

Research on model for grain storage and transportation security and construction of information network integration platform

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Abstract

Grain is perceived as the strategic material affecting the national economy and the people's livelihood, and its security lays the material foundation for building a harmonious society. As the key part in the grain logistics, grain storage and transportation work to guarantee the food security, which is based on the constantly improved safety management level in the course of storing and transporting. According to the common problems in food storage and transportation, the paper is to adopt the safe storage-distribution information technology and management technology which are widely applied in other field in the era of information, for the sake of addressing the traditional problems existing in food security. On this basis, the model for safe grain storage and transportation is constructed. And the information network integration platform for safe food logistics is structured from three functional layers including logistics entity, logistics data collection layer and logistics data service layer, to realize resource integration, monitoring management, inspection management and logistics supervision. In the paper, grain reservation and transportation safety management is provided with a simple, operational and powerful management tool, which enriches the grain safety management system in China and is of practical significance.

Key words: *information network, grain, security, model*

1 Introduction

As the vegetable food essential for the basic survival of mankind, grain is considered to be the general term of edible cereals, legumes and tubers, marked by non-substitutability, supply elasticity, small demand elasticity, hard storage and fluctuating prices. It is crucial to ensure the food security of the country for the reason that grain is one kind of special commodity and the strategic supply vital to national well-being and the people's livelihood.

From the perspective of industrial chain, production, circulation and consumption are the key parts for grains. However, its value can be reflected and enhanced in the process of circulation, because that it is given the significant seasonality and circulation is inevitable owing to the separated places for production and consumption. The safe grain circulation consists of grain acquisition, storage, transportation, processing and sale safety, ensuring to provide the secure marketable grain for consumers eventually. As the key part in the grain logistics, grain storage and transportation work to guarantee the food security, which is based on the constantly improved safety management level in the course of storing and transporting. On account of the absent systematic operating mechanism for grain storage and transportation safety management, there are great fluctuations occurring in grain circulation, reservation and transportation business, triggering the delayed partial food supply and the rising market price.¹

First of all, grain transportation safety is all about the technical problem. Only when the advanced and scientific grain storage and transportation technology is mastered, can the scientific green food storage and transportation target which is safe storage, secure transportation, low loss, oligosaprobic, low-cost, high-quality, nutritious and profitable be realized. Secondly, it is involved in management. Based on the status quo of China, it is looming to set up the food safety storage and transportation system with Chinese characteristics.

Grain storage and transportation safety technology is about the various food tools, equipment, facilities and other means of material which are used by human when reserving and distributing foods, as well as diversified methods, skills and operating procedures developed by modern technologies like scientific knowledge, labor experience, computer software and communications. Mastering and selecting the effective, scientific and economic technology for food transportation to build the grain storage and transportation safety management model guarantees the solution to present food storage and transportation.

Nowadays, information society is approaching and it is trend of times to perform security management by applying information technology. Cao Wei (2010) has built the grain logistics information management system which is established with the help of modern information technology.² And Pang Yanbo (2013) has provided the reference for the construction of grain storage and transportation safety informatization in China by comparing the food flow system from the United States, Japan and Europe. Based on the previous studies, the paper is to found

the information network integration platform designed to manage the grain transportation, which is of great significance for the secure logistics in the long run.³

2 Grain storage and transportation safety technology

According to technical form, grain storage and transportation safety technology can be categorized into grain storage and transportation safety information technology and management technology.

2.1 Grain storage and transportation safety information technology

2.1.1 Grain quality safety traceability technology based on RFID

RFID technology, radio frequency identification technology, is one kind of contactless automatic identification technique which is to identify object to be recognized automatically by applying the spatial inductance of radio frequency signals or the transmission characteristic of electromagnetic coupling. Generally, the radio frequency identification system is comprised of electronic tag, reader, antenna and middleware system. Owing to the features of food transportation, the grain safety traceability information system shall be the integration of hierarchicalization, compositive multiple technologies and diversified applications. Therefore, it can be used to work out the problem of hierarchical network model complexity.

2.1.2 The multi-sensor information fusion measurement and control technology of grain

Owing to the frequent mildew in the grain storage, the multi-sensor information fusion measurement and control technology of grain is promoted in the country. It is to observe the status in grain depots in real time and to reflect the operation of grain protection equipment veritably, and its accuracy and reliability are directly related to the application effects of new grain storage technologies and the security of foods.

