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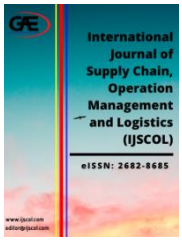

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RESEARCH ON THE APPLICATION OF INTERNET OF THINGS IN THE COLD CHAIN LOGISTICS OF AGRICULTURAL PRODUCTS

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Abstract:

Based on the introduction of the concept and characteristics of cold chain logistics for agricultural products e-commerce, this article explains the rapid development of e-commerce and the application of the Internet of things in cold chain logistics have brought earth-shaking changes to people's consumption patterns, the current deficiencies in the cold chain logistics management of agricultural products and the urgent needs for the application of the Internet of things information system, and analyzes the application of Internet of things in different stages of cold chain logistics for fresh agricultural products such as pre-cooling at the place of production, processing and packaging, cold chain transportation and sales. Research conclusions show that by using Internet of things to optimize the cold chain logistics system of fresh agricultural products as a whole, building a fast, effective, and full traceable cold chain IOT information system can promote the efficient and stable development of cold chain logistics and transportation of fresh agricultural products.

Keywords:

Internet Of Things, E-Commerce, Cold Chain Logistics, Agricultural Products

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Introduction

In recent years, the upgrading and popularization of Internet of things have exacerbated the changes in people's consumption patterns. Online consumption has gradually become a living habit, and consumers can purchase high-quality goods from all over the world without leaving their homes. The combination of e-commerce and the fresh agricultural product industry based on Internet of things has overturned the traditional agricultural product sales model. The data shows that the China's fresh food e-commerce transaction scale is developing rapidly at a growth rate of more than 30%. As of 2020, the nation's transaction scale has reached a new high of 400 billion yuan, a year-on-year increase of nearly 40%. This is expected in 2021, and the data will exceed 550 billion, a year-on-year increase of 37.50% (Wang, Wang et al. 2021). With the continuous deepening of Internet applications and the rapid expansion of e-commerce platforms, fresh food e-commerce continues to attract major domestic e-commerce companies to participate in market competition (Qu, Mao et al. 2017). With the rapid development of domestic agricultural product e-commerce, how to reduce cold chain distribution costs? Improving the timeliness of cold chain logistics has become the biggest problem facing the development of major e-commerce companies (Ban, 2018). Transportation cost is the most important part of cold chain logistics distribution cost, and the most critical one is the choice of specific transportation methods (Zhao, Zhang et al. 2020). In the currently widely used traditional transportation methods, fresh products have many perishable and easily damaged phenomena during the transportation process, resulting in severe waste.

Based on the research statistics, due to the high loss during transportation and loading and unloading, about 70% of the cost of fresh agricultural products is occupied by cold chain logistics costs, which far exceeds the United States, Japan, Europe, and other countries (Ma, Wang et al. 2018). High cold chain logistics costs have increased the selling prices of fresh agricultural products on e-commerce platforms, making enterprises more sensitive to logistics costs. In addition, the loss rate of fresh agricultural products in circulation is very high, with an average of as high as 30%, while the ordinary commodity wastage rate is less than 1% (Wang, Wei et al. 2018). Once the commodity does not meet consumer expectations and returns or exchanges, it may not be sold again according to the shelf-life theory of fresh agricultural products. Therefore, it also creates very high reverse logistics costs.

E-commerce fresh cold chain logistics is required to have sensitive and accurate market response capabilities, and it has high requirements for coordination between upstream and downstream links. It needs to be closely connected between links to ensure that the fresh food categories meet the required temperature, humidity, and efficient circulation in the environment. Substantial information technology is necessary to ensure that the quality of fresh agricultural products in cold chain logistics meets market expectations through practical information guidance.

In the 21st century, cold chain logistics has entered an era of rapid development in China, especially since 2012 (Sun, Gao et al. 2020). With the popularization of the Internet, fresh agricultural products worldwide have entered ordinary people's homes through cold chain logistics. The rapid development of the domestic cold chain logistics industry is mainly based on two reasons. Firstly, the rise of fresh food e-commerce is an important driving force for the cold chain. From the perspective of the number of completed orders, the emergence of cold chain logistics has greatly promoted the transactions of fresh food e-commerce, and the rise of fresh food e-commerce has also promoted the development of cold chain logistics. The total

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output value of China's food industry accounted for 7.1% of the whole national industry (Sun and Ahn, 2018). By 2014, the total output value of the food industry reached 12.3 trillion yuan, an annual growth rate of 15% (Wang, 2016). The proportion is still very low, and its market share of fresh agricultural products is even lower. Although since 2013, food e-commerce has begun to explode, the average annual transaction volume of platforms such as Tmall, JD, and COFCO has increased rapidly, and the fresh food e-commerce system has become more mature, but it accounts for the market entity. The circulation ratio is still very low. The current market share is only about 1%, far lower than clothing, electronic products, skincare cosmetics, and other categories (Only 2017).

