

Safety Evaluation of Port Fruit Cold Chain Logistics Based on FTA

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Abstract

With the rapid development of China's economy and the continuous improvement of people's living standards, the requirements for fruit products are also constantly improving. It is of practical significance to study the safety of fruit cold chain logistics systems. For the dangerous accidents that may occur in each link of the port fruit cold chain logistics security system, the method of combining fuzzy number theory and the accident tree model can analyze the dangerous elements in the port fruit cold chain logistics link, and then propose corresponding improvement measures Provide a reference for port construction.

Keywords

Fruit cold chain logistics; Logistics safety; Accident tree; Fuzzy number.

1. Introduction

China's modern ports have experienced the development and transformation from the first generation port to the current fourth generation port, from a single service to a diversified integrated logistics system, more and more ports focus on developing their own port logistics services and strengthen Construction of container berths and yards. As the current international shipping market continues to decline, many port economies have encountered resistance and development has stalled. Therefore, the development of cold chain logistics in ports is a transformation method that conforms to the current situation ^[1].

China's economy is developing rapidly, people's needs for a better life are diverse, and the demand for high-end fruits at home and abroad is also rapidly increasing. In the past, due to the slow development of China's cold chain logistics industry, the loss of fresh products in transportation, the high price, and other reasons, the terminal price of a large number of imported fruits in the Chinese market was more than several times the purchase price of foreign sources, many fruits could not be delivered To remote towns. The development of fruit cold chain logistics at the port can not only save a lot of unnecessary social costs, but also increase the number of types of fresh products, and actually improve people's living standards. In fruit cold chain logistics, port safety is a key factor. How to ensure the smooth operation of the port fruit cold chain in all links of the logistics system, while not delaying the efficiency of the logistics and supply chain is now the focus of most scholars. Therefore, it has practical significance for the research of fruit cold chain logistics safety performance evaluation of the terminal fruit cold chain logistics system. Supported by specific quantitative or qualitative safety evaluation indicators obtained through investigation and research, it can guide the safety evaluation of the terminal fruit cold chain logistics system, and can effectively improve the safety factor of the terminal fruit cold chain logistics and fruit quality assurance.

China's fruit production is in the forefront of the world. From 2000 to 2016, China's total fruit production continued to increase, from 62.215 million tons to 28.351 million tons, with an average

annual growth rate of 9.9%. Among them, the fruit production in 2003 saw a sharp increase, an increase of 108.8% over the same period in previous years, and an increase of 3.6% in 2016 over the same period in previous years [2]. Although China's fruit production volume is leading in the world, due to the late start of the cold chain logistics industry, the industrial infrastructure is not perfect enough to effectively solve the problem of cargo damage caused by the process of grading, pre-cooling, refrigeration and transportation [3]. Weihua Liu used the ANP (network analysis) method to evaluate the service level of supply chain logistics. In 2012, he used the ANP-Fuzzy (network analysis and fuzzy comprehensive evaluation) method to evaluate the performance of logistics services in the process of supply chain process. Analysis [4]. Hong Huo and Qing Lin jointly used grey correlation and entropy weight method to analyze and evaluate the performance of logistics services [5]. Yueha Xu and Yijun Liu used principal components and factor analysis to analyze more than 20 evaluation parameters to reduce the adverse effects between the parameters and build a third-party logistics performance evaluation system [6]. So far, in some developed countries in Europe and the United States, a large number of processing modes such as pre-refrigeration after fruit collection, modified atmosphere storage, fruit washing and waxing, sorting and cold chain standard transportation have been widely adopted. The subsequent commercial processing of fruit collection is almost 100%, a complete fruit cold chain logistics model has been formed [7]. Cai Jingjing built an agricultural product online marketing performance evaluation model based on rough set theory. It uses the importance of calculating decision indicators to reduce the decision table, and obtains the exact weight coefficient of each index, effectively increasing the objectivity of determining the weight coefficient [8]. Hua Jiang used the principle of purpose to construct a model for evaluating the marketing performance of agricultural products on the Internet, and used an analytical hierarchy model (AHM) to analyze the reasons [9]. Liu Mingfei expounded the basic principles of the establishment of an agricultural product evaluation model for cold chain logistics service performance, and constructed a performance evaluation index model for agricultural product cold chain logistics from the aspects of industry environment, resources, risk management, etc. Evaluation of agricultural cold chain logistics service performance [10].