2.1.3 Integrated management technology of grain supply chain based on internet of things

There is missing complete grain supply chain in grain circulation system in China, failing to research by integrating all the nodes and links of the grain industry. Accompanying with the development and maturity of Internet of things technology, the application of Internet of things in grain logistics will come true, and the technology will improve all operation parts of grain logistics. In the context, the integrated management technology of grain supply chain based on Internet of Things shall be boosted in the research and development of macro

strategic planning of grain supply chain system, mid-view management of grain logistics and micro key technologies of grain logistics and information networks as well as technologies.

2.1.4 Grain transportation vehicle monitoring technology based on GPS or GPRS

According to the characteristics of grain transportation, the grain transportation vehicle monitoring system integrating GPS positioning technology and GPRS communication technology is designed to realize the real-time tracking and positioning of grain transportation terminal, gather the information about grains in the process of transporting and achieve the constant communication with the remote control center. And it is also the information technology to guarantee the safe storage and distribution of foods.

2.2 Grain storage and transportation safety management technology

2.2.1 QR technology and ECR technology in grain supply chain management

QR, namely Quick Response, is one kind of supply chain management strategy, in which the strategic cooperative partnership among members of supply chain will be built, to shorten delivery cycle, reduce inventory, improve customer service level and enterprise competitiveness in the way of exchanging and sharing information with the help of EDI and other information technology and supplementing goods by distribution means of high frequency small quantity. It will play an important role in managing food supply chain by establishing QR technology of the reactive food supply chain. ECR, namely Efficient Consumer Response, is one supply chain management strategy that distributors and suppliers work closely to eliminate unnecessary costs in the system and to bring greater benefits to customers. The establishment of ECR cannot only satisfy the requirements of customers and minimize logistics costs, but also react timely to optimize the good supply and service process provided.

2.2.2 Grain inventory management technology based on grain supply chain

It is one part to manage chain inventory in grain safety management. In order to cut down inventory costs and maximize profits, the inventory management method or mechanism is of the essence. And the simple and convenient operation shall be designed to combine the methods or mechanisms with practice. Therefore, the grain inventory management technology based on the grain supply chain is introduced in the paper. After ensuring the safety of the data, the inventory at all levels shall be checked at fixed periods and the finished goods shall

be coordinated and distributed on this basis to realize automatic management and coordination of multi-inventory. In that way, it improves the service level, cut down the management and inventory costs and enhance the profitability of the food supply chain.

2.2.3 CPFR technology based on grain supply chain

CPFR (Collaborative Planning, Forecasting & Replenishment) is to apply a series of processing and technical models and provides a collaborative process covering the entire supply chain. Through the process of joint business management and shared information, it is to better partnership between grain retailers and suppliers and to strengthen the accuracy of forecasts, realizing the lifted supply chain efficiency, reduced inventory and enhanced customer satisfaction eventually.

2.2.4 Optimal dispatching technology of grain distribution vehicle based on BP neural network

To reduce the logistics cost of grains effectively, it is important to curtail expenses happening in the course of grain transportation. In terms of transportation and distribution of grain, the dispatching of transport vehicles shall be given the priority. The optimal dispatching technique of grain distribution vehicle based on BP neural network can dispatch vehicles correctly and reasonably, better reduce the empty driving rate of vehicles and realize the transportation with the reasonable route, so as to reduce expenses for transporting, save transportation time and get more benefits.

2.2.5 Safe grain storage technology based on biological engineering

Safe grain storage technology based on Biological Engineering is considered as one green grain storage technology without any chemical agent. It is to bring prevention and control in the round by effective ecological means, keep the grains from contamination, protect the environment and ensure the safety of grain storage, providing people with the food which is fresh, nutritious, savory and non-toxic. To achieve green grain storage, there are two ways: firstly, it is to prevent or reduce the infection and invasion of harmful organisms and enhance the resistance of grain; secondly, the ecological balance of pests shall be destroyed to prevent or minimize hazardous organisms and guarantee the safe grain.

2.2.6 Grain quality safety monitoring technology based on HACCP

HACCP (Hazard Analysis Critical Control Points), the systematic approach to identify, assess and control food safety hazards, can prevent food borne disease arising from chemical, physical and biological pollution, and avert the hazards from aging grains. For the reason that there are many factors such as insect attack, mildew and aging to affect the quality and safety when storing and transporting, it is imperative to apply HACCP system in analyzing the hazards and monitoring the quality of grain storage and transportation industry in China.

3 Model of grain storage and transportation safety system

3.1 Model of grain storage and transportation safety system

Grain security is primarily divided into grain logistics security and quality safety, including the part like production, circulation and consumption and involved in several departments such as government, regulatory administration, food suppliers and grain distributors. From the aspects of comprehensive control mechanism of grain storage and transportation safety management, safety guarantee system, safety technology, management model and information network integration platform, the paper is to build the grain storage and transportation safety system model.