However, the development level and scale of China's fresh food e-commerce are still in its infancy. The overall scale is small, and the consumer groups and market are not significant—for example, e-commerce giants such as Tmall and JD, who have more advanced systems and management. The logistics informatization and information interaction of small enterprises are not enough, and most of them are in the initial stage of optimization. Therefore, the informatization construction of the e-commerce platform can help improve the timeliness of cold chain logistics and ensure the freshness of agricultural products so that the e-commerce of agricultural products can quickly gain market share and enhance the competitiveness of the e-commerce platform (Qu, Mao et al. 2017).

The Definition Concept

The Concept Of Fresh Product E-Commerce And The Characteristics Of Fresh Agricultural Product E-Commerce Logistics

The Concept Of Fresh Food E-Commerce

Fresh product e-commerce refers to the use of e-commerce to directly sell fresh products online. Fresh products include fresh fruits and vegetables. The fresh food e-commerce market has enormous potential. It has a large-scale screen name base, its market share is low, and its room for improvement is evident (Zeng, Jia et al. 2017).

Fresh food e-commerce optimizes the supply chain, enables cold chain logistics, enhances information transparency, and delivers fresh products to consumers efficiently and transparently (Qu, Mao et al. 2017). Among them, China pointed out in the "Development Plan for Cold Chain Logistics of Agricultural Products" that the cold chain logistics of agricultural products means that fresh agricultural products such as meat, poultry, aquatic products, fruits, vegetables, eggs, etc. are harvested (or harvested or slaughtered) from the place of production and then processed. Storage, transportation, distribution, retail, and other links are always in a suitable low-temperature control environment to ensure product quality and quality safety to the greatest extent, reduce losses, and prevent pollution (Shi, Xie et al. 2018). The cold chain logistics of fresh agricultural products is a systematic project, which requires the support of product manufacturers or producers, cooperatives, agricultural associations, distributors, etc., is the cold chain logistics of the entire supply chain from farmland to consumers (Jing, Wen et al. 2019).

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Characteristics Of E-Commerce Logistics Of Fresh Agricultural Products

Its Primary Task Is To Ensure The Quality Of Agricultural Products

The particularity of e-commerce and the perishable nature of fresh agricultural products determine that the logistics and transportation of fresh agricultural products have different characteristics from general logistics (Zhang and Huang, 2015). Compare with the previous purchases of vegetables in physical stores in the market, e-commerce is completely different due to its virtual nature. Consumers ordering fresh agricultural products such as vegetables and fruits online are invisible and intangible. They are the first time they consume. It is only through product description details or evaluation to purchase goods, so the first consumer experience is very important, depending on the quality of the agricultural products themselves. From the agricultural products in the fields to consumers, in this entire supply chain link, a visual e-commerce information management system is used to ensure the controllable state of product quality(Zhang and Huang, 2015). It is of great help to consumers in establishing online shopping information.

Ensure The High Timeliness Of The Distribution Process

Due to its perishable nature, the shelf life of fresh agricultural products is relatively short. People pay attention to whether the products are fresh when buying. It is required faster and timely logistics and distribution, and the operation time of the fresh produce supply chain process should be kept to the shortest (Wang et al. 2013). The freshness of the product can be guaranteed, thereby enhancing customer satisfaction and experience. In addition, the current target customers of fresh agricultural products e-commerce are mainly office workers, and their receiving time is greatly restricted, which has higher requirements for the logistics and distribution of agricultural products (Ban, 2018). Enterprises are also solving this problem. Now, many e-commerce companies of agricultural products can deliver home delivery services the next day in the same city or deliver them to consumers on the same day at an appointment time(Jing, Wen et al. 2019).

