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# Research on Optimization Strategies for Cold Chain Logistics of Agricultural Products: A Case Study of H Company

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## Abstract

This study aims to propose an optimized model for agricultural product cold chain logistics through a systematic analysis and innovative design. The goal is to enhance the efficiency and responsiveness of the entire supply chain. A questionnaire survey was conducted among employees of H Company to analyze the main challenges faced by agricultural cold chain logistics, including imprecise temperature control, high logistics costs, insufficient informatization, and environmental sustainability issues.

**Keywords:** Agricultural products; Cold chain logistics; Supply chain management.
**JEL Classification:** *L92; Q13; Q18.*

## 1. Introduction

With the rapid development of China's economy, the quality of life has significantly improved, and people now demand higher food quality. Agricultural products play an essential role in daily life, with their quality and safety directly affecting public health and safety. Due to the characteristics of agricultural products, they are vulnerable to damage throughout production, storage, transportation, and sales, which may lead to deterioration or spoilage. Therefore, establishing a robust cold chain logistics system for agricultural products in China is of vital importance.

Cold chain logistics refers to a specialized logistics model that maintains products under appropriate low-temperature conditions throughout their entire production, processing, storage, transportation, sales, and consumption stages. This ensures product quality while minimizing losses. Although research on cold chain logistics for agricultural products in China has made progress, there are still many challenges, such as inadequate infrastructure, low technological levels, lack of standardization, and difficulties in cost control. These issues severely restrict the improvement of cold chain logistics efficiency in China.

Globally, cold chain logistics for agricultural products is receiving increasing attention, especially in developed countries, where it has become a key component for ensuring food safety and improving logistics efficiency. For example, Japan is globally recognized for its high-tech and mechanized cold chain logistics, characterized by low-cost logistics that have entered a mature stage. However, once Japan's cold chain logistics reaches a critical point, new logistics models are likely to emerge. Japan's cold chain logistics success is largely attributed to its advanced infrastructure. In 2014, Japan had around 120,000 refrigerated vehicles, which increased to 150,000 by 2016, accounting for 2.65% of total freight vehicles, with a refrigerated transportation rate of over 90%, and product spoilage rates as low as 5% (Zheng, 2017).

### *1.1. International Trends in Cold Chain Logistics*

Technological Advancements: Developed countries continually innovate in cold chain logistics technologies, including advanced refrigeration equipment, temperature monitoring systems, and automated warehouse management systems, significantly improving the efficiency and safety of cold chain logistics.

Standardized Processes: Cold chain logistics systems in developed countries typically have well-established standards and regulations to ensure product quality and safety throughout the supply chain.

Environmental Sustainability: As environmental concerns grow, China's cold chain logistics industry is also exploring more eco-friendly solutions, such as using renewable energy and reducing greenhouse gas emissions.

Education and Training: Developed countries emphasize the training of cold chain logistics professionals through specialized education and training to enhance the skills and knowledge of workers.

International Cooperation: With globalization, international cooperation has become increasingly important in cold chain logistics. Collaborations between multinational companies and international organizations help share best practices and improve the global cold chain logistics level.

Consumer Demand: In developed countries, consumers' increasing demand for fresh, high-quality agricultural products drives the development and improvement of cold chain logistics services.

Waste Reduction: Effective cold chain logistics management in developed countries significantly reduces losses during transportation and storage, conserving resources and minimizing waste.

### 1.2. Cold Chain Logistics Development in China

In contrast to foreign countries, China's cold chain logistics began relatively late. Enterprises focusing on cold chain logistics have not yet formed large-scale industries, resulting in a need to improve the overall level of cold chain logistics (Zhao, 2021). Currently, cold chain logistics in China is in the early stages of development, with the majority of logistics handled by self-operated logistics of production enterprises or distributors, accounting for about 80% of total logistics, while third-party logistics constitutes around 20%. However, with the increasing concentration of food resources in economically developed regions, the cold chain logistics system is gradually being established and operating more professionally (Wang, 2016).

In recent years, China's cold chain logistics market has grown rapidly, expanding at an average annual rate of 17%. The total sales volume of the industry reached 339.1 billion RMB, a 17.5% increase from the previous year. It is expected that by 2025, the market size will increase to around 897 billion RMB (Si, 2023).

### 1.3. Current Challenges in China's Agricultural Cold Chain Logistics

Market Imbalance: Cold chain logistics facilities and companies are unevenly distributed across regions, with more facilities in the east and fewer in the west, leading to resource allocation imbalances that affect overall efficiency.

