Food Supply Chain Risk Analysis and Prediction – Analysis Based on Beijing Food Safety Incidents

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Abstract. This article measures and predicts the risks in the food supply chain using fault tree analysis and Bayesian networks. It also proposes relevant solutions to enhance consumer trust and purchasing intention in the Chinese food industry. In recent years, food safety incidents have not only caused panic among consumers but also significantly impacted the development of our country's food industry. The lack of consumer trust not only damages companies but also has a negative impact on the entire supply chain. Therefore, this article aims to analyze various aspects of the food supply chain, evaluate risk indicators, and provide targeted recommendations to address safety risks in the food supply chain. The ultimate goal is to increase consumer trust in the Chinese food industry and further promote its developmentr.

Keywords: food supply chain; risk analysis and prediction; Bayesian networks.

1. Introduction

Food safety is directly related to everyone's daily life and health, showing its immense importance. With the improvement of living standards, people's pursuit of food has gradually experienced a process from merely being satiated, to seeking quality and healthy food. This reflects the rapid development of our country's economy as people strive for a higher quality of life. On the other hand, the longing for healthy and safe food also reveals the seriousness of food safety issues.

Food safety is a process that involves multiple stages, and risks exist in various stages of the food supply chain, including agriculture (cultivation), production processing, distribution, sales, and consumption. Each stage carries various degrees of risk factors, any of which can lead to food safety incidents. Therefore, it is necessary to prevent and control food safety incidents by systematically managing the entire supply chain. However, relying solely on empirical research, statistical analysis methods, fuzzy theory, and analytical models like the analytic hierarchy process typically addresses the current understanding of regulating safety risks in the food supply chain at a macro level. It fails to offer solutions for predicting future safety risk levels of the entire food supply chain and its nodes. To address this issue, this paper utilizes Fault Tree Analysis (FTA) and Bayesian Networks (BN) theory to study food supply chain safety risks. This approach not only calculates the probability of food safety risks but also accurately predicts the risks present in various stages of the food supply chain.

2. Literature Review

Both domestically and internationally, there is considerable research focusing on the technical aspects of food safety risk assessment. Scholars emphasize the comprehensive risk analysis and management process "from farm to table." The HACCP (Hazard Analysis and Critical Control Points) food safety assurance system is a typical example. However, the analysis and warning of risks throughout the entire process are based on extensive testing of physical, chemical, and microbiological hazard factors, undoubtedly leading to significant increases in the cost of risk management [1]. Brown, M., discussed the application and potential future development of microbiological risk assessment [2]. Additionally, some scholars have constructed Bayesian network models for food safety risk assessment to evaluate and predict food safety risks [3]. Zhang Hongxia and colleagues systematically analyzed the risk factors at each stage and introduced the risk matrix analysis method to comprehensively assess the risk levels of various factors [4]. Cui Fengxia and others analyzed the scope, specific operational steps, and application of the risk-benefit method in food safety risk assessment [5]. These research methods have essentially provided a comprehensive evaluation of food safety risks. Moreover, there are evaluations of risk levels. Liu Peng measured the changing trend of China's food safety from 1990 to the present and found that China's food safety situation has undergone a distinct V-shaped development process [6]. Chen Qiuling and others used a mutation model to assess the overall risk level of China's food safety in recent years, concluding that the overall risk value has been decreasing but with occasional fluctuations [7]. Regarding the management and control within the food supply chain, scholars believe that food safety control is a valuable dimension for observing contemporary Chinese government and policies, revealing the primary responsibilities of the government and related agencies [8]. Some scholars argue that as China's unique socialist system enters a new era, major livelihood issues such as food safety become crucial benchmarks for assessing the transformation of government functions [9].

It is considered the largest livelihood issue, the most fundamental public safety concern, an economic problem, and a political issue. This underscores that food safety is a complex systemic engineering task. Every link in the entire chain of food production, processing, distribution, and consumption may have different degrees of risk factors that require attention. There is limited literature systematically identifying and assessing risk factors in various links of the food supply chain from a management perspective. This paper hopes to build on previous research, focusing on the perspective of the food supply chain, and conduct further research on the risk factors existing in each link and the severity of each risk factor. This will provide a reference basis for advancing the comprehensive safety management of the food supply chain.