The Particularity Of Transportation Equipment And Technology

Due to the particularity of the transport of goods, the technology of storage, packaging, transportation, and other links will directly affect the quality of fresh products. Many fresh agricultural products have high water content and short fresh-keeping period. Therefore, some special refrigerated transportation must be used in the cold chain logistics system (Bao, Zhang et al. 2018). Since the transportation tools are specially made according to the characteristics of the goods, they must be equipped with low-temperature storage warehouses, food preservation boxes, and refrigerated transport vehicles accordingly (Navazi, Tavakkoli-Moghaddam et al. 2018). Therefore, transportation technology and equipment are tough conditions directly linked to the freshness of fresh products so that the freshness of the products can be maintained during the transportation process (Ma, Wang et al. 2018).

The Distribution Network Is Simplified, But The Distribution Points Are Scattered

The consumption points of households are scattered in the city, resulting in many distribution points and increasing the difficulty of distribution (Ma, Wang et al. 2018). Unlike the traditional distribution of food distributors to significant supermarkets and markets, these logistics points are concentrated, and the delivery volume is large, the cost is relatively low, and the logistics route is easy to plan. However, now it is highly scattered, and the unit delivery volume is small. It is difficult to control the distribution route and time, which requires scientific planning of the distribution route to meet customer requirements (Xiao, Zhao et al.

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2019). Despite the above problems, the distribution of agricultural products under e-commerce does reduce many circulation links and increases efficiency compared with the traditional model (Bao, Zhang et al. 2018).

Results And Discussion

Application of Internet Of Things In Different Stages Of Cold Chain Logistics Of Fresh Food E-commerce Agricultural Products

Fresh agricultural products have the characteristics of perishability and high timeliness. Therefore, in the essential links of production, storage, transportation, and sales included in cold chain logistics, Internet of things is used to optimize fresh agricultural products' cold chain logistics system throughout the process (Wang, Zhang et al. 2015). Internet of things is used in the cold chain logistics transportation system of agricultural products to realize the whole process of visualization of the entire cold chain logistics transportation to improve transportation efficiency and ensure the cold chain logistics system (Liu, Xu et al. 2016).

The Application Of The Internet In The Production Area Pre-cooling, Processing, And Packaging Links

Since the "first mile" of agricultural products is far away from consumers, fresh food e-commerce and consumers often do not pay attention to its role in the supply chain, leading to an endless loop of excessive investment in the "last mile" but not apparent results. The "first kilometer" is of great importance in the entire supply chain. By introducing a comprehensive quality management system, pre-control is emphasized so that the control effect and cost savings are significantly improved compared to post-control, and the entire management is realized—optimization of the system (Zhao, Li et al. 2019). The temperature of fresh agricultural products is quickly reduced to the optimal storage temperature after being picked, which is called pre-cooling at production. Pre-cooling at the place of production can effectively preserve the freshness of the product and extend the shelf life, reducing its loss in the circulation process. In actual business, because some companies worry that this link will increase the cost of cold chain logistics, nearly 80% of agricultural products enter the circulation link directly without pre-cooling (Liu, Xu et al. 2016). This situation makes agricultural products seriously depleted in the transportation process and leads to the country's agricultural products. The consumption has been at a high level.

Based on the application of Internet of things, agricultural products can be pre-cooled immediately after harvesting to supervise the whole process so that the loss of agricultural products can be effectively reduced (Li and Keat, 2021). Modern pre-cooling technologies mainly include cold storage pre-cooling, ice-touch pre-cooling, forced air pre-cooling, water pre-cooling, vacuum pre-cooling, etc. Among them, vacuum pre-cooling technology is the most commonly used technical means in the cold chain logistics of agricultural products.This technology can quickly evaporate water under vacuum conditions, effectively ensuring the freshness and quality of the product. The primary purpose of this technology is to cool the product to the previously set temperature quickly, take off items from the equipment, and then process, store, transport, and sell. It is a fast and effective processing method (Gruyters, Defraeye et al. 2019).

After the agricultural products are pre-cooled, their shelf life, freshness, etc., will be longer than those before the pre-cooling, and even some agricultural products can be sold directly. Appropriate packaging of fresh agricultural products after pre-cooling is indispensable,

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especially for fresh food e-commerce, which requires light, fast and straightforward product packaging and can also keep fresh for a long time. Among many packaging methods, modified atmosphere packaging can effectively meet the particular requirements of fresh food e-commerce companies (Gruyters, Defraeye et al. 2019). This method is light and simple and can most effectively maintain the original quality of the product. Table 1 summarizes and compares the storage period of some agricultural products after vacuum pre-cooling and ordinary pre-cooling.

