectively address these issues. In the context of the digital economy, information technology provides new regulatory methods and tools for various aspects of the supply chain, contributing to enhancing overall regulatory efficiency and transparency. For example, Internet of Things (IoT) technology enables real-time monitoring of agricultural product planting, breeding, processing, and transportation processes. Blockchain technology ensures the transparency and tamper-proof nature of supply chain data. Big data and artificial intelligence (AI) technology can analyze large amounts of data to identify potential quality safety hazards. The application of these technologies not only improves the precision and efficiency of regulation but also enhances consumer confidence in the quality and safety of agricultural products[1].

## 2. The Impact of the Digital Economy on the Fresh Agricultural Products Supply Chain

With the rapid development of the digital economy, the application of information technology in the agricultural supply chain has become increasingly widespread, providing robust support for the quality and safety supervision of fresh agricultural products[2].

Firstly, information transparency and data-driven decision-making. The digital economy facilitates the acquisition and transmission of information, achieving transparent management across all stages of the supply chain. Technologies such as the Internet of Things (IoT) and blockchain can monitor and record real-time data throughout the production, processing, and transportation stages of fresh agricultural products, effectively preventing information asymmetry. For example, sensors can monitor

environmental parameters in the fields and record the use of pesticides and fertilizers, while blockchain technology ensures the authenticity and immutability of this data. Consumers can scan the product's QR code to view production and processing information, increasing their trust in product quality[3].

In the context of the digital economy, big data analytics has become an important tool for managing the fresh agricultural products supply chain. By comprehensively analyzing market demand, production conditions, and quality inspection data, enterprises and regulatory bodies can extract valuable information from vast amounts of data to make precise decisions. Big data analysis helps enterprises accurately predict market demand and optimize production plans, avoiding resource waste. For example, by analyzing historical sales data, seasonal variations, and consumer preferences, enterprises can adjust planting and production strategies to match product supply with market demand, improving sales efficiency. Big data technology can also monitor and analyze the production process in real time, identifying potential issues. By collecting data on soil moisture, temperature, and pest conditions through sensors and combining it with meteorological data for analysis, abnormalities can be detected and addressed promptly, ensuring healthy growth and high-quality output of agricultural products. Analysis of quality inspection data helps enhance the overall quality control level of the supply chain. By summarizing and analyzing quality inspection data from various stages, enterprises and regulatory bodies can identify the sources and trends of quality issues, making targeted improvements in production and management processes to ensure product quality stability and safety. Big data analysis also optimizes logistics and inventory management. By analyzing sales data and inventory levels, enterprises can reasonably arrange logistics distribution, reduce transportation costs and inventory backlog, ensuring the freshness of fresh agricultural products and the efficient operation of the supply chain. Data-driven decision-making not only improves the quality and supply efficiency of fresh agricultural products but also enhances enterprises' ability to respond to market changes, providing solid technical support for optimized supply chain management[4].

Secondly, intelligent regulation. The application of artificial intelligence (AI) technology enables regulatory bodies to achieve intelligent monitoring of the quality and safety of fresh agricultural products, significantly enhancing regulatory efficiency and accuracy. Image recognition technology is widely used in the quality inspection of the appearance of agricultural products. Traditional manual inspection is not only time-consuming and labor-intensive but also easily influenced by human factors. By introducing image recognition technology, the appearance quality of agricultural products can be automatically detected. For example, AI can capture images of agricultural products through cameras and instantly analyze parameters such as color, shape, size, and surface defects to quickly determine whether the products meet quality standards. This not only improves inspection speed and accuracy but also enables large-scale, around-the-clock quality monitoring. Machine learning algorithms can predict potential quality and safety risks. By analyzing historical data, machine learning models can identify key factors and potential patterns affecting the quality of agricultural products. For example, by combining environmental data (such as temperature, humidity, precipitation) and production data (such as pesticide usage, fertilization conditions), machine learning models can predict pest outbreaks and the growth status of agricultural products, allowing for preventive measures to be taken in advance, reducing losses. AI technology can also be applied to the intelligent regulation of logistics and storage. Smart sensors and RFID tags can monitor environmental parameters such as temperature, humidity, and vibrations during transportation in real time, ensuring fresh agricultural products are transported and stored under optimal conditions. Once an abnormal situation is detected, the system automatically issues an alert, prompting relevant personnel to take measures to prevent product quality deterioration. Intelligent regulatory systems can integrate multiple data sources for comprehensive analysis. For instance, by combining weather forecasts, market demand predictions, and real-time data from various supply chain stages, AI systems can dynamically optimize the entire supply chain, ensuring products reach the market at the optimal time, maximizing freshness and quality. The application of artificial intelligence technology provides strong technical support for the quality and safety supervision of fresh agricultural products[5].