High Loss Rates: The loss rate for fruits and vegetables in China is as high as 15%, compared to around 5% in developed countries, due to a lack of awareness regarding cold chain logistics.

Cultural and Consumption Habit Differences: China's per capita consumption of frozen foods is only 10 kg annually, significantly lower than in Japan (20 kg) or the US (60 kg), reflecting cultural and habitual differences in consumer demand for cold chain logistics (iMedia, 2024).

In summary, while developed countries have established mature cold chain logistics systems that are technologically advanced and well-managed, China's cold chain logistics is still developing and facing significant challenges. To foster industry development, improvements are needed in policy support, technological innovation, infrastructure, and workforce training, alongside efforts to raise consumer awareness of cold chain logistics.

## 2. Literature Review

### 2.1. Cold Chain Logistics

Cold chain logistics ensures that perishable products, such as fresh food, pharmaceuticals, and certain chemicals, maintain a controlled temperature throughout their production, storage, and distribution process. The development of this logistics model is essential for ensuring product safety and reducing spoilage during transit. Cold chain logistics is characterized by its complexity, coordination requirements, and high operational costs, as temperature-controlled equipment such as refrigerated trucks and low-temperature storage facilities are needed.

### 2.2. Agricultural Cold Chain Logistics

Agricultural cold chain logistics is a critical part of the entire supply chain management, especially for perishable agricultural products. Cold chain logistics helps to maintain product safety, reduce losses, and enhance product quality. As consumer demand for fresh, healthy, and safe food increases, efficient cold chain logistics is vital for expanding the sales scope of agricultural products and promoting agricultural industry upgrades.

### 2.3. Components of Agricultural Cold Chain Logistics

The main components of agricultural cold chain logistics include production, processing, transportation, storage, distribution, packaging, delivery, and consumption. Each stage plays a crucial role in maintaining the freshness and safety of agricultural products, ensuring they reach consumers in optimal condition.

## 3. Methodology

### 3.1. Questionnaire Survey

This study uses a questionnaire survey to investigate the cold chain logistics of agricultural products at H Company in Guangdong Province. The questionnaire covers five main areas: cold chain facilities and equipment, cold chain management, product handling, distribution efficiency, and customer service and feedback. The survey was conducted online, and a total of 154 valid responses were collected.

#### 3.1.1. Questionnaire Design and Compilation

The questionnaire was designed based on existing research (Zheng, 2017) and (Pang, 2024) to assess H Company's cold chain logistics. It was divided into seven sections, with 17 questions focusing on cold chain logistics processes at the company.

#### 3.1.2. Questionnaire Distribution

The survey was distributed online, and data was collected via an online platform. A total of 154 completed questionnaires were returned, with a 98% valid response rate after excluding incomplete or rushed submissions.

This study aims to address the optimization of cold chain logistics in China by analyzing H Company's logistics system, identifying challenges, and proposing strategies to improve efficiency and reduce product losses, ultimately benefiting the agricultural logistics sector.

# 4. Results

## 4.1. Cold Chain Equipment Status

Compared to conventional logistics that operates at ambient temperatures, cold chain logistics requires more specialized equipment and information systems, necessitating larger investments for infrastructure development. Consequently, it represents a niche and sophisticated segment within the logistics industry. Cold chain logistics is primarily employed for perishable goods such as fruits, vegetables, poultry, eggs, seafood, as well as frozen meats, frozen processed foods, chocolates, and ice cream. Additionally, it finds application in the transport of chemical raw materials and pharmaceuticals. Depending on the specific needs of the logistics sector, it is crucial to adjust temperatures precisely during transportation to meet customer requirements (Qian et al., 2024).

From Table 1, it is evident that agricultural products like fruits and vegetables require maintenance of a relatively stable low temperature during transportation. The subsequent equipment includes refrigerated trucks, railway refrigerated containers, and shipping containers. Most agricultural products are perishable and need to be kept fresh throughout the circulation and storage processes, thereby imposing high demands on logistics and storage practices.