Table 1: Comparison Analysis Of The Storage Period Of Some Fresh Agricultural Products After Vacuum Pre-cooling And Ordinary Pre-cooling (Unit: Day)

Description	Ordinary Cold Storage Pre-cooling	Vacuum Pre-cooling	Vacuum Pre-cooling + Modified Atmosphere Packaging (MAP)
Spinach	7-10	40	50
Mushrooms	2-3	10	16
Strawberries	5-7	9	15
Celery	8	40	54
Cabbage	8	39	50
Bayberry	10	20	30
Green peas	4-7	14	30

Source: China Meat Machinery Net (http://www.mpmpc.cn/)

In pre-cooling at the place of production and processing and packaging, various information about agricultural products needs to be collected, including information on the place of origin, product information, packaging information, and farmer information. The collected data are all established production files and uploaded to the information system of the production enterprise to facilitate subsequent product information inquiries. Information can be transmitted in real-time so that the entire harvesting and pre-cooling process can be monitored in real-time, and the information collection and traceability process at this stage can be completed, as shown in Table 2 and Figure 1.

Table 2: Information Collection And Equipment At The Harvest Stage

Link	Data Collection	Internet Technology Required
Picking	Inspection Data for Growth Information of Fresh Agricultural Products	"RFID" Electronic Tag and "RFID" Reader
pre-cooling	Temperature information	Temperature Sensor
Processing and Packaging	Packaging Materials, Processing Time, Working Staff and other information	"RFID" Electronic Tag and "RFID" Reader

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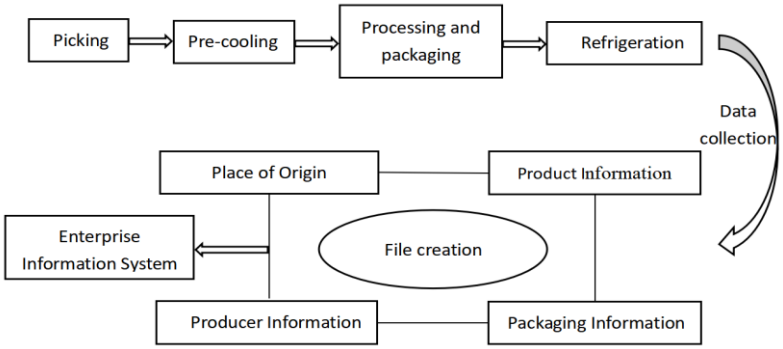

Figure 1: Flow Chart Of Pre-Cooling And Processing And Packaging Of Origin
(Gruyters, Defraeye Et Al. 2019)

The Application Of The Internet In The Cold Chain Transportation Stage

The distribution of fresh agricultural products is quite different from ordinary products. Due to its unique perishable and high timeliness, it has higher requirements for all aspects of logistics and transportation. Although fresh agricultural products can achieve a certain degree of freshness preservation in traditional logistics and distribution, they cannot achieve the entire cold chain logistics and distribution (Navazi, Tavakkoli-Moghaddam et al. 2018). The limitations of traditional logistics distribution are mainly reflected in the poor connection of various links in distribution, the inability to achieve effective information collection and low interaction capabilities, and the inability to understand the transportation environment of goods in transit in time, which can easily lead to a higher rate of cargo damage, and it may also be possible It causes food pollution, which has an impact on the quality of agricultural products, seriously threaten consumer safety, and results in low customer satisfaction. Therefore, the key issue that needs to be solved urgently in the development process of fresh food e-commerce is to realize the entire cold chain transportation of agricultural products (Ma, Wang et al. 2018). From the perspective of the future development trend of Internet technology, the construction of a cold chain traceability query information system is a key link in the realization of Internet technology in cold chain logistics and transportation (Weng, Chuanfang et al. 2019). Based on Internet of things, build a cold chain logistics traceability information management system for fresh agricultural products, gradually improve the information filing system for each link in the cold chain logistics of agricultural products, and improve the quality and safety of each link in the cold chain logistics (Ridwan, Santoso et al. 2019). Enhancing the whole-process monitoring will help the government and related departments, fresh food e-commerce, agricultural product processing enterprises, cold chain logistics industry, and consumers to detect, supervise and control agricultural product logistics activities.