In this paper, the theoretical knowledge of safety system engineering is used, and the accident tree analysis method is used to analyze the causes of the failure of the port fruit cold chain logistics, so as to sort out the dangerous elements that affect the safe implementation of fruit cold chain logistics. Through the analysis of risk factors, the specific aspects that need to be focused on are controlled by the failure of the cold chain to lead to the occurrence of "chain breakage", and the probability of the occurrence of various basic accidents is calculated to conclude that the port fruit cold chain logistics system is difficult to be safe Probability of operation. Because of the complexity of the basic accidents and unpredictability of unexpected events in the cold chain logistics link of the port, it is extremely difficult to accurately measure the practical data. This paper uses a combination of fuzzy number theory and accident tree model to complete the port Evaluation and analysis of the safety of fruit cold chain logistics system.

2. Port fruit cold chain logistics safety performance evaluation model

2.1 Accident tree analysis

The accident tree analysis method is widely used to deal with the reliability level of complex systems. This method uses a logical method to carry out related risk analysis, draw the dangerous accidents to be studied as the starting point of the analysis at the top of the accident tree (ie, the top event), and then cause the possible causes of the hazard according to the causal logic relationship layer It is listed in layers and constructed into a logical model with a tree diagram [11]. Since the accident tree analysis method is used for quantitative analysis, the probabilities given by the basic event analysis to be analyzed must be accurate. In the case where the probability of occurrence of the basic event under study is difficult to give accurately, the use of fuzzy numbers to calculate the probability of accidents to complete the quantitative analysis part.

A9	Natural disasters occurred during transportation	
A10	Accident during transportation	
A11	Improper choice of means of transportation	
A12	Transport workers have low safety literacy	
A13	Improper handling of transport workers	
A14	Unsuitable storage temperature	
A15	The storage ambient air requirements are not up to standard	
A16	Unsuitable humidity in storage environment	
A17	Damaged storage equipment	(x17,m17,y17)
A18	Improper operation of warehouse workers	(x18,m18,y18)

Among them, the possible range of applied probability and the possibility and severity of the occurrence of the event are shown in Table 2.2.

Table 2.2 The link between the possible range of probabilities and the probability of occurrence

Probability range	Probability and severity of the incident
$0 < d_i < 0.1$	Impossible
$0 < d_i < 0.1$	Low probability
$0.1 < d_i < 0.3$	Possible but rarely happen
$0.3 < d_i < 0.5$	Possible and generally serious consequences
$0.5 < d_i < 0.7$	High probability and serious consequences
$0.7 < d_i < 0.9$	Completely possible and serious consequences

Use the Hideo Tanka method to obtain the fuzzy importance of each basic event, see Table 2.3.

Table 2.3 Analysis table of importance of fuzzy

Symbol	Significance	Probability of basic accident d_i	Probability of occurrence of top event under the condition that the basic accident does not occur $Z(S_i)$	Importance V_i	Arrangement
S	Dangerous factors of dock fruit logistics based on cold chain				
A1	Incomplete packaging				
A2	The air requirement in the packaging bag does not meet the standard				
A3	Uncomfortable temperature during packaging				
A4	Packers mishandled				
A5	The temperature is uncomfortable during loading and unloading				
A6	Damaged handling equipment				
A7	Improper handling of loading and unloading workers				
A8	The temperature in the transport vehicle is uncomfortable				
A9	Natural disasters occurred during transportation				

A10	Accident during transportation				
A11	Improper choice of means of transportation				
A12	Transport workers have low safety literacy				
A13	Improper handling of transport workers				
A14	Unsuitable storage temperature				
A15	The storage ambient air requirements are not up to standard				
A16	Unsuitable humidity in storage environment				
A17	Damaged storage equipment				
A18	Improper operation of warehouse workers				