### **3. Current Status of Quality and Safety in Hainan's Fresh Agricultural Products Supply Chain**

Despite the new tools and methods that the digital economy offers for quality and safety supervision of fresh agricultural products, the actual situation of Hainan's fresh agricultural products supply chain still faces numerous challenges.

### **3.1 Complex Supply Chain**

Hainan's fresh agricultural products supply chain involves multiple stages, including planting, breeding, processing, transportation, and sales. The numerous and complex stages increase the difficulty of quality and safety supervision. Each stage can pose quality and safety risks, and the transmission and coordination of information between stages are often inefficient, making it difficult to promptly detect and resolve issues[6]. For example, in the planting and breeding stages, the use of pesticides and veterinary drugs and the quality of feed directly impact the safety of agricultural products. In the processing stage, the hygiene of the processing environment and the use of additives require strict supervision. In the transportation stage, the control of temperature and humidity is crucial to maintaining the freshness and safety of fresh agricultural products. In the sales stage, storage conditions and management during the sales process are equally important. The complexity of the supply chain requires precise and efficient means for supervision at each stage.

### **3.2 Information Asymmetry**

In traditional supply chain management, information from various stages is often difficult to share in a timely manner, leading to information asymmetry, which severely affects the effectiveness of supervision. In the production stage, data on pesticide and fertilizer use and monitoring of the production environment often cannot be promptly transmitted to the processing and sales stages. Farmers and producers typically use manual records and paper documents, resulting in untimely information updates and incomplete data. This lag in information makes it difficult for downstream stages to grasp the actual production situation, increasing quality and safety risks. In the processing stage, key parameters such as temperature and humidity during the processing cannot be shared in real time with other stages and regulatory bodies. For example, cold chain management is crucial during the processing of meat products, but if processing companies do not upload temperature control data to a shared platform in real time, the transportation and sales stages cannot ensure that the products are handled under optimal temperature conditions, thus affecting product quality and safety. In the transportation stage, the issue of information asymmetry is also prominent. Environmental parameters such as temperature, humidity, and vibration during transportation are difficult to convey to the recipients and regulatory authorities in a timely manner, preventing the recipients from preparing appropriate storage and handling measures in advance. If there are anomalies in transportation conditions, such as cold chain breakage or exceeding environmental parameters, the quality and safety of fresh agricultural products will be severely impacted, and such anomalies are usually only discovered when the products reach the terminal, delaying the response time. In the sales stage, retailers and consumers have limited access to product information, especially regarding the production, processing, and transportation stages. This information asymmetry not only undermines consumer confidence in product quality but also makes it difficult to trace the source of quality issues once they arise, increasing the complexity of supervision. Information asymmetry also poses significant challenges for regulatory bodies during the supervision process. Due to the lack of comprehensive and real-time data support, regulatory bodies cannot effectively monitor and intervene in real time at all stages of the supply chain and must rely on post-event sampling and spot checks. This approach is not only inefficient but also cannot cover all stages and enterprises, leading to regulatory blind spots. The problem of information asymmetry severely constrains the quality and safety supervision of the fresh agricultural products supply chain and needs to be addressed through digital means and information technology to enhance the transparency and traceability of the entire supply chain.