3.1.1 Comprehensive control mechanism of grain storage and transportation safety management

The comprehensive control of grain storage and transportation safety management can work under the collaboration from three levels which are government regulation, industry self-discipline and enterprise governance. In ensuring the security of grains, the government is obliged to control crisis and regulate routinely. Grain crisis management responsibility is about the obligation for emergency response to food safety problem in the face of serious natural disasters, wars, international blockades, epidemics and other emergencies to result in excessive fluctuation happening in food market or panic buying. And the grain regulation responsibility refers to the related regulatory duties beyond the responsibility of crisis management to keep basic balance of the total and stable market, crack down on counterfeit and ensure quality and safety.

3.1.2 Grain storage and transportation safety guarantee system

Under the guidance of the comprehensive control of grain storage and transportation safety management, the safety management strategy is adopted to set up the grain storage and transportation safety guarantee system which is made up of circulation guarantee system, consumption guarantee system and macro-control guarantee system. Among them, the logistics guarantee system of circulation guarantee system incorporates the establishment of unified grain logistics facilities system, supporting logistics informatization, the thorough grain logistics supply chain management and the ingenious measurement and control system.

3.1.3 Grain storage and transportation safety technology

During the construction, the grain storage and transportation safety guarantee system shall be supported by the grain storage and transportation safety technology which is perceived as the crucial method to realize the integrated control of grain storage and transportation safety management and the structure of grain storage and transportation safety guarantee system. At the same time, the technology categorized into safety information technology and safety management technology for grain storage and transportation shall be applied under the action of integrated control mechanism and security system.

3.1.4 Grain storage and transportation safety management model

The model is to apply grain storage and transportation safety management technology synthetically. Based on food supply chain, it weighs up the grain quality safety and logistics security from all directions to make the process of warehousing and shipping efficient, fast and scientific and realize cost cutting.

3.1.5 Grain storage and transportation safety management model

When administrating security, information plays a pivotal role. Especially in the context of network economy, it is imperative to build grain storage and transportation network for bringing integrated management of information in the course of storing and transporting. Based on grain storage and transportation information network system, the platform is designed to achieve storage and transportation information which is electronic and digital. After completing the network, it comes at the automatic collection, processing, storage, transmission and exchange of information, in an attempt to develop and widely share storage

and transportation information resources, reduce logistics costs and improve logistics efficiency eventually.

3.2 Model of grain storage and transportation safety management

On the basis of grain supply chain, model of grain storage and transportation safety management is established in the paper to integrate and coordinate diversified grain storage and transportation safety management techniques and realize the management which is efficient, rapid and scientific, so as to lower the costs to distribution and ensure that grains can reach to consumers effectively and promptly.

3.2.1 Logistics management in grain storage and transportation

The grain supply chain is distinctive. First of all, grain as the commodity is closely related to the national welfare and the people's livelihood, so the supply chain shall be operated under the support of strong grain reserves. Moreover, grain is seasonal and affected by climate. Therefore, it is not goanna work to realize “zero inventory” as other enterprises, and the balance between supply and demand as well as structural balance shall be controlled. Vendor managed inventory policy, joint inventory management (JMI), collaborative planning as well as forecast and recharge applications can be applied in management, and the proper inventory control methods can be selected in line with the specific situation of the grain supply chain and the goals to be achieved.

While shortening the delivery cycle, reducing inventory, improving customer service level and enterprise competitiveness, the adoption of QR technology and ECR technology can also meet consumer needs with the better, faster and lower-cost services. By using optimal dispatching technique of grain distribution vehicle based on BP neural network can cut down transportation costs, save transportation time and improve economic efficiency effectively.

3.2.2 Quality management in grain storage and transportation

It strengthens the supervision of grain quality and safety, sets up the grain quality and safety guarantee system, adopts the HACCP-based system and makes the systematic and comprehensive analysis on various hazards leading to food pollution or development during the course from food material cultivation to food intake. After analyzing, the key control points which can prevent, alleviate or eliminate all hazards effectively are determined.

Therefore, those hazards shall be controlled in the critical control points, and the control shall be supervised to correct and supplement the control techniques

During the period of grain storage, it is to monitor the grain conditions and apply the storage technology. When it comes to the grain monitoring, it focuses on controlling stock quality inspection and temperature, moisture and pest. When improving the technologies like automatic temperature measurement, recirculation fumigation, grain cooling and ventilation as well as mechanical ventilation, the grain monitoring means will keep working to set up the monitoring system and changing the status quo of “advanced grain storage technology + traditional management methods”. The monitoring system giving the priority to mater food quality inspection and temperature, moisture and pest is helpful to learn the changes in grains for leaders of grain depot and experts of storage in time, so as to take the scientific and valid measures like cooling, precipitation and fumigation and make business decisions timely.

