Quality control of agricultural product supply chain: a case study of Mengniu supply chain

Hanzhi Zhang
Huazhong University of Science and Technology, School of Artificial Intelligence and Automation, Wuhan, 430074, China

Abstract. With the increasingly serious food safety problem and more and more attention from all walks of life today, the safety of agricultural products as the source of food raw materials should also receive more attention. Therefore, focusing on quality control in the agricultural supply chain is important in this context. This paper explores the progress of research on quality control of agricultural products supply chain from different directions: including product quality traceability system, a combination of quality supervision and new technology, and risk factor analytical methods based on mathematical algorithms; then, there is an analysis based on the specific case of Mengniu's product supply chain. These studies and case analyses jointly demonstrate the importance of building a complete quality management system for agricultural supply chains and improving industry-related standards. Meanwhile, supply chain quality and safety management must keep pace with the times.

1 Introduction
In recent years, the quality and safety of agricultural products are gradually receiving attention. The author believes that the reasons are mainly as follows: First because a variety of agricultural product safety problems are emerging one after another, which in turn has caused various food safety problems, seriously threatening the personal safety and health of consumers; Second, the Chinese government has gradually recognized the loopholes in the quality management of agricultural products, as well as the importance and necessity of ensuring the quality and safety of agricultural products.

Firstly, the author will focus on the typical quality and safety of agricultural products in 2022: many incidents of villagers who used pesticides banned in vegetables in violation of regulations; live cattle were slaughtered without quarantine, and water was injected into the meat; the black chicken products produced by a company which used raw materials with pesticide veterinary drug residues; and pickled sauerkraut with poor conditions was widely exposed through the 3.15 evening. These are typical agricultural safety issues in 2022. And it occurs in different phases of the agricultural product supply chain: from the production phase of agricultural products to the production process of entering the next level of production enterprises as raw materials, the quality and safety of agricultural products occur. Therefore, quality control in the agricultural product supply chain is particularly important. For example, in the case mentioned above of a company producing black chicken with veterinary drug residues, if the black chicken with veterinary drug residues underwent a quality inspection before entering the transportation phase, customers would not buy these raw materials, that is, food companies, through the logistics phase.

With the rapid development of China's social economy and the emergence of quality and safety issues of agricultural products, the government attaches more importance to food safety and the quality and safety of the agricultural product supply chain. This reflects the country's emphasis on the quality and safety of agricultural products and the progress of the quality and safety management system of agricultural products. However, various agricultural product quality problems still emerge, and the research and development of quality control of the agricultural product supply chain still has a long way to go.

For example, in the United States, the Environmental Protection Agency and the Department of Agriculture's Animal and Plant Quarantine Bureau are responsible for source supervision of agricultural products; the government and all states have established agricultural product quality and safety monitoring agencies, which are mainly responsible for testing the quality and safety of agricultural products in the production area and production and processing, and assisting in market access, risk assessment and monitoring of agricultural products [1].

In the EU, based on the EU and the own agricultural product quality and safety standards and laws and regulations of each country, EU countries have established unique agricultural product quality and safety monitoring systems to ensure the quality and safety governance of agricultural products and strictly prevent
unqualified agricultural products from entering the market; at the same time, EU countries have relatively sound third-party agricultural product quality and safety monitoring agencies, whether they are EU government designated institutions and private voluntary institutions, which can systematically monitor all phases of the agricultural product supply chain with the support of the state [1].

The application of foreign advanced experience needs to be established under a complete agricultural product quality and safety governance system and safety technical standards, and at the same time, it is inseparable from perfect laws and regulations on the quality and safety of agricultural products.

In contrast, the quality and safety management of the Chinese agricultural product supply chain started late, and there was a gap with foreign countries in terms of governance system, safety standards and legal and regulatory construction. With the gradual attention of the national government and consumers' greater attention to food safety issues, the rapid development of Internet technology, and the reference of successful foreign experience, the quality and safety control of the Chinese agricultural product supply chain can also be rapidly developed and improved. The quality and safety of agricultural products and consumers' relevant rights and interests can also be better guaranteed.

2. Quality control in the agricultural supply chain

2.1 Agricultural supply chains

The agricultural product supply chain is based on agricultural products as the core, through the control of information flow, logistics and capital flow to coordinate the supply and demand relationship between agricultural production material suppliers, farmers, agricultural product operators and consumers, and then complete a series of processes of agricultural product production operations, transportation, and distribution.