To build a cold chain logistics traceability inquiry system using Internet of things, temperature and humidity sensors must be installed in all directions in the refrigerated vehicle to enable it to collect the information in the refrigerated vehicle accurately and to scan the product package with "RFID"(Radio Frequency Identification) temperature and humidity The label can monitor the temperature and humidity of the goods at all times. This information will not only be transmitted to the computer or mobile phone terminal in the cockpit, but also the various monitored data will be fed back to the remote monitoring center through the "GPRS" (General Packet Radio Service) wireless communication method (Hao, Qiu et al. 2017).

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Real-time monitoring of the temperature and humidity of the refrigerated truck, when various unexpected situations occur, the system will immediately issue an alarm and immediately notify the driver to take corresponding measures, which can avoid all kinds of unnecessary losses in time (Gholamhassan et al. 2014). In addition, the "GPS" (Global Positioning System) positioning and tracking system is installed on the refrigerated vehicle to obtain the accurate location, vehicle group number, operating status, and real-time road conditions of the vehicle to locate and track the vehicle to ensure that it arrives on time. Finally, a "GIS" (Geographic Information System) system can be installed on the refrigerated truck. Through wireless transmission, the vehicle's real-time position can be monitored, and the relevant data can be transmitted to the monitoring center in real-time.

The provided man-machine interface is graphical and operable. Thus it can monitor various vehicles in transit in real-time, zoom in and out as needed, and accurately display the real-time location of transport vehicles (Bao, Zhang et al. 2018). According to the technology of the "GIS" system, the traffic conditions of the entire road can be monitored in real-time. Then information and data such as the loading capacity of the transport vehicle, the size of the vehicle type, the delivery place, the customer address, and the real-time road conditions can be obtained for calculation. Through the rapid processing of the data, It can automatically select the optimal distribution route, guide freight flow, improve transportation efficiency, and reduce logistics costs. The specific process is shown in Figure 2.

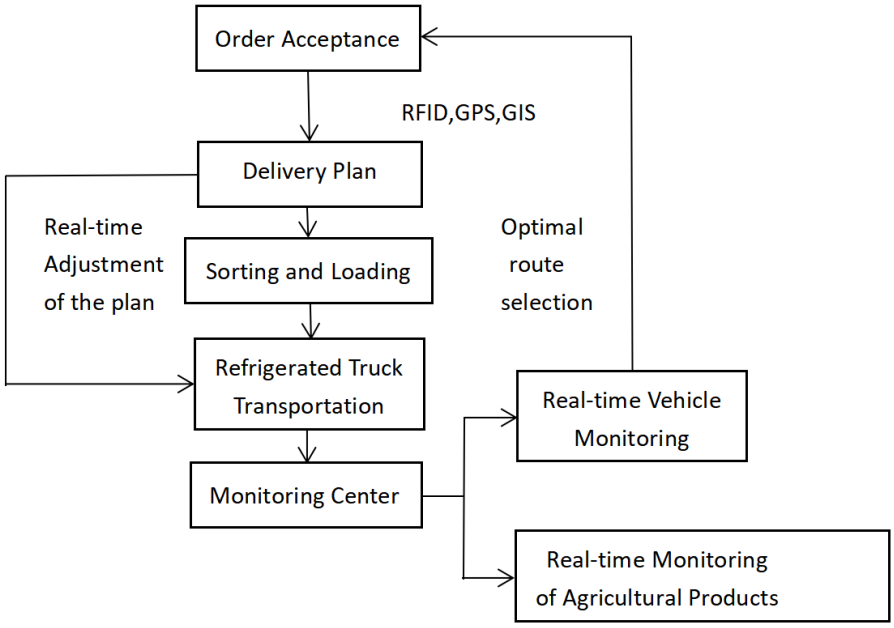

Figure 2: The Cold Chain Logistics And Distribution Process Of Agricultural Products Based On The Internet

(Cao, Shao Et Al. 2019)

The Application Of The Internet In The Sales Phase

The sales stage is the last in the cold chain logistics of fresh e-commerce agricultural products, and it is also the only link where consumers directly contact the product. Consumers will use various methods to check whether the fresh produce is fresh or deteriorated. If the chain breaks in the sales link, it will affect the quality of the product and significantly compromise the merchant's reputation (Shacklett, 2019). Therefore, it is still necessary to monitor its quality and feedback data in the final stage to build a complete traceability system from production to