3. Risk Probability Calculation and Prediction of Food Supply Chain Based on Fault Tree to Bayesian Neural Network Transformation

3.1 Relevant Assumptions and Definitions

1. The food supply chain can be divided into four parts: agricultural production, food production and processing, agricultural product/food distribution, and catering consumption (referred to as production, processing, distribution, and consumption).

2. Food safety risk refers to all objective factors present in food that may cause harm or potential harm to human health. From the perspective of harmful substances, the main factors contributing to food quality and safety risks are natural toxins, biological hazards, chemical hazards, and so on.

3. Food safety issues refer to the phenomenon, state, or situation where food safety risks are not properly controlled and pose an actual threat to people. The difference between food safety issues and food safety risks lies in the former being the objective existence while the latter is the "activated" state of objective factors in reality. Therefore, although most of these risk factors in the food supply chain system stem from improper practices in the production, processing, distribution, and consumption of food, causing contamination by harmful substances, they alone cannot constitute food safety issues. They are merely one of the reasons for activating food safety risk factors. Only when there is a lack or inadequacy of monitoring and control in the relevant supply chain links, these risk factors will transform into food safety issues.

4.The occurrence of various phenomena that violate national laws and regulations, which does not allow the existence or exceed the standard of various food hazard factors that may cause harm or potential harm to human health, is referred to as an exceedance event. Since the external manifestations of food safety problems generally involve the presence or exceedance of natural toxins, biological hazards, or chemical hazards, this experiment categorizes food hazard factors into three types: exceeding natural toxin limits, exceeding biological hazard limits, and exceeding chemical hazard limits. Violations or non-compliant conditions in the supply chain that lead to food contamination are referred to as operational faults, and it is defined that an operational fault event in the supply chain leading to the exceedance of a certain type of hazard substance is denoted as x_{ij} (i=1,2,3,4;j=1,2,3).

5.Events in the relevant supply chain links where contaminated food (raw materials, semi-finished products) should be detected and discovered during the generation and backward transmission of risk factors but, in fact, are not detected and discovered are referred to as monitoring faults. It is defined that a monitoring fault event in the i-th supply chain link leading to the occurrence of a certain type of hazard substance is denoted as y_{ij} (i=1,2,3,4;j=1,2,3)。

3.2 Food Safety Supply Chain Fault Tree Model Based on FTA

Fault Tree Analysis (FTA) is a logical diagram that represents the causal relationships between specific events or undesired events and the failures of their subsystems or components within a system. It uses symbols with specific meanings and is drawn in an upside-down tree structure according to certain rules. Establishing a fault tree serves as the foundation for conducting risk assessment and optimizing regulatory decisions in food safety. When using the FTA method for system modeling, undesirable events are typically identified as the top event, while the primary events that do not require further investigation and can be addressed through corrective measures are considered as the bottom events. All the events between the top and bottom events are referred to as intermediate events. In the process of food safety management, preventing food safety issues is the fundamental goal and responsibility, and therefore, the occurrence of food safety incidents is the least desired outcome.

In the context of addressing food safety issues, this experiment selects food safety issues as the top event of the fault tree. Based on premises and definitions, exceeding the limits of natural toxin levels, biological hazard factors, and chemical hazard factors are chosen as intermediate events of food safety issues. This forms the fault tree for the food safety issue in the supply chain.