3. Case application

3.1 Case background

Port A is a deep-water quality port with superior geographical location and sufficient resources. It occupies a major position in China's comprehensive transportation system and provides unique basic conditions for the vigorous development of cold chain logistics in the port. The main business of Port A is container trunk line transportation, which is mainly responsible for the transit transportation of materials needed for the development of its coastal areas, which is an important guarantee for the economy of its provinces and cities. The people in this area have a higher standard of living and a higher standard of quality of life. Therefore, there is an extremely high consumption demand for fruit cold chain products. At present, the well-developed traditional container logistics in Port A also provides excellent basic conditions for the development of port cold chain logistics.

3.2 Evaluation and Analysis of Fruit Cold Chain Logistics Performance in Port A

The problem of basic events that affect the failure of port fruit cold chain logistics is very complicated. The probability of accurate basic events is difficult to give. In order to enable the probability of each basic event to accurately reflect the actual situation of the event, this article collects a large number of relevant materials and listen Expert opinions estimate the probability of each basic accident, and use triangular fuzzy numbers to give the probability of the basic event. The results are shown in Table 3.1.

Table 3.1 Fuzzy probability table represented by triangular fuzzy numbers

Symbol	Basic accident	Probability represented by triangular fuzzy numbers d_i
A1	Incomplete packaging	(0.01, 0.02, 0.03)
A2	The air requirement in the packaging bag does not meet the standard	(0.15, 0.20, 0.25)
A3	Uncomfortable temperature during packaging	(0.20, 0.25, 0.30)
A4	Packers mishandled	(0.10, 0.15, 0.20)
A5	The temperature is uncomfortable during loading and unloading	(0.20, 0.25, 0.30)
A6	Damaged handling equipment	(0.01, 0.02, 0.03)

A7	Improper handling of loading and unloading workers	(0.10, 0.15, 0.20)
A8	The temperature in the transport vehicle is uncomfortable	(0.20, 0.25, 0.30)
A9	Natural disasters occurred during transportation	(0.01, 0.02, 0.03)
A10	Accident during transportation	(0.10, 0.15, 0.20)
A11	Improper choice of means of transportation	(0.05, 0.10, 0.15)
A12	Transport workers have low safety literacy	(0.15, 0.20, 0.25)
A13	Improper handling of transport workers	(0.10, 0.15, 0.20)
A14	Unsuitable storage temperature	(0.20, 0.25, 0.30)
A15	The storage ambient air requirements are not up to standard	(0.15, 0.20, 0.25)
A16	Unsuitable humidity in storage environment	(0.05, 0.10, 0.15)
A17	Damaged storage equipment	(0.01, 0.02, 0.03)
A18	Improper operation of warehouse workers	(0.10, 0.15, 0.20)

Use formula 3.1 to calculate the probability of error in the port fruit cold chain logistics link:

$$d = \left[1 - \prod_{i=1}^{18} (1 - d_i) \right] = \left[1 - \prod_{i=1}^{18} (1 - x_i), 1 - \prod_{i=1}^{18} (1 - m_i), 1 - \prod_{i=1}^{18} (1 - y_i) \right] \tag{3.1}$$

Using the data in Table 3.1, the probability of errors in the port fruit cold chain logistics link can be calculated as (0.9276, 0.9714, 0.9894). The probability of this result is still a fuzzy probability. We can preliminarily think that the probability of occurrence of a sticky event is 0.9714, and the probability of occurrence of a sticky event ranges from 0.9276 to 0.9894, but the probability of occurrence of 0.9714 is the largest. The degree of ambiguity of the basic event determines the degree of ambiguity of the top event, and the retention of this degree of ambiguity can more clearly recognize the essential situation of things. Use the three formulas of the Hideo Tanka method to calculate the fuzzy importance of each basic event:

$$Z(S) = Z(d_1, \dots, d_i, \dots, d_n) = (x^S, m^S, y^S) \tag{3.2}$$

$$Z(S_i) = Z(d_1, \dots, d_{i-1}, 0, d_{i+1}, \dots, d_n) = (x^{S_i}, m^{S_i}, y^{S_i}) \tag{3.3}$$

$$V[Z(S), Z(S_i)] = (x^S - x^{S_i}) + (m^S - m^{S_i}) + (y^S - y^{S_i}) \tag{3.4}$$

The calculation results are shown in Table 3.2.