**Table 1.** Required Cold Chain Temperature for Different Products.

| Category | Subcategory | Temperature |
|---|---|---|
| High-Value Products | Pharmaceuticals | 2–6°C |
| | Restaurant Chains | 0–5°C |
| | Fast-Moving Consumer Goods | 0–15°C |
| Industrial and Processed Goods | Dairy Products | 2–5°C |
| | Frozen Foods, Rice, Noodles | -18°C |
| Food Ingredients | Poultry, Seafood | -18 to -20°C |
| Agricultural Wholesale | Fruits, Vegetables | 0–5°C |

**Source:** Sun, 2022.

Given the vast geographical span of agricultural production areas and long crop production cycles, coupled with the dispersal of resources, centralized storage would inevitably increase costs. Thus, enhancing the storage and extending the shelf life of fresh produce while reducing storage costs is a central issue (Qi, 2012).

As shown in Table 2, survey results indicate that 83.12% of respondents prefer using air cargo refrigerated containers, followed by 46.1% who prefer railway refrigerated boxes, and 27.92% who rely on shipping containers. Additionally, 52.6% believe refrigerated trucks are the primary mode of transportation.

**Table 2.** Main Equipment Used During Transportation.

| Option (Multiple Choice) | Subtotal | % |
|---|---|---|
| Refrigerated truck | 81 | 52.6% |
| Container | 43 | 27.92% |
| Railway refrigerated box | 71 | 46.1% |
| Air-conditioned cargo hold | 128 | 83.12% |

Regarding cold chain storage facilities, Table 3 illustrates the challenges within this area. In a sample of 154 valid surveys, 94.81% of respondents believed their company's cold chain facilities were outdated. Furthermore, 83.12% felt their facilities were insufficient in number, and 88.96% reported low staff expertise and management levels. Additionally, 25.97% of respondents identified a lack of facility variety.

**Table 3.** Issues with Cold Chain Facilities.

| Option (Multiple Choice) | Subtotal | % |
|---|---|---|
| Few types of cold chain facilities | 40 | 25.97% |
| Cold chain facilities | 146 | 94.81% |
| Insufficient number of cold chain facilities | 128 | 83.12% |
| Low level of operators and management | 137 | 88.96% |

Regarding cold chain interruptions due to equipment failure, as depicted in Table 4, 76.62% of respondents reported experiencing at least seven instances of equipment failure leading to cold chain disruption in the past year, while 23.37% reported fewer disruptions (six or less).

**Table 4.** Frequency of Equipment Failures in Company.

| Option | Subtotal | % |
|---|---|---|
| Over 10 times | 74 | 48.05% |
| 7-9 times | 44 | 28.57% |
| 4– -6 times | 26 | 16.88% |
| Below 4 times | 10 | 6.49% |

In terms of maintenance frequency, as shown in Table 5, 72.73% of respondents stated that their company conducts maintenance on cold chain equipment once a month on average.

**Table 5.** Frequency of Cold Chain Equipment Maintenance.

| Option | Subtotal | % |
|---|---|---|
| 0-15 Days | 60 | 38.96% |
| 15-30 Days | 52 | 33.77% |
| 30-60 Days | 30 | 19.48% |
| More than 60 days | 12 | 7.79% |

### *4.2. Cold Chain Management Issues*

As depicted in Table 6, 64.94% of respondents acknowledged temperature control problems in the post-harvest handling stages, while 28.57% observed temperature control issues during delivery. Post-harvest and storage phases are critical for maintaining optimal conditions. Utilizing advanced cold chain technology, such as automated temperature control and rapid cooling systems, is crucial for minimizing these problems. Furthermore, professional cold chain transportation equipment, like refrigerated trucks and containers, should be prioritized to ensure product safety during transport (Wang, 2016).

**Table 6.** Stages Prone to Temperature Control Issues.

| Option (multiple choice) | Subtotal | % |
|---|---|---|
| Post-harvest treatment memory | 100 | 64.94% |
| Storage | 92 | 59.74% |
| Transport | 44 | 28.57% |
| Dispatching | 42 | 27.27% |

Regarding satisfaction with real-time temperature monitoring, as shown in Table 7, 29.87% of respondents expressed dissatisfaction or indifference, while 70.13% were satisfied or very satisfied.

**Table 7.** Satisfaction with Real-Time Temperature Monitoring.

| Option | Subtotal | % |
|---|---|---|
| Very Satisfied | 59 | 38.31% |
| Satisfied | 49 | 31.82% |
| Generally | 32 | 20.78% |
| Dissatisfied | 11 | 7.14% |
| Very Dissatisfied | 3 | 1.95% |

In terms of operational issues within the cold chain process, Table 8 reveals that the most common issue, cited by 34.42% of respondents, was low operational competency among staff, followed by 7.14% who believed transportation capacity was insufficient.