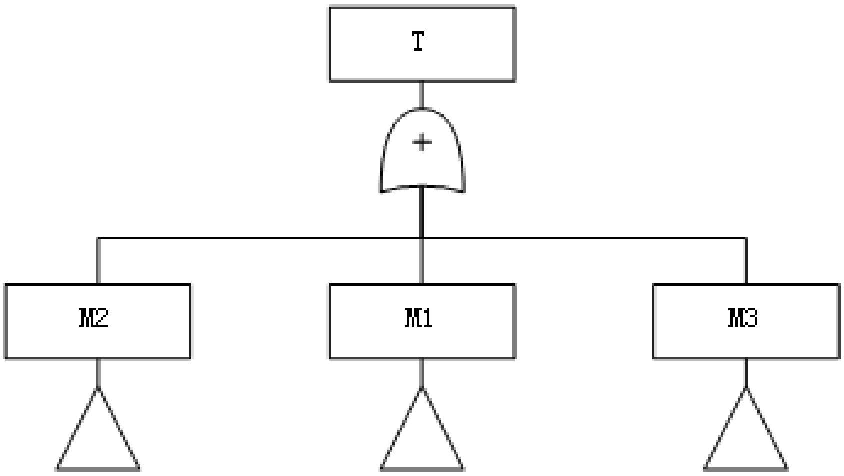

Fig. 1: Fault Tree for Food Safety Problems in the Supply Chain

Based on the analysis, the occurrence of exceeding the limits of natural toxin levels, biological hazard factors, and chemical hazard factors is fundamentally caused by operational failures in relevant supply chain stages and subsequent monitoring failures in the supply chain. From the perspective of optimizing regulation, once the problematic stage or monitoring stage is identified, it becomes easier to propose improvement or corrective measures. Therefore, it is necessary to further establish fault trees for natural toxin level exceeding, biological hazard factor exceeding, and chemical hazard factor exceeding as the top events from the perspective of the supply chain.

3.2.1 Fault Tree for Excessive Natural Toxins

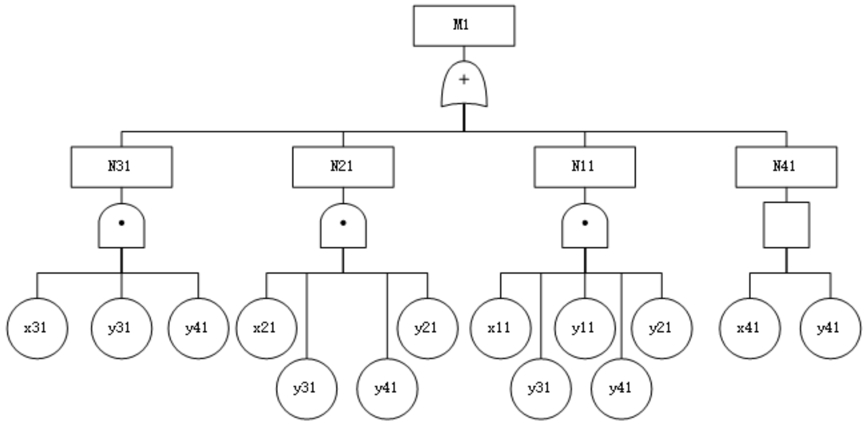

Fig. 2 Fault Tree for Exceeding Natural Toxins

Choosing the exceeding of natural toxins as the top event, the fault tree established for the exceeding of natural toxins is shown in Fig. 2. In the tree-building process, N_{ij} is introduced as a virtual event needed for expressing the logical relationships between events. Its specific meaning is "an event of food safety problems formed by the operational failure of risk factors in category j of supply chain link i." From the causal relationship of event occurrence, the occurrence of each N_{ij} event is jointly caused by the operational failures of relevant links in the supply chain and the subsequent monitoring failures of supply chain links. Taking N_{11} as an example, the N_{11} event represents the occurrence of a food safety problem formed by the operational failure of natural toxin risk factors in the breeding (planting) supply chain link. The occurrence of this event is due to the operational failure of natural toxin exceeding in the breeding (planting) link (X_{11} occurrence), and monitoring failures of natural toxin exceeding occur in the breeding (planting), production and processing, distribution, and consumption links (y_{11} occurrence,y_{21} occurrence,y_{31} occurrence, y_{41} occurrence). The relationships of other N_{ij} with x_{ij} and y_{ij} are similar. Refer to Table 6-1 for the names of related bottom events.

Table 1 Names of Bottom Events in the Fault Tree for Exceeding Natural Toxins

Serial Number	Event Code	Event Name
1	x_{11}	Operational failure leading to excessive natural toxin levels in aquaculture (farming) or cultivation
2	x_{21}	Production Operation Failure Leading to Excessive Levels of Natural Toxins
3	x_{31}	Operational Failure in Circulation Resulting in Excessive Levels of Natural Toxins
4	x_{41}	Operational Failure in Consumption Leading to Excessive Levels of Natural Toxins
5	y_{11}	Monitoring Failure of Natural Toxins in the Farming (or Cultivation) Stage
6	y_{21}	Monitoring Failure of Natural Toxins in the Production Stage
7	y_{31}	Monitoring Failure of Natural Toxins in the Distribution Stage

8	y_{41}	Monitoring Failure of Natural Toxins in the Distribution Stage

3.2.2 Fault Tree for Excessive Biological Hazards

Choosing the exceeding of biological hazard factors as the top event, the fault tree established for exceeding biological hazard factors is shown in the following figure. Refer to Table 2 for the names of related bottom events.