The agricultural product supply chain comprises four phases: supply, production, processing, and distribution. Specifically, the agricultural supply chain reflects the process from suppliers of inputs to producers of agricultural products, i.e., farmers, agricultural suppliers to agricultural product processors, and finally, through distributors and retailers at all levels to be bought by consumers.

2.2 Quality and Safety of agricultural products and quality control of agricultural product supply chain

The quality and safety of agricultural products refer to plant products, animal products, edible fungus products and their processed products, etc.; the entire production process and terminal products; rigorously inspected, all technical indicators and health indicators conform to national or relevant industry standards. Since the quality and safety of agricultural products involve all phases, from their production process to the final product, the control of the quality and safety of agricultural products from the perspective of agricultural product supply chain is conducive to tracking and guaranteeing the situation of agricultural products from the source of production materials to the production and processing of agricultural products, to distribution and sales.

3. Research progress on quality control of agricultural product supply chain

3.1 Different traceability systems in the agricultural product supply chain

3.1.1 Soybean supply chain traceability system based on Ethereum blockchain and smart contracts

Taking the soybean supply chain as an example, Salah et al. built a supply chain traceability system based on the Ethereum blockchain and completed the transaction activities through smart contracts [2].

The researchers first analyzed the product flow in the soy supply chain to build a framework for blockchain based on the existing product flow of the soy supply chain. Blockchain technology can ensure that soybean products are well documented, shareable and tamper-proof at all stages of the supply chain, such as from raw materials to consumers. In this way, traceability of product information can be achieved.

Ethereum is a programmable blockchain platform. The business logic of the blockchain corresponding to the soybean supply chain can be managed through Ethereum, including interaction and access.

A smart contract is a protocol that enables digitally placed and traceable trusted transactions without the intervention of a third party.

The system can complete the traceability of products through information such as Ethereum addresses, product IDs, and purchase dates of customers and suppliers; Trading activities are completed through smart contracts. After the transaction and other operations are completed, the customer's purchase and the supplier's sales status are changed. All users in the blockchain can know the sales information of the product.

The advantage of this system is that the blockchain is easy to trace and cannot be tampered with, ensuring the credibility of traceability information. At the same time, the transaction is completed through smart contracts, avoiding the intervention of intermediaries or third parties.

3.1.2 Architecture based on Petri network modeling
Jiao et al. research objects on beef supply as fresh agricultural products, based on .NET technology and Petri net modeling theory, build a beef quality and safety information traceability platform [3].

Jiao et al. believe that according to the circulation process and organizational carrier of fresh agricultural products, there can be three different forms of agricultural product supply chain: market-oriented supply chain, leading enterprise-farmer-type supply chain and chain distribution supply chain. The traceability system developed by Jiao et al. adopts the modeling method of the Petri network to complete the traceability model based on the Petri network and specifically realizes the design of the feeding phase information model, processing phase information model and sales phase information model to realize product information data update in different phases.

The advantage of this system is that it can fully meet the production management needs of each enterprise in the process of supply and circulation of fresh agricultural products, the quarantine information query and management need of units between fresh agricultural products, and the product history information query needs of consumers. Based on the strong analysis ability of the Petri network, the system analyzes the traceability model of the Petri network to ensure that the traceability system model is scientific and reasonable.

3.1.3 Traditional traceability system

Unlike the former tracing systems are combined with modern computer technology, there are also traditional tracking approaches based on printed documents like ticket tracking and label tracking. These approaches were used before the widely usage of computers.

First, the author will focus on the ticket tracking system. This traceability system refers to the traceability method by which consumers confirm the relevant responsible person by asking for proof of purchase when purchasing agricultural products. This traceability method can be realized from consumers to agricultural market stallholders to their superior suppliers, and the traceability phase of this method is short. As a result, it’s difficult to trace and solve the actual problems of consumers and even more difficult to ensure the safety of the same batch of other products.

Second, this paper will discuss the label traceability scheme. This scheme refers to attaching labels with product production information approved by relevant departments and classified according to different product types. During the implementation of the program, due to the diversity of sources and types of agricultural products, it is difficult to record label information step by step, it is difficult to ensure that all products are labeled, and it is also difficult for regulatory authorities and consumers to supervise and inquire about quality.

The traditional tracking approaches based on printed documents have great limitations with modern views, and the traditional agricultural product traceability scheme separated from computer information technology and RFID technology is not only cumbersome to implement but also difficult to cover diversified product information fully. For consumers, product information could be more intuitive.