### **3.3 Lagging Regulatory Measures**

The existing quality and safety regulatory measures mainly rely on manual inspections and sampling tests, which have obvious drawbacks and cannot meet the demands of modern supply chains. Manual inspections and sampling tests are inefficient. Since the fresh agricultural products supply chain involves multiple stages, each stage requires a significant amount of manpower and time for inspections. Manual inspections involve visually inspecting products and manually recording data, which is labor-intensive and slow, making it difficult to keep up with the rapid flow of fresh agricultural products. While sampling tests can improve efficiency to some extent, they can only check a portion of the samples and cannot comprehensively cover all products, leaving blind spots that might miss problematic products. Manual inspections and sampling tests are also susceptible to human factors. The professional level, experience, and work attitude of inspectors directly affect the accuracy and consistency of test results. Human errors and oversights are inevitable, especially when faced with

large volumes and high-frequency testing tasks, where fatigue and subjective judgments can further reduce reliability. Additionally, in remote areas or stages with weak regulatory capacity, the deployment and management of inspectors are insufficient, further increasing the difficulty of supervision. The existing regulatory measures are inadequate for real-time monitoring and dynamic management of the supply chain. Traditional regulatory approaches mainly involve post-event inspections and cannot provide real-time monitoring and early warnings for production, processing, and transportation stages. As a result, quality and safety issues are often only discovered when they reach the sales or consumption stage, making it difficult to contain and resolve problems promptly. Post-event handling not only increases governance costs but also poses risks to consumer health and affects market trust. The lagging nature of regulatory measures makes it difficult for regulatory bodies to respond to sudden issues and complex situations in the supply chain. For instance, agricultural products may suffer quality issues due to cold chain breakages during transportation, but without real-time monitoring tools, regulatory bodies cannot promptly detect and intervene, causing greater losses. Additionally, when new quality and safety risks emerge, such as new pests or pollution sources, traditional regulatory measures are slow to respond and adapt in time.

The current regulatory system's information is insufficient, with severe data silos. Due to the lack of a unified information platform, information sharing and collaboration between regulatory bodies and enterprises are inefficient, and data from various stages are difficult to integrate and utilize, leading to isolated and scattered regulatory work with low efficiency. This situation not only limits the upgrade and optimization of regulatory measures but also affects the formulation and implementation of regulatory policies. The existing quality and safety regulatory measures are lagging, unable to fully cover all stages of the supply chain, and have certain regulatory blind spots.

#### **4. Quality and Safety Regulation Strategies in the Digital Economy**

To address the complexities, information asymmetries, and lagging regulatory measures in the supply chain of fresh agricultural products in Hainan, the digital economy offers effective solutions. By introducing advanced technologies and innovative management methods, the efficiency and effectiveness of quality and safety regulation can be significantly improved.

##### ***4.1 Building a Digital Regulation Platform***

Building a digital regulation platform that covers the entire supply chain is the foundation for efficient regulation. Through technologies such as the Internet of Things (IoT), blockchain, and big data, it is possible to achieve full-process monitoring and traceability of fresh agricultural products from production to sales. Such a platform not only increases information transparency but also enhances the coordination capabilities of all supply chain links. In the production stage, IoT devices such as sensors can monitor environmental parameters like soil moisture, temperature, and light in real-time, recording the usage of pesticides and fertilizers, and uploading data to the platform. Blockchain technology ensures the authenticity and immutability of this data, providing reliable information for subsequent stages. In the processing and transportation stages, the platform can integrate data from temperature control and humidity monitoring devices to track product status in real-time. If any anomalies occur, such as exceeding temperature thresholds or failing to meet humidity requirements, the platform will automatically issue warnings, prompting relevant personnel to take measures to ensure product quality. In the sales stage, the digital regulation platform can display information about production, processing, and transportation to consumers through QR codes, enhancing consumer trust in product quality. Consumers can scan QR codes to view detailed product information such as production date, location, and inspection reports, gaining insights into the product's entire life-cycle. Additionally, the digital regulation platform should possess robust data analysis capabilities. Through big data analysis, potential risks in the supply chain can be identified, production and logistics processes optimized, and overall supply chain efficiency improved. The platform can also predict market demand based on historical and real-time monitoring data, helping companies adjust production and inventory strategies to reduce waste and overstock. Building a digital regulation platform not only enables comprehensive monitoring and traceability of fresh agricultural product quality and safety but also enhances supply chain transparency and coordination, providing strong technical support to regulatory authorities and significantly improving quality and safety regulation levels.