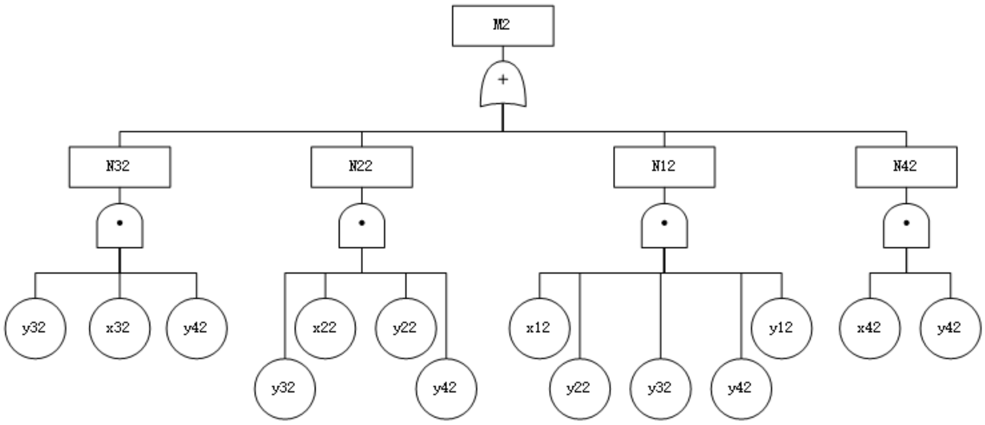

Fig. 3 Fault Tree for Exceeding Biological Hazard Factors

Table 2 Names of Bottom Events in the Fault Tree for Exceeding Non-hazardous Biological Factors

Serial Number	Event Code	Event Name
1	x_{12}	Operational failure in breeding (planting) causing exceeding of biological hazard factors
2	x_{22}	Operational failure in processing causing exceeding of biological hazard factors
3	x_{32}	Operational failure in distribution causing exceeding of biological hazard factors
4	x_{42}	Operational failure in consumption causing exceeding of biological hazard factors
5	y_{12}	Monitoring failure of biological hazard factors in the breeding (planting) link
6	y_{22}	Monitoring failure of biological hazard factors in the production link
7	y_{32}	Monitoring failure of biological hazard factors in the distribution link
8	y_{42}	Monitoring failure of biological hazard factors in the consumption link

3.2.3 Fault Tree for Excessive Chemical Hazards

Choosing the exceeding of chemical hazard factors as the top event, the fault tree established for exceeding biological hazard factors is shown in Figure 4. Refer to Table 3 for the names of related bottom events.

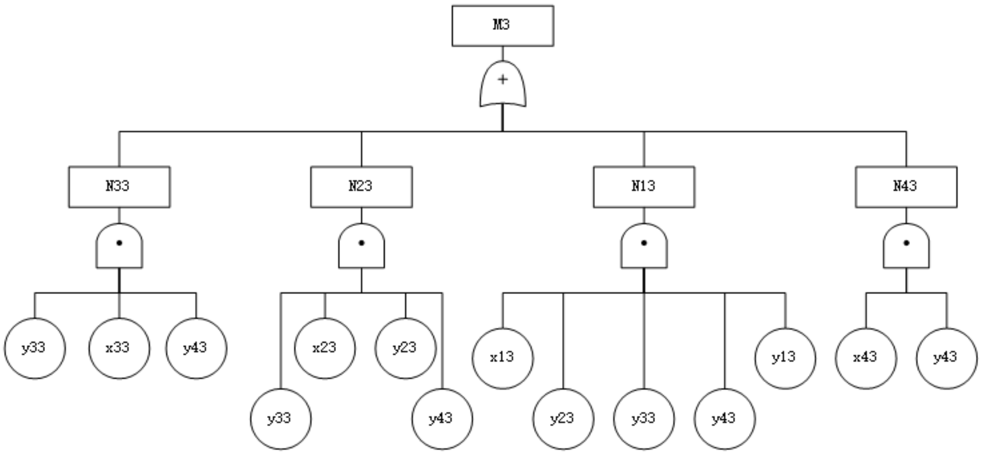

Fig.4 Fault Tree for Exceeding Chemical Hazard Factors

Table 3 Names of Bottom Events in the Fault Tree for Exceeding Chemical Hazard Factors