3.2 Combination of quality control and new technologies in the agricultural product supply chain

3.2.1 Quality control in the agricultural product supply chain based on the Internet plus initiative

Qiang et al. studied a quality control supply chain model using the Internet plus initiative paradigm, considered the loss of reputation caused by inferior products and external liability, and explored the impact of different factors on the quality of agricultural products from this perspective [4]. This study carried out model analysis and simulation, simulated different measures and their effects on quality control in the agricultural product supply chain, and emphasized that strengthening the responsibility of each link in the supply chain for inferior products is the focus of quality control of the agricultural product supply chain.

Liu et al. studied the quality supervision system of the agricultural product supply chain in Jilin Province based on the Internet Plus initiative analyzed the quality and safety issues of the agricultural product supply chain in Jilin Province and the possibility of relying on the Internet Plus initiative to build a quality supervision system for agricultural product supply chain, and explored the operation mode of agricultural product supply chain and its quality supervision method on this basis [5].

The above two studies explore the combination of quality control and Internet technology in the agricultural product supply chain from two perspectives. Liu et al.’s research mainly analyze the current development trend and its possibilities; The research of Qiang et al. explores the key factors affecting the quality control of agricultural product supply chains through model construction and simulation analysis, which is highly innovative.

3.2.2 Quality control in the agricultural product supply chain based on Blockchain

Leng et al. studied the shared blockchain of agricultural supply chain systems based on the double-chain structure [6]. The storage mode under the double-chain structure and the rent-seeking and matching of resources are explored. Blockchain can ensure that the stored information is open and tamper-proof while using the PoS consensus algorithm to solve the two-way selection and matching of resources and users. The researchers also set up simulation experiments to verify the double-stranded structure system.

Zhong et al. studied the quality and safety management methods of the dairy supply chain from the
perspective of blockchain application [7]. Blockchain is a distributed system with core technologies such as public and private key technology and consensus mechanism. Every action of the participants is recorded in the blockchain, and everyone can use the recorded data and cannot change or delete it. This enables technical enhancement of quality and safety management in the dairy supply chain. In the process of using blockchain technology to manage the quality of the dairy supply chain, real-time monitoring of supply chain quality and safety is realized through the characteristics of blockchain decentralization; Improves the efficiency of security monitoring through the consensus mechanism in the blockchain to ensure data consistency and record validity; the authenticity of quality and safety information is ensured through the public and private keys.

3.3 Quality risk analysis in the agricultural supply chain

3.3.1 Supply chain quality risk analysis based on AHP

Qin et al. evaluated different risk factors in the cold chain of fresh agricultural products based on the AHP analytic hierarchy method [8].

The study first identifies different risk factors and then quantitatively analyzes these different risk factors based on the basic principles of analytic hierarchy, constructs a judgment matrix, scores and evaluates the environmental risk factors, human resource risk factors, technical risk factors and product processing risk factors in the cold chain process, and finally obtains the risk analysis results.

The evaluation system results are: environmental risk has the largest weight among the first-level risk indicators, reflecting the low prevention efficiency of this risk; It is followed by product processing risk and human resource risk, while technology risk accounts for the least weight.

The study also gives recommendations based on this risk assessment: strengthen awareness of natural risk prevention, Improve relevant and industry-standard systems, and strictly review product processing phases and their processing enterprises.

3.3.2 Supply chain quality risk analysis based on ISM

Zheng et al. studied agricultural product supply chain quality and safety risk analysis using the ISM explanatory structure model method [9].

This method invites experts to negotiate the specific risk influencing factors, constructs a binary matrix of the quality and safety risk constraint relationship of agricultural product supply chain, and then constructs its adjacency matrix and reachability matrix, establishes an explanatory structure model based on the results embodied in the matrix, and summarizes the extent of influence of each factor on the quality and safety of agricultural products and the dependence between different factors through the clustering method.

The conclusions of the evaluation system are as follows: the quality and safety risk factors of the agricultural product supply chain at the macro level include imperfect laws and regulations and lax supervision, imperfect testing system and a changeable production environment; At the meso level, there are information transmission obstacles in various phases in the supply chain and incongruity between enterprises; Micro-level factors include poor quality awareness, backward quality control technology and cost problems, and lack of social responsibility.