#### **4.2 Promoting Standardization**

Promoting standardization is a crucial measure for improving quality and safety in the fresh agricultural product supply chain. By formulating and promoting standardized operating procedures for production, processing, and transportation, we can ensure that operations at all stages meet quality and safety requirements, thereby reducing the occurrence of quality and safety issues.

(1) Formulating standardized operating procedures for production.

In the cultivation and breeding process, strict standards for the use of inputs like pesticides, fertilizers, and feed should be established to ensure their usage complies with national and international quality and safety standards. Detailed production record-keeping systems should be established, requiring producers to meticulously record every batch's production process, including seeding, fertilizing, spraying, and harvesting. These standardized procedures can effectively reduce harmful residues in agricultural products, ensuring their safety.

(2) Promoting standardized operating procedures for processing.

In the processing of agricultural products, detailed standards covering all stages such as washing, cutting, packaging, and storage should be formulated. This includes setting hygiene standards for processing sites, requirements for the cleaning and maintenance of processing equipment, and restrictions on the use of additives to ensure that the processing meets food safety standards. A quality control system for the processing stage should be established, requiring companies to conduct quality inspections on every batch of products and retain inspection records for traceability and review.

(3) Formulating standardized operating procedures for transportation.

Fresh agricultural products are susceptible to quality degradation due to factors like temperature, humidity, and vibration during transportation. Therefore, cold chain transportation standards should be established, specifying requirements for temperature and humidity control during transportation, and hygiene standards for transportation tools. Transportation companies should be required to monitor environmental parameters in real-time and upload data to the digital regulation platform, achieving full-process monitoring and early warning to ensure that fresh agricultural products are transported under optimal conditions.

Promoting standardization in information collection and data exchange is key to achieving data interoperability between different systems and devices. Unified information collection standards should be established, specifying the format, content, and frequency of data collection at each stage to ensure data completeness and consistency. Promoting interoperability between various monitoring devices and information systems and establishing a unified data exchange platform can achieve data sharing across different stages and companies. For example, production companies, processing companies, transportation companies, and regulatory authorities can share data through a unified platform, gaining real-time insights into each stage of the supply chain for effective quality and safety monitoring and coordinated management.

Standardization efforts also need to be strengthened through training and publicity to improve the standardization awareness and capabilities of industry personnel. The government and industry associations can organize training courses and develop training materials to help industry personnel understand and master standardized operating procedures. Additionally, through publicity and promotion activities, public awareness of standardization can be raised, enhancing consumer confidence in the quality and safety of fresh agricultural products. By formulating and promoting standardized operating procedures and pushing for the standardization of information collection and data exchange, the quality and safety levels of the fresh agricultural product supply chain can be effectively improved, ensuring standardized and transparent operations at all stages, and providing consumers with safe and high-quality agricultural products.

#### **4.3 Enhancing Technological Innovation**

To better enhance the quality and safety regulation levels of the fresh agricultural product supply chain, companies and research institutions need to be encouraged to increase investment in the development of digital technologies and explore new quality and safety monitoring methods.

(1) Using drones and remote sensing technology to monitor farmland production. Drones equipped with high-resolution cameras and sensors can achieve comprehensive monitoring of farmland,

including soil quality, vegetation conditions, and pest situations. Remote sensing technology can acquire large-scale data remotely and, through image analysis and data processing, promptly identify anomalies in farmland, providing precise technical support for agricultural production.

(2) Using blockchain technology to ensure data authenticity and immutability. Blockchain is a distributed database technology characterized by decentralization, immutability, and traceability, effectively addressing issues of information asymmetry and data tampering. In the fresh agricultural product supply chain, blockchain technology can establish a fully traceable data chain, recording information at every stage of production, processing, and transportation to ensure data authenticity and credibility. Consumers can query the product's source and production process through the blockchain platform, enhancing their confidence in product quality and safety.