Table 3.2 Fuzzy importance analysis table

Symbol	Significance	Probability of basic accident di	Probability of occurrence of top event under the condition that the basic accident does not occur Z(Si)	Importance Vi	Arrangement
S	Dangerous factors of dock fruit logistics based on cold chain	(0.9276, 0.9714, 0.9894)			
A1	Incomplete packaging	(0.01, 0.02, 0.03)	(0.9268, 0.9708, 0.9891)	0.0016	15
A2	The air requirement in the packaging bag does not meet the standard	(0.15, 0.20, 0.25)	(0.9148, 0.9642, 0.9858)	0.0235	5
A3	Uncomfortable temperature during packaging	(0.20, 0.25, 0.30)	(0.9095, 0.9618, 0.9848)	0.0322	2

A4	Packers mishandled	(0.10, 0.15, 0.20)	(0.9195, 0.9663, 0.9867)	0.0158	8
A5	The temperature is uncomfortable during loading and unloading	(0.20, 0.25, 0.30)	(0.9095, 0.9618, 0.9848)	0.0322	2
A6	Damaged handling equipment	(0.01, 0.02, 0.03)	(0.9268, 0.9708, 0.9891)	0.0016	15
A7	Improper handling of loading and unloading workers	(0.10, 0.15, 0.20)	(0.9915, 0.9663, 0.9867)	0.0158	8
A8	The temperature in the transport vehicle is uncomfortable	(0.20, 0.25, 0.30)	(0.9095, 0.9618, 0.9848)	0.0322	2
A9	Natural disasters occurred during transportation	(0.01, 0.02, 0.03)	(0.9268, 0.9708, 0.9891)	0.0016	15
A10	Accident during transportation	(0.10, 0.15, 0.20)	(0.9195, 0.9663, 0.9867)	0.0158	8
A11	Improper choice of means of transportation	(0.05, 0.10, 0.15)	(0.9238, 0.9682, 0.9875)	0.0089	13
A12	Transport workers have low safety literacy	(0.15, 0.20, 0.25)	(0.9148, 0.9642, 0.9858)	0.0235	5
A13	Improper handling of transport workers	(0.10, 0.15, 0.20)	(0.9195, 0.9663, 0.9867)	0.0158	8
A14	Unsuitable storage temperature	(0.55, 0.60, 0.65)	(0.8390, 0.9284, 0.9697)	0.1512	1
A15	The storage ambient air requirements are not up to standard	(0.15, 0.20, 0.25)	(0.9148, 0.9642, 0.9858)	0.0235	15
A16	Unsuitable humidity in storage environment	(0.05, 0.10, 0.15)	(0.9238, 0.9682, 0.9875)	0.0089	13
A17	Damaged storage equipment	(0.01, 0.02, 0.03)	(0.9268, 0.9708, 0.9891)	0.0016	15
A18	Improper operation of warehouse workers	(0.10, 0.15, 0.20)	(0.9195, 0.9663, 0.9867)	0.0158	8