Serial Number	Event Code	Event Name
1	x_{13}	Operational failure in breeding (planting) causing exceeding of chemical hazard factors
2	x_{23}	Operational failure in production causing exceeding of chemical hazard factors
3	x_{33}	Operational failure in distribution causing exceeding of chemical hazard factors
4	x_{43}	Operational failure in consumption causing exceeding of chemical hazard factors
5	y_{13}	Monitoring failure of chemical hazard factors in the breeding (planting) link
6	y_{23}	Monitoring failure of chemical hazard factors in the production link
7	y_{33}	Monitoring failure of chemical hazard factors in the distribution link
8	y_{43}	Monitoring failure of chemical hazard factors in the consumption link

3.3 Bayesian Network Model for Food Supply Chain Safety Risk Prediction

By applying the Bayesian theorem and fault tree analysis theory, the fault tree can be transformed into a Bayesian network model. The specific steps are as follows：

Step one: Generate variables relevant to the BN model along with their explanations. Transfer variables from the fault tree model to the Bayesian network, where each root node in the Bayesian network should correspond to the basic events in the fault. Logical gates in the fault tree should also be created in the Bayesian network. For identical events that occur multiple times in the fault tree, only one root node needs to be established in the Bayesian network.

Step two: Construct a directed acyclic graph. Connect each node to establish an open directed acyclic graph, using arrows to represent the inheritance relationships between parent and child nodes.

Establish the conditional probability distribution table for the BN model. The occurrence probability of bottom events in the fault tree is the prior probability of each root node. The logic gates and corresponding nodes generate the conditional probabilities between nodes. Assuming the output event in the fault tree is T and the input events are $M_i(i = 1,2,\cdots,n)$,If the logical symbol between input and output events is an "OR" gate, the conditional probability of transforming the fault tree into a Bayesian network is:

$$P(T = 1 \mid (1 - M_1)(1 - M_2)\cdots(1 - M_n) = 0) = 1, P(T = 1 \mid (1 - M_1)(1 - M_2)\cdots(1 - M_n) = 1) = 0 \quad (1)$$

If the logical symbol between input and output events is an "AND" gate, the conditional probability of transforming the fault tree into a Bayesian network is:

$$P(T = 1 \mid M_1M_2\cdots M_n = 1) = 1, P(T = 1 \mid M_1M_2\cdots M_n = 0) = 0 \quad (2)$$

According to the transformation rules from FTA to BN, the BN model generated by the fault tree of food supply chain safety problems shown in Figures 1, 2, 3, and 4 is presented in Figure 5. Its conditional probability table is generated by the logic gates corresponding to the nodes, as shown below.

$$P(T = 1 \mid (1 - M1)(1 - M2)(1 - M3) = 1) = 0 \quad (3)$$

$$P\left(M_j = 1 \mid \prod_{i=1}^{4}(1 - N_{ij}) = 0\right) = 1 \quad (4)$$

$$P\left(M_j = 1 \mid \prod_{i=1}^{4}(1 - N_{ij}) = 1\right) = 0, (j = 1,2,3) \quad (5)$$

$$P\left(N_{ij} = 1 \mid x_{ij}\prod_{k=i}^{4} y_{kj} = 1\right) = 1 \quad (6)$$

$$P\left(N_{ij} = 1 \mid x_{ij}\prod_{k=i}^{4} y_{kj} = 0\right) = 0, (i = 1,2,3,4; j = 1,2,3) \quad (7)$$