**Table 8.** Common Problems in Cold Chain Process.

| Option | Subtotal | % |
|---|---|---|
| The cold-chain equipment is damaged during the work process | 49 | 31.82% |
| The operation level of the staff in the cold chain link is not high | 53 | 34.42% |
| The efficiency of cold-chain logistics is not high | 27 | 17.53% |
| The transportation capacity in the cold chain logistics is insufficient | 11 | 7.14% |
| Poor temperature control in the transportation and storage links | 14 | 9.09% |

### *4.3. Product Handling in the Logistics Process*

The refrigeration technology used in agricultural cold chain logistics is critical for ensuring product freshness and safety throughout the supply chain. Table 9 shows that H Company uses multiple preservation technologies, with the most frequently used being temperature monitoring, adopted by 77.92% of respondents. This is followed by automation and information technology (56.49%) and eco-friendly refrigeration technology (55.19%). Pre-cooling and rapid freezing techniques were used by 49.35% and 35.71% of respondents, respectively.

**Table 9.** Preservation technologies used in cold chain logistics.

| Option (multiple choice) | Subtotal | % |
|---|---|---|
| Pre-cooling technology | 76 | 49.35% |
| Frozen technology | 55 | 35.71% |
| Large-scale packaging technology | 78 | 50.65% |
| Temperature monitoring technology | 120 | 77.92% |
| Environmental protection refrigeration technology | 85 | 55.19% |
| Information technology and automation technology | 87 | 56.49% |

As shown in Table 10, 42.21% of respondents believed the overall product quality remained excellent from market to consumer, while 26.62% felt that the quality retention was poor to average. According to He Deming, assessing the economic benefits of cold chain logistics involves analysis of profitability, risk management, and sensitivity analysis (He, 2019). Failure to optimize product quality retention could hinder the achievement of desired economic outcomes.

**Table 10.** Product Quality Maintenance During Transport.

| Option | Subtotal | % |
|---|---|---|
| Very good | 65 | 42.21% |
| Good | 48 | 31.17% |
| Generally | 27 | 17.53% |

**Table 10.** Product Quality Maintenance During Transport(continuous).

| Option | Subtotal | % |
|---|---|---|
| Bad | 9 | 5.84% |
| Very bad | 5 | 3.25% |

### 4.4. Distribution Efficiency

Table 11 reveals that 77.93% of respondents believed that the time from order receipt to delivery was within three days, while only 7.79% reported it taking more than five days.

**Table 11.** Product Distribution Efficiency.

| Option | Subtotal | % |
|---|---|---|
| Within 1 day | 68 | 44.16% |
| 2-3 Days | 52 | 33.77% |
| 4-5 Days | 22 | 14.29% |
| More than 5 days | 12 | 7.79% |

In the survey on distribution process issues, as shown in Table 12, all seven listed problems were identified by respondents, with 86.36% citing insufficient staff training, followed by 68.18% noting non-optimized delivery routes. Other issues included low packaging and loading efficiency (57.14%) and outdated equipment (25.97%).

**Table 12.** Issues in Distribution Process.

| Option (Multiple choice) | Subtotal | % |
|---|---|---|
| Improper inventory management | 33 | 21.43% |
| Distribution route is not optimized | 105 | 68.18% |
| Insufficient personnel training | 133 | 86.36% |
| Low packaging and loading efficiency | 88 | 57.14% |
| Equipment and technology are backward | 40 | 25.97% |
| Order processing is inefficient | 98 | 63.64% |
| Regulatory and compliance issues | 67 | 43.51% |

Regarding the logistics information system, Table 13 indicates that 14.28% were dissatisfied, while 22.73% were indifferent. A majority, 50.6%, expressed satisfaction or strong satisfaction with the system.

**Table 13.** Satisfaction with Logistics Information System.

| Option | Subtotal | % |
|---|---|---|
| Very Satisfied | 41 | 26.62% |
| Satisfied | 56 | 36.36% |
| Generally | 35 | 22.73% |
| Dissatisfied | 13 | 8.44% |
| Very Dissatisfied | 9 | 5.84% |

### 4.5. Customer Service and Feedback

As seen in Table 14, 96.75% of respondents noted frequent complaints about product damage or spoilage, and 87.01% cited issues with service quality. All six listed issues were selected by respondents as common complaints.