4 Management information network integration platform for grain storage and transportation safety

From the perspective of implementation, the platform consists of three different functional layers which are separately logistics entity, logistics data collection layer and logistics data service layer, with the logic between layers and primary applied technology as shown in Fig 1. In management information network integration platform for grain storage and transportation safety, grain logistics management, quality rapid detection information collection and traceability, grain monitoring and reliable circulation information are collected. All of the data are to process each function module existing in the information network resource integration and data acquisition system for grain storage and transportation. If it is needed to publish or share data outside, you are allowed to publish it to public information platform or logistics management public platform of data service layer by means of authorization, to make it possible for producers, consumers and middlemen to inquire.

Information network resource integration and data acquisition system for grain storage and transportation is given the following functions:

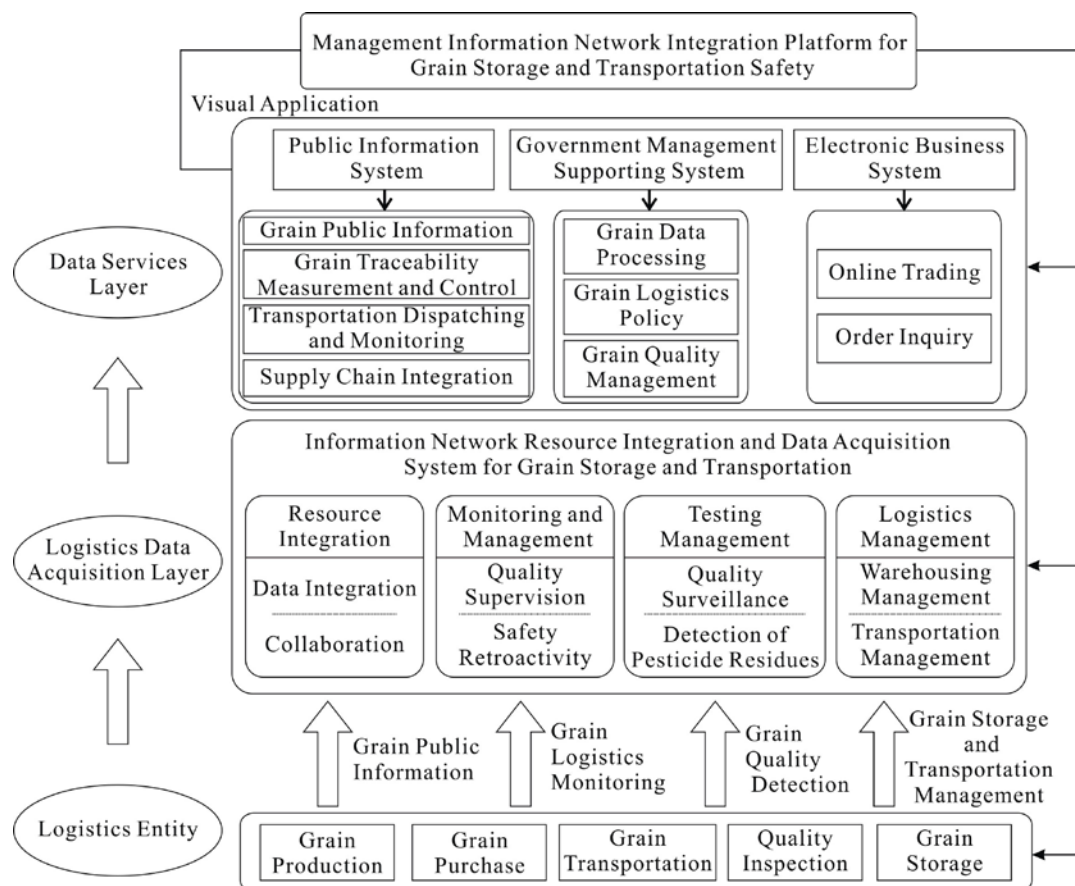


Fig. 1 – Management Information Network Integration Platform for Grain Storage and Transportation Safety

4.1 Resource integration

It is to collect and process the data in the grain storage and transportation network. Applying the distributed database and personalized interface control technology, the management information network integration platform can share and exchange data with all logistics entities. By using the integrated management technology of grain supply chain based on Internet of things and grain transportation vehicle monitoring technology based on GPS or GPRS, the grain cooperative procurement, warehousing and transportation based on the grain supply chain can be conducted with the help of decision-supporting system for grain storage and transportation. It realizes logistics allocation and virtual logistics delivery in the virtual space, coordinate transportation routes in real time and provide the other value-added services. In virtue of virtual stowage, the shippers are allowed to find the transport vehicles fitting them and the vehicle owner can deploy the vehicle reasonably. And the real-time optimization technology of the virtual logistics delivery plays a role in reducing unloaded ratio and realizing vehicle real-time dispatching, path arrangement and constant monitoring.