Even if the risk factors of the two options are not the same, we can still find similarities in their conclusion analysis: that is, it is important to strengthen the quality system and improve the relevant standards of the industry; Scrutiny of relevant enterprises at all levels of the agricultural supply chain should also be intensified to minimize the main risks posed by these factors.

4. Supply chain quality and safety analysis taking Mengniu as an example

Mengniu is one of China's leading dairy suppliers and a global leader in the industry. It owns multiple dairy brands, multiple sources of milk and proprietary farms worldwide, and a strong supply chain network. This chapter provides a detailed analysis of Mengniu's quality and safety management. Mengniu strengthens quality control in product production and market access and introduces international standards; At the product traceability level, Mengniu has in-depth cooperation with JD and gives products unique anti-counterfeiting identification codes through advanced Internet of Things and blockchain technology to ensure product quality safety and traceability.

4.1. Product Quality Assurance

Mengniu's milk powder brand started late, and at the beginning of its establishment, it cooperated with a European dairy company to jointly establish a quality and safety system while introducing international standards to ensure the reliability of product quality. At the same time, based on strict EU regulatory policies, Mengniu's cooperation with the European company has led to the traceability of its milk powder products throughout the production process.

In addition, Mengniu pays attention to product market access standards, strengthens product quality control in the upstream of the supply chain, and uses new sanitize technology and production technology to ensure that the outgoing quality of products is qualified; in the downstream of the supply chain, including distribution, retail and other phases, sales quality management personnel are equipped to strengthen the supervision of product quality in each phase of the supply chain by increasing the number of management personnel.
4.2. Traceability system and blockchain

Mengniu cooperated with JD Group to realize the traceability of the products sold through JD's blockchain technology.

Some dairy companies have their anti-counterfeiting traceability system. Still, they can only contain the source and production information of the product, and it is challenging to cover and track the whole process of product storage, sales, and distribution. JD cooperates with various brands to build an anti-counterfeiting traceability platform, using advanced Internet of Things technology to give each product an anti-counterfeiting identification code so that consumers can view the whole process information of the product from the source of production materials, production phase, storage phase, distribution phase, sales phase, etc. At the same time, the blockchain system is jointly built by various enterprises in the phase, and the relative independence of each phase is realized while establishing the mutual trust mechanism of the enterprise to ensure the relative confidentiality and non-tampering of product information [10].

5. Conclusion

This paper first analyzes the objective existence of the quality and safety of agricultural products in China and the increasing attention of the national government, introduces the relevant concepts of the agricultural product supply chain, and analyzes and summarizes the quality control of agricultural products from the perspective of the supply chain:

From the perspective of the traceability system, there is already a user-oriented traceability system architecture, a traceability idea based on the Petri network and a traditional paper archive traceability scheme. The traceability system should conform to the trend of the times and develop in the direction of digitalization and systematization.

From the perspective of new technologies, the current relevant research has tended to combine advanced Internet of Things and blockchain technology and the related ecology of Internet + to build a perfect quality and safety management system for agricultural product supply chains.

From the perspective of risk analysis, the current relevant research has based on AHP analytic hierarchy method to analyze risk factors and ISM explanatory structure model method for modeling and correlation analysis, under different risk factors and different analysis methods, the conclusions reached also have their similarities: it is important to strengthen the construction of quality system and improve relevant industry standards.

Mengniu's supply chain quality and safety management case strongly supports the first three conclusions: Mengniu strictly requires international standards in the production and sales of products and cooperates with JD.com to build a blockchain system at the product traceability level to ensure that product production and circulation information can be traced and trusted by consumers.

With the development of the times and the rapid progress of Internet technology, the quality management and traceability system of the agricultural product supply chain will also develop in a more digital and information-based direction, and the quality and safety control and problem product traceability in the agricultural product supply chain will become more efficient and accurate. In the context of the increasing attention of the national government and the increasing concern of consumers about food safety, there will be more agricultural product quality and safety issues that will be nowhere to hide, and China's agricultural product supply chain quality and safety governance system and industry-related standards will be more complete.

References

1. X. Lei, C. Du, Heilongjiang Animal Husbandry and Veterinary Medicine 22, 258 (2017)
5. Z. Liu, X. Li, Mod. Mark. 08, 84 (2020)
7. H. Zhong, Y. Yu, Y. Liu, Chin. Market. 01, 175 (2023)
8. Q Ying, Henan Agric. 23, 58 (2019)