**Table 14.** Common Customer Complaints.

| Option (Multiple choice) | Subtotal | % |
|---|---|---|
| Damage or deterioration of the goods | 149 | 96.75% |
| Delayed service problem | 53 | 34.42% |
| Distribution error problem | 90 | 58.44% |
| Quality of service | 134 | 87.01% |
| Cost problem | 110 | 71.43% |
| Insurance and indemnity issues | 84 | 54.55% |

In handling negative customer feedback, as illustrated in Table 15, 94.81% of respondents believed that their company conducts thorough investigations into customer issues, and 70.13% indicated learning from negative feedback. Other measures included explaining improvements to customers (52.6%) and offering solutions (20.78%).

**Table 15.** How H Company Handles Negative Customer Feedback.

| Option (Multiple choice) | Subtotal | % |
|---|---|---|
| Timely response | 40 | 25.97% |
| Problem survey | 146 | 94.81% |
| Provide solutions | 32 | 20.78% |
| Improvement and prevention | 108 | 70.13% |
| Communication and education | 81 | 52.6% |
| Record and analysis | 52 | 33.77% |

Table 16 shows the actions H Company employees believe the company should take to improve customer satisfaction, with 87.66% suggesting optimizing delivery processes, followed by 81.17% recommending improvements in packaging and loading.

**Table 16.** Measures to Improve Customer Satisfaction.

| Option (multiple choice) | Subtotal | % |
|---|---|---|
| Optimize the distribution process | 135 | 87.66% |
| Strengthen personnel training | 58 | 37.66% |
| Improve the equipment and technology | 69 | 44.81% |
| Improved packaging and loading methods | 125 | 81.17% |
| Implement quality control measures | 102 | 66.23% |
| Establish a customer feedback mechanism | 73 | 47.4% |

# 5. Discussion (Optimization and Innovation Strategies)

## *5.1. Cold Chain Equipment Optimization*

Based on the issues identified in H Company's cold chain equipment (Section 4.1), it is recommended that the company invest in advanced cold chain infrastructure to address outdated equipment and occasional disruptions. In particular, upgrading equipment to improve capacity and variety is essential. Additionally, it is critical to enhance staff training and development to meet the professional demands of cold chain logistics.

## *5.2. Cold Chain Management Optimization*

To address temperature control issues in logistics (Section 4.2), the implementation of precision temperature control systems using advanced variable frequency technologies is recommended. Upgrading equipment like refrigerated trucks and containers, alongside improving storage facilities and operational standards, will enhance the cold chain process. Furthermore, adjusting environmental factors like oxygen and carbon dioxide ratios can extend product shelf life.

## *5.3. Product Handling Optimization*

Given the challenges in maintaining product quality (Section 4.3), optimizing transportation routes, developing contingency plans for emergencies, and adopting a flexible logistics network are crucial strategies. Furthermore, promoting green logistics practices and robust risk management will ensure product safety and sustainability.

## *5.4. Distribution Efficiency Optimization*

To improve distribution (Section 4.4), optimizing delivery routes, increasing load efficiency, and integrating advanced information management systems like IoT and AI will streamline logistics processes. Enhancing collaboration with suppliers and adopting flexible delivery models will further improve service quality and efficiency.

## *5.5. Customer Feedback Optimization*

Addressing frequent issues like product damage and long delivery times (Section 4.5) requires optimizing the supply chain layout, updating transport equipment, and focusing on cost reductions. Establishing multiple feedback channels, fast response systems, and continuous improvement based on customer input will enhance customer satisfaction.

## *5.6. Practical Significance*

The development of cold chain logistics plays a crucial role in advancing rural economies and meeting the rising demand for high-quality, environmentally sustainable agricultural products. Optimizing cold chain logistics not only boosts consumer satisfaction but also drives broader economic development and enhances the logistics industry's overall service levels and efficiency.

# 6. Conclusion

## *6.1. Research Findings*

This study identified key issues and proposed optimization strategies for H Company's cold chain logistics. Key recommendations include equipment and technology upgrades, cost control, regulatory compliance, green logistics, and improving market responsiveness.

## *6.2. Future Outlook*

Looking forward, with ongoing technological advancements and expanding market demand, H Company has significant growth opportunities in cold chain logistics. Continued investment and innovation will enable the company to achieve breakthroughs in efficiency, cost management, and service quality, positioning it as a leader in the industry.

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