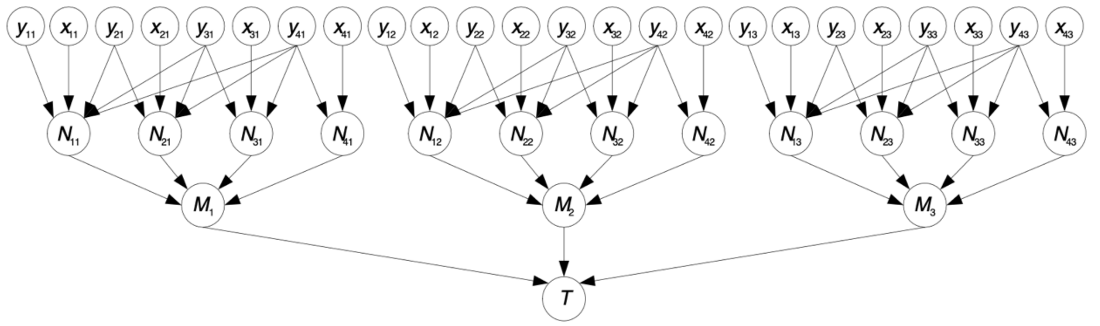

Fig.5 Bayesian Network Model Transformed from Fault Tree

Based on the analysis results above, the evaluation value of the current reliability of food supply chain safety can be obtained from the joint probability distribution (prior probability) $P(T)$ as shown in the formula. On this basis, according to Bayes' theorem, the predicted probability values of safety issues occurring in various basic events in the food supply chain (posterior probability) $P(S_{ij} \mid T)$ can be obtained as shown in the formula. Furthermore, the predicted probability value of the entire food supply chain experiencing safety issues (posterior probability) $P(T')$can be derived.

$$P(T) = \sum_{j=1}^{3}\sum_{i=1}^{4} P\left(x_{ij} = 1, \prod_{k=i}^{4} y_{kj} = 1\right) = \sum_{j=1}^{3}\sum_{i=1}^{4}\left[P(x_{ij} = 1) \times \prod_{k=i}^{4} P(y_{kj} = 1)\right] \quad (8)$$

$$P(S_{ij} \mid T) = \frac{p(S_{ij} = 1, T = 1)}{p(T = 1)} = \frac{p(S_{ij})}{p(T)} p(T \mid S_{ij}), (S = x, y; i = 1,2,3,4; j = 1,2,3) \quad (9)$$

$$P(T') = \sum_{j=1}^{3}\sum_{i=1}^{4} P\left(x_{ij}\middle|T,\prod_{k=i}^{4} y_{kj}\middle|T\right) = \sum_{j=1}^{3}\sum_{i=1}^{4}\left[P(x_{ij} \mid T) \times \prod_{k=i}^{4} P(y_{kj} \mid T)\right] \quad (10)$$

4. Case Study

4.1 Data Source and Preprocessing

This article collected data from the "Announcement of Food Safety Supervision and Sampling Information by the Beijing Municipal Market Supervision Administration for the 60th to 70th periods in 2023," which was released by the Beijing Municipal Market Supervision Administration. A total of 10,517 sampling batches were collected, with information on 101 non-compliant batches, as shown in Table 4.

At certain times, it may be difficult to distinguish between various links. In this article, the classification is based on the sales entities: enterprises that provide dining places such as restaurants and hotels and supply ready-to-eat food are classified under the consumption link. On the other hand, businesses and organizations such as convenience stores, supermarkets, grocery stores, secondary food retailers, farmers' markets, and food wholesale enterprises that sell ready-to-eat food without providing dining places are classified under the circulation link. In addition, businesses and organizations that sell self-produced ready-to-eat food without providing dining places, such as secondary food stores, supermarkets, grocery stores, secondary food retailers, farmers' markets, and food wholesale enterprises, belong to the production and processing link.

Table 4 Information about non-compliant batches

Inspection Stage	Number of Inspected Batches	Hazardous Substances	Source of Detected Hazardous Substances			
			Farming	Production Processing	Distribution	Consumption
Farming	210	Natural Toxins	0	0	0	0
		Biological Hazards	0	0	0	1
		Chemical Hazards	0	0	0	1
Production Processing	1472	Natural Toxins	0	0	0	0
		Biological Hazards	0	2	0	1
		Chemical Hazards	6	2	0	1
Distribution	4838	Natural Toxins	1	4	0	0
		Biological Hazards	0	6	2	0
		Chemical Hazards	17	7	0	0
Consumption	3996	Natural Toxins	0	0	0	0
		Biological Hazards	0	2	0	5
		Chemical Hazards	6	2	0	9

4.2 Numerical Calculations

According to the previous definitions, it can be known that x_{ij} refers to the occurrence of operational failure events in supply chain link i leading to excessive hazardous substances of type j. Therefore, the probability value of the x_{ij} event occurring can be calculated using the ratio of the number of batches with type j hazardous substances exceeding the standard, detected and discovered in all supply chain links, originating from link i, to the total number of batches inspected in link i.