Analyzing the results of this table, it can be found that the magnitude of the fuzzy importance of the basic events is: $V_{14} > V_3 = V_5 = V_8 > V_2 = V_{12} > V_4 = V_7 = V_{10} = V_{13} = V_{18} > V_{11} = V_{16} > V_1 = V_6 = V_9 = V_{15} = V_{17}$. Through the analysis of the dangerous factors that affect the fruit cold chain logistics link of the port, we can know that there are many problems in the fruit cold chain logistics link of the port. The possibility of fruit damage and loss during transportation, loading and unloading, packaging and storage is very high. Through the analysis of the fuzzy importance of basic events, it can be concluded that the storage ambient air requirements are not up to standard, the temperature is uncomfortable during packaging, the temperature is unsuitable during loading and unloading, the temperature in the transport vehicle is unsuitable, the air in the packaging bag is not up to standard, and the safety literacy of transport workers is low. The ambiguity of such events is important, and it can be known that errors in the port fruit cold chain logistics link are greatly affected by these factors. In order to reduce the occurrence of errors in the port fruit cold chain logistics link and enhance the safety guarantee of the fruit cold chain logistics system, we must start from the above aspects, focus on control, and put forward effective improvement suggestions in the next section.

3.3 Suggestions for Port A to improve the performance of fruit cold chain logistics

3.3.1 Strengthening the construction of port fruit cold chain basic equipment

Because fruits generally have biological characteristics that are prone to decay and aging, the circulation difficulty coefficient and risk coefficient are relatively high. In all logistics links from fruit picking, purchasing, transportation to listing, the storage, temperature of the transportation

environment, and gas composition of the environment must be strictly controlled. If the temperature is too low or too high, it will cause damage to the fruit; some gases will also cause catastrophic ripening, causing the fruit to lose its original value. Develop cold chain logistics Strengthen the modernization and use of modern cold chain logistics infrastructure and equipment. Ports should establish a refrigerated supply chain to keep fruits in a standard low-temperature environment during packaging, loading and unloading, transportation, and storage to reduce fruit loss. Prevent deterioration and spoilage. The port must strengthen the introduction of advanced technical facilities at home and abroad, mostly use refrigerated transport vehicles, set up an advanced fruit cold chain logistics system, speed up the technological innovation of the cold storage, and improve the response capacity of the cold chain link in order to effectively reduce the "broken chain" situation. possibility.

3.3.2 Strengthen the quality education construction of relevant practitioners

No matter how good the conditions of the cold chain infrastructure of the port are, the safe implementation of the cold chain logistics link requires the staff to have a high level of knowledge and practice in refrigerated trucks and refrigerated units. Therefore, the port must develop a long-term and stable safety quality education system to make the training courses on the use of refrigerated vehicles easy to understand. The port can also cooperate with advanced ports at home and abroad to organize on-the-job training and quality education for employees to learn the scientific fruit cold chain logistics technology at home and abroad.

3.3.3 Strengthening the standardization and construction of port fruit cold chain logistics

The implementation of standardized construction needs to promote fruit cold chain logistics technical standards and specifications. Relevant departments need to actively and scientifically formulate technical standards related to the cold chain logistics, such as cold chain loss and efficiency standards, standard operation standards in the cold chain logistics process, fruit cold chain health and safety standards, cold storage environmental temperature and humidity standards, cold storage Standards such as temperature and humidity in the transportation vehicle ensure the standard operation of the cold chain logistics industry. The implementation of professional construction requires the development of a certain number of ports with scientifically advanced management concepts and management methods and strong core competitiveness, and the establishment of a cold chain logistics security system based on the port.

4. Conclusion

The degree of damage and loss of port fruits directly reflects the safety level of the port fruit cold chain logistics system. Therefore, the evaluation and analysis of the safety performance of the port fruit cold chain logistics system can effectively meet the advanced trends of port development. In this paper, the theoretical knowledge of safety system engineering is used to summarize 18 dangerous elements that may affect the failure of the port fruit cold chain logistics link from the four aspects of packaging, warehousing, loading and unloading, and transportation. The accident tree method is used to construct the port fruit cold chain Logistics safety performance evaluation model. In this paper, the concept of fuzzy numbers is used to quantitatively calculate the degree of ambiguity of the port fruit cold chain logistics. The dangerous factors that have a great impact on the safety implementation of the port fruit cold chain logistics are obtained. Specific improvement suggestions such as strengthening the standardization and construction of port fruit cold chain logistics, and enhancing the standardization and construction of port fruit cold chain logistics.

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