4.2 Monitoring management

It covers grain commodity information identification, real-time collection of grain information, information transmission, processing, analysis, early warning, providing and adopting tracking system of grain quality, building various supervision subsystems for grain products and designing the collection system for grain information. Meanwhile, the grain quality safety traceability technology based on RFID is put into use to track and manage the products in two ways, namely the origin and whereabouts. When establishing traceability database and whole traceability system of regional characteristic grain quality and safety, it is comprised of inspection information of grain history, origin information, traceability information and relevant standard information as well as the collection, transmission, analysis, processing, early warning and utilization about the data.

4.3 Testing management

It is to develop rapid acquisition technology of grain quality parameters and to explore food quality and pesticide residue parameters interactive transmission system on the basis of low-cost data transmission processing technology. After building mathematical model and developing system software, it conducts the real-time dynamic summarization, statistics, analysis and tabulation processing on all data to be tested. And the data of grain quality inspection stations is put into networked and centralized processing by taking the advantage of Internet technology to supervise network monitoring points constantly. The measurement and control technology based on multi-sensor information fusion is adopted in the construction of dynamic food quality monitoring and pesticide residue monitoring system.

4.4 Logistics management

It covers the management in the whole process of grain storage and transportation, like procurement, transportation, warehouse, distribution, delivery and receiving.

The management information network integration platform is able to realize prefabrication, customization, collection and delivery of the grain logistics information, with the push mechanism of related logistics information set inside. As the platform for comprehensive information service, data exchange, logistics transaction support, cargo tracking and industry application hosting service, it satisfies information needs of multiple participants and provides the query function which is convenient, fast and abundant. Along with the implementation of

this platform, the promotion and development of the data integration and sharing technology of the grain logistics information platform can be accelerated, to improve production efficiency, cut down production cost, decrease the informatization input of grain storage and transportation enterprises, avoid repeated investment of the enterprises, speed up the informatization process and enhance the core competitiveness of the enterprises involved in food storage and transportation.

5 Conclusions

According to the risks existing in the process of grain storage and transportation, the information technology which can be applied in the grain storage and transportation safety is sorted out in the paper, and it constructs the grain storage and transportation safety model and makes the research on information network integration platform. Through the study, it can draw the conclusions as follows:

The information technology applied in the grain storage and transportation safety covers Grain Quality Safety Traceability Technology based on RFID, the Multi-Sensor Information Fusion Measurement and Control Technology of Grain, Integrated Management Technology of Grain Supply Chain based on Internet of Things as well as Grain Transportation Vehicle Monitoring Technology based on GPS or GPRS. In terms of safety management technologies of grain storage and transportation is made up of QR Technology and ECR Technology in Grain Supply Chain Management, Grain Inventory Management Technology based on Grain Supply Chain, CPFR Technology based on Grain Supply Chain, Optimal Dispatching Technology of Grain Distribution Vehicle based on BP Neural Network, Safe Grain Storage Technology based on Biological Engineering and Grain Quality Safety Monitoring Technology based on HACCP.

The model of grain storage and transportation safety system built in the paper can deal with the risks in the process of storing and transporting from five aspects, including Comprehensive Control Mechanism of Grain Storage and Transportation Safety Management, Grain Storage and Transportation Safety Guarantee System, Grain Storage and Transportation Safety Technology, Grain Storage and Transportation Safety Management Model and Management Information Network Integration Platform for Grain Storage and Transportation Safety. And the integrated platform covers logistics entity, logistics data collection layer and logistics data service layer and it is able to realize four functions which are separately

resource integration, monitoring supervision, inspection management and logistics management.

Acknowledgements

I would like to express my gratitude to all those who helped me during the writing of this paper.

References

1. *W. Zheng, S. M. Peng*, Research on China's Safety Management and Operation Mechanism of Grain Storage and Transportation, *Shandong Social Sciences* **6** (2014) 179-183.
2. *W. Cao*, Construction of Grain Logistics Information Management System under the Condition of E-commerce, *Journal of Hunan University of Commerce* **3** (2010) 100-103.
3. *Y. H. Pang*, Comparative Study on Food Flow System among America, Japan and Europe, *Manager* **5** (2013) 50.