Similarly, y_{ij} is calculated based on the ratio of the number of batches with type j hazardous substances exceeding the standard, detected and discovered in all subsequent supply chain links after link i, originating from link i and its preceding supply chain links, to the number of batches with type j hazardous substances exceeding the standard present in link i. From this, the probability of the occurrence of the bottom event in the food supply chain can be determined.

Table 5 Prior Probability of Occurrence of Bottom Events in the Food Supply Chain

Event	x_{11}	x_{21}	x_{31}	x_{41}	x_{12}	x_{22}	x_{32}	x_{42}	x_{13}	x_{23}	x_{33}	x_{43}
Probability	0.0047	0.0027	0.0000	0.0000	0.0000	0.0068	0.0004	0.0018	0.1381	0.0075	0.0000	0.0028
Event	y_{11}	y_{21}	y_{31}	y_{41}	y_{12}	y_{22}	y_{32}	y_{42}	y_{13}	y_{23}	y_{33}	y_{43}
Probability	4.0000	1.2500	0.0000	0.0000	0.0000	1.0000	1.0000	0.7143	1.0000	1.0000	0.0000	0.2222

Based on the above data, this paper calculates (P(T)), (P(S_{ij}|T)), and (P(T')) through a Python program: obtaining (P(T)=0.0071). The posterior probabilities are shown in Table 6.

Table 6: Posterior Probabilities

Event	x_{11}	x_{21}	x_{31}	x_{41}	x_{12}	x_{22}	x_{32}	x_{42}	x_{13}	x_{23}	x_{33}	x_{43}
Probability	0.0035	0.0016	0.0000	0.0000	0.0000	0.0077	0.0005	0.0187	0.1276	0.0163	0.0000	0.0024
Event	y_{11}	y_{21}	y_{31}	y_{41}	y_{12}	y_{22}	y_{32}	y_{42}	y_{13}	y_{23}	y_{33}	y_{43}
Probability	1.0000	1.2500	0.0000	0.0000	0.0000	1.2342	0.9643	0.6342	0.8451	0.9673	0.0000	0.4324

Obtained $P(T')$ =0.01901.

4.3 Results Analysis

The posterior probability $P(T')$ =0.01901 belongs to a low-risk level, and the predicted result is consistent with the food safety risk level in Beijing. From the prior probability table and posterior probability table, it can be observed that the probability of monitoring failure events, whether historical values (prior probability) or predicted values (posterior probability), is significantly higher than the probability of operational failure events. Additionally, as shown in Table 1, although the Beijing Municipal Market Supervision Administration regularly samples for food safety, the sampling and testing intensity for the farming link is evidently insufficient. The analysis results indicate that the probability of "operational failure in farming (cultivation) causing excessive chemical hazards" is the highest, suggesting that most sources of food safety risks across various links originate from the farming link.

Therefore, the focus of future improvement should be on monitoring the farming link. If the monitoring link behind farming is well-controlled, the probability of subsequent risks will be significantly reduced, effectively controlling the occurrence of risks. Based on this method, we can further optimize the model to predict the probability of food safety events occurring in subsequent links, identify the most critical links to control, and implement a series of preventive measures to reduce the probability of monitoring failure events. This may involve updating monitoring equipment, improving monitoring processes, and providing relevant training to enhance the sensitivity of employees to monitoring links.

5. Food Safety Risk Management Based on Food Supply Chain

From the results of risk identification and assessment, it can be seen that at every stage in the entire chain of food production, processing, distribution, and consumption, there are varying degrees of risk factors. To ensure the ultimate safety of food, corresponding measures need to be taken at each stage, advancing comprehensive supply chain-based food safety risk management.