#### ***4.4 Enhancing the Quality of Regulatory Personnel***

To better adapt to the construction and application of digital regulation platforms, training for regulatory personnel must be strengthened to improve their application skills in digital technology and regulatory levels. Additionally, incentive mechanisms should be established to encourage regulatory personnel to actively participate in the construction and use of digital regulation platforms, thereby enhancing the overall quality and execution ability of the regulatory team.

Targeted training courses should be conducted for regulatory personnel at different levels and positions, covering basic knowledge of digital technology, operational skills of regulation platforms, data analysis, and processing methods. Training content should be combined with practical cases, focusing on the integration of theory and practice to improve regulatory personnel's professional skills and knowledge. Regulatory work is a continuously developing and changing process, requiring regulatory personnel to constantly update their knowledge and skills to adapt to the application of new technologies and methods. A regular training plan and training system should be established, providing regulatory personnel with continuous learning and growth opportunities. Forms such as expert lectures, seminars, and field visits can be organized for training activities, promoting the exchange and sharing of knowledge.

Besides theoretical knowledge, regulatory personnel also need practical operational abilities. Through simulation drills and field visits, regulatory personnel can participate in the construction and application of digital regulation platforms, honing their practical skills and problem-solving abilities. Through hands-on experience, regulatory personnel can become more familiar with and proficient in regulatory work processes and techniques. Moreover, establishing incentive mechanisms to encourage regulatory personnel to actively participate in the construction and use of digital regulation platforms is essential for improving their quality. Reward systems, commendation for outstanding individuals and teams, and providing promotion opportunities can motivate regulatory personnel's enthusiasm and creativity, promoting effective construction and application of digital regulation platforms.

#### ***4.5 Strengthening Public Participation***

To enhance the quality and safety regulation effectiveness of the fresh agricultural product supply chain, public participation should be strengthened, increasing consumer trust in product quality and safety. By using digital platforms to open certain regulatory data to the public and establishing consumer feedback mechanisms, information sharing and interaction can be realized, enhancing the transparency and credibility of regulation.

Firstly, utilizing digital platforms to open part of the regulatory data to the public: An open and transparent regulatory data platform should be established, where some regulatory data such as product sampling results, inspection records of production stages, and penalties for company violations can be made available to the public. Through digital platforms, consumers can easily access product quality and safety information, enhancing their trust in products. Regulatory authorities can also leverage public supervision to compel companies to strictly adhere to relevant regulations and standards.

Secondly, establishing consumer feedback mechanisms: Through digital platforms, consumer feedback channels should be established, encouraging consumers to promptly provide feedback on product quality issues and suggestions. Online complaint, reporting channels, or customer service hotlines can be set up, enabling consumers to conveniently raise issues and suggestions to regulatory authorities or relevant companies. Regulatory authorities should promptly collect and address consumer complaints and suggestions, establishing a communication bridge between consumers, regulatory

authorities, and companies, enhancing the targeting and effectiveness of regulation.

Additionally, digital platforms can be used to conduct consumer education and publicity activities. By creating promotional videos, publishing safety knowledge, and organizing public lectures, quality and safety knowledge of fresh agricultural products can be popularized among the public, improving consumers' food safety awareness and self-protection abilities. Regulatory authorities can also use digital platforms to issue safety tips and warnings, informing the public of product quality issues and risks, guiding consumers to make informed choices.

Lastly, a long-term mechanism for consumer participation in regulation should be established. Consumers should be encouraged to actively participate in regulatory activities, such as product sampling and monitoring company production and sales behaviors. Regulatory authorities can establish volunteer teams for consumer participation in regulation, regularly conducting activities involving consumer supervision, enhancing the inclusiveness and public involvement in regulation.

## 5. Conclusion

The digital economy brings new opportunities for quality and safety regulation in Hainan's fresh agricultural product supply chain. By building a digital regulation platform, promoting standardization, enhancing technological innovation, improving the quality of regulatory personnel, and strengthening public participation, the quality and safety levels of fresh agricultural products can be effectively improved. In the future, it will be necessary to continuously monitor the development trends of the digital economy, continuously optimize and refine regulatory measures according to actual conditions, and promote the high-quality development of Hainan's fresh agricultural product supply chain.

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