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sales. The sales link does not exist in isolation, and it is closely related to the production and processing, warehousing, transportation, and distribution of fresh agricultural products in cold chain logistics(Weng, Chuanfang et al. 2019). In the sales stage of fresh agricultural products, the merchants should check whether the refrigerated temperature in the refrigerated transport vehicle is consistent with the transportation temperature standard set for the transported product and check whether the basic information of the products' batch of the products is striving for it (Mahajan, Garg et al. 2017).For products that require secondary processing, it is also necessary to monitor and collect relevant information such as the temperature, processing time, and operators of the workshop that processes the batch of products to prevent quality problems (Wang et al. 2013). Internet of things can also track the sales speed and sales of goods, allowing merchants to purchase goods based on sales. At the same time, the use of Internet technology can promptly discover and process products that are about to expire, improve product quality, ensure food safety, and can also intelligently identify unsalable products and perform statistical data, and use this as the basis of analysis to make corresponding price adjustments (Jing, Wen et al. 2019).

Finally, the "RFID" electronic tags on the product packaging are converted into barcodes or two-dimensional codes, convenient for customers to query product information through mobile phones and other terminals. After the sale is completed, consumers can use mobile phones and other terminals to feedback after-sales information to the merchant's website or cold chain Internet of Things information center, mainly related to service attitude, delivery time, product quality, and other related information (Li and Huo, 2016). The monitoring center can make improvements based on the after-sales feedback information. Moreover, after placing an order, customers can inquire about real-time logistics information of goods in transit and various product information through mobile phones and other terminals at any time, as shown in Figure 3.

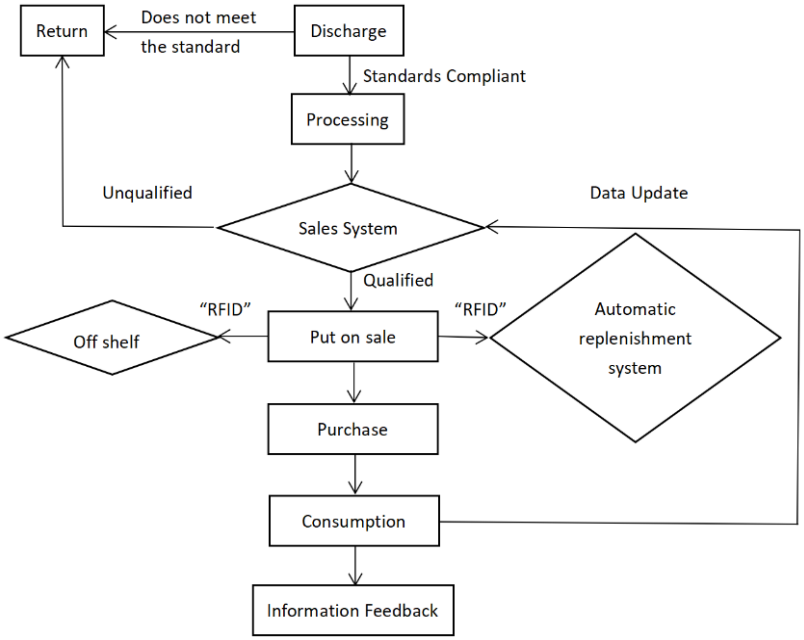

Figure 3: The Cold Chain Logistics Sales Process Of Agricultural Products Based On The Internet

(Li And Huo, 2016)

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Conclusion

The introduction of Internet of things into the cold chain logistics and transportation of fresh agricultural products can improve the level of cold chain logistics and transportation of fresh agricultural products. Accelerating the development of cold chain logistics can extend the shelf life and sales period of agricultural products and reduce the loss rate in the transportation of agricultural products while ensuring product quality, thereby reducing logistics costs and ensuring the economic benefits of fresh food e-commerce. Through the use of networking technology in the cold chain logistics of agricultural products, on this basis, a business process-oriented cold chain Internet information system is constructed, which provides a reference for how to realize high-speed and effective cold chain logistics transportation for fresh food e-commerce enterprises. From the above research, it can be found that the use of Internet technology in the cold chain logistics of fresh agricultural products can promote the improvement of cold chain logistics operation efficiency and realize the whole process of visual monitoring and traceability. Taking into account the particularity of fresh agricultural products, in the application of Internet technology, the entire process includes harvesting, product pre-cooling, processing and packaging, cold chain transportation, and sales phases, which are combined with the three-tier architecture model of the Internet of Things, based on The foundation for the construction of cold chain logistics business processes will eventually lead to the formation of the cold chain Internet of Things architecture system.

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