Firstly, it is essential to promote safe planting/farming to eliminate production-related risks. The production phase serves as the source of ensuring food safety and is fundamental in safeguarding it. Controlling food safety risks effectively from the source not only reduces the probability of risk occurrence but also saves substantial human and material resources. However, as the farming phase often involves multiple regions rather than a single province or city, it requires joint efforts from national regulatory bodies to control risks from the source. Firstly, it's crucial to standardize the agricultural input market, intensify market supervision of agricultural inputs, accelerate the elimination of highly toxic agricultural inputs, promote the development of efficient and low-residue agricultural inputs, actively implement restricted-use systems for agricultural inputs, address counterfeit agricultural inputs, and the pollution caused by banned pesticides on agricultural products, thereby creating a favorable market environment for the production of safe agricultural products. Secondly, efforts should be made to enhance publicity and law enforcement, raising awareness among growers and breeders about safety management, and regulating cultivation/farming practices through various mechanisms such as industry standards, safety demonstrations, and safety criteria. Furthermore, there should be increased emphasis on technological innovation, developing scientifically proven planting/farming techniques adaptable to different regional climates and production characteristics. These may include soil improvement techniques, the use/application of pesticides/veterinary drugs and fertilizers/feeds, and agricultural product quality and safety detection technologies.

Secondly, it is crucial to strengthen the monitoring and management of the food processing process to reduce processing risks. The processing phase is the core of the food supply chain and, at the same time, the phase with the highest number of risk factors. Enhancing the safety management of the food processing phase holds significant importance for improving the overall performance of the entire food chain's safety management. According to the assessment results of risk factors, the three most critical factors in the processing phase are "use of unsafe additives," "unsanitary processing environment," and "use of substandard raw materials." Therefore, first and foremost, strict control should be exercised over food additives such as food additives in the production materials market. For enterprises producing harmful additives, their sales ledger records should be strictly regulated to prevent entry into the food industry. Clear quantity limits should be established for permitted additives to prevent excessive use. Mandatory regulations for food responsibility subjects should be implemented, and their input factor records should be inspected. Secondly, it is necessary to revise and improve the hygiene standards of food processing enterprises, mandating them to produce and process food according to hygiene standards. The entry threshold for the food processing industry should be raised, and illegal food processing sites such as "black workshops" should be rigorously investigated. Additionally, the sources of raw materials for processing enterprises should be scrutinized to prevent waste, inferior, and substandard food from entering food processing enterprises. The use of packaging materials by packaging production enterprises should also be further regulated. The establishment of a joint liability mechanism for accidents between food production enterprises and food packaging production enterprises should be implemented to regulate their production behavior.

Thirdly, it is crucial to enhance the technical equipment and management measures in the distribution sector to mitigate distribution risks. Food is prone to microbiological, physical, and chemical contamination during transportation and storage. Particularly, fresh foods and dairy products are susceptible to issues in the distribution and sales process. Cold chain logistics is a key measure to ensure the quality and safety of food in the distribution and sales phases. To develop cold chain logistics, firstly, it is necessary to promptly establish standards for cold chain logistics and improve the management system. Secondly, there is a need to integrate social resources and vigorously develop third-party cold chain logistics. Thirdly, it is important to upgrade the technical equipment of cold chain logistics. Additionally, regulatory efforts in the distribution phase should be strengthened, with timely removal and tracking inspections of expired and substandard food to prevent their continued circulation in the market.

Fourthly, it is crucial to enhance regulatory efforts in the catering industry to eliminate consumer risks. The catering industry is prone to frequent safety incidents, especially in school cafeterias, surrounding catering businesses near schools, construction site cafeterias, agritainment venues, and small-scale catering units, all of which are hotspots for issues. Clear regulations should be established for their hygiene environment and operational qualifications. Rigorous inspections of their procurement channels should be conducted. Strict measures should be taken against behaviors such as purchasing and using diseased or unexplained livestock and their products, using unidentified edible oils, using substandard seasonings, and abusing food additives or illegally adding non-edible substances. Secondly, efforts should be made to enhance the health management of industry personnel and provide training in food hygiene knowledge. General consumers should be educated on preventing food poisoning, avoiding the consumption of naturally toxic foods, and preventing food poisoning due to improper processing procedures.

Fifthly, it is crucial to establish a coordinated information mechanism for the food supply chain and strengthen overall risk management in the supply chain. Food safety risks arise at various stages of the food supply chain, and the fundamental reason for the existence of these risks is the imbalance and lack of information sharing in the food supply chain. Therefore, it is essential to establish an information coordination mechanism for the food supply chain, promoting coordination and information sharing among various entities. This helps to foster an overall risk awareness and establish a comprehensive risk management mechanism for the supply chain, ultimately reducing or eliminating food safety risks at their roots. However, this is a systematic endeavor that requires collaborative efforts from government departments and relevant entities within the food supply chain.

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