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Consumers' Risk Perception of Triploid Food: Empirical Research Based on Variance Analysis and Structural Equation Modeling

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Abstract: With the advancement of new food processing technology, triploid technology has emerged as a viable option to enhance plant yield and improve crop stress resistance. However, like many emerging technologies, food produced using triploid technology has sparked controversy regarding its safety since its inception. Particularly, consumers generally have a limited understanding of new technologies employed in food production, leading to concerns about potential risks and uncertainties associated with these technologies. Such concerns can significantly impact consumers' acceptance and purchasing intentions toward foods modified using new technologies. This study collected 375 questionnaires from both online and offline sources and conducted a detailed analysis of consumers' demographic variables, fear degree regarding triploid food, social trust, and concerns about food safety. SPSS and AMOS software were utilized for reliability and validity analysis, variance analysis, multiple comparisons, and confirmatory factor analysis. A structural equation model was developed to comprehensively examine consumers' risk perception of triploid food and its influencing factors. The results indicate that consumers' risk perception of triploid food is influenced by various factors. Notably, significant differences were found in consumers' risk perception of triploid food based on age, educational background, residency, and employment status. Additionally, this study identified a negative correlation between consumers' risk perception of triploid food and their levels of fear and social trust. Conversely, a positive correlation was observed between risk perception and the degree of attention given to food safety.

Keywords: triploid food; risk perception; influencing factor; variance analysis; multiple comparisons; confirmatory factor analysis; structural equation model; sustainable food

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1. Introduction

Polyploidy is a common phenomenon in plants, primarily occurring through three mechanisms: unreduced gametes, somatic doubling, and polyspermy [1]. Common methods of inducing polyploidy in plants include natural selection, artificial hybridization, and endosperm regeneration, which result in desirable traits such as larger organs, bigger fruits, vigorous growth, high yields, strong adaptability, and enhanced resistance [2]. Triploids, a type of polyploid, exhibit two main characteristics: increased cell volume leading to enlarged size and sterility due to abnormalities in cell meiosis [3]. Triploid plants hold significant economic value and have been instrumental in developing new agronomic, horticultural, and forestry plant varieties [2]. Triploid technology has been widely adopted as an efficient and rapid breeding method [4–9].

In addition to common examples like seedless watermelon and seedless grapes in the plant kingdom [10,11], triploid induction technology finds widespread application in aquaculture [12–15]. Triploid induction technology involves genetic manipulation of animal chromosome numbers, enabling control over the reproductive process and promoting animal growth rates [16]. Widely utilized in shrimp culture, this technology contributes to increasing shrimp size and accelerating growth rates, alongside other successful techniques such as unisexual cultivation, polyploid induction, gynogenesis, and hormone induction [17]. In mollusk aquaculture, triploid induction technology induces gonadal infertility, thereby enhancing growth. For fish, triploid induction addresses issues related to sexual maturity such as reduced growth rates, increased disease incidence, and sensory trait deterioration. Additionally, triploid technology enhances the viability of certain hybrids, showing promise for genetic control in cultured shellfish and fish [12]. Triploid oysters offer a number of benefits in the oyster industry, including faster growth, better meat quality, partial sterility, and increased survival due to enhanced disease resistance [18].

At present, triploid breeding technology has made remarkable progress [19,20]. The government and relevant research institutions have actively promoted this advancement [21,22], particularly in the case of triploid oysters [23], and the management from seedling to the table is gradually becoming more refined [24]. However, simultaneously, it faces several challenges such as non-standard management and the lack of unified industry standards and norms. These issues have resulted in challenges like market chaos and a crisis of consumer trust [25].

With the wide application of new technologies in food production, consumers pay more attention to the quality and health benefits of the products they purchase and put forward higher requirements, which also produce psychological fear and exclusion [26]. Giordano et al. [27] showed in a systematic review of the factors that determine neophobia and neophilia that, in terms of new technologies applied to the food industry, consumer acceptance is driven by risk perception and perception of potential benefits. Nowadays, consumers are paying more and more attention to the choice of food, and they have higher requirements for the quality and health benefits of new foods. Cox et al. [28] investigated the influence of information and beliefs about technology on the acceptance of new food technologies, and 453 prawn consumers in four places in Australia were tested for the text description of new technology. The results showed that all participants preferred the traditional prawns, although the triploid breeding technology did have a relatively positive effect. Kulesz and others [29] concluded in their investigation of the reproductive intervention cases of farmed fish that the word "biotechnology" had a certain impact on consumer behavior, so measures should be taken to reduce consumers' confusion about the word biotechnology. Vidigal et al. [30] interviewed 389 respondents from Belo Horizonte-MG, Brazil, through a questionnaire survey and collected consumers' views on new technologies according to the Food Technology Neophobia Scale (FTNS). The results suggested that neophobia regarding food technology is very important in explaining consumer behavior in relation to new technologies.

It is evident that triploid food, as a product of new technology, has sparked controversy surrounding its safety and risks. Consumers exhibit caution toward the utilization of new technologies in food production, expressing concerns about potential unknown risks that may affect their acceptance and purchasing intentions [31,32]. However, there is currently a dearth of studies focusing on consumers' risk perception of triploid food, with a lack of systematic and comprehensive research addressing aspects such as consumers' awareness of triploid food safety, health risks, and environmental impacts, as well as their attitudes, psychological responses, and behavioral reactions to these risks. Consequently, it is necessary to study consumers' risk perception of triploid food.

In the era of open information on the Internet, public opinions regarding food safety disseminate rapidly, giving rise to consumer skepticism about food security. Consumers' risk perception of new food technology is a complicated and important issue [33,34]. Numerous factors influence consumers' perception of food safety risks, including demographic characteristics, such as sex, age, race, employment, place of residence, and education level; food information channels, such as media reports, expert consultation, and official websites;

government management, such as food safety supervision and handling of food safety incidents; as well as consumers' comprehension of food processing technology, among others. These factors have a positive or negative impact on consumers' food safety risk perception [35–37]. The purpose of this study is to investigate consumers' risk perception of triploid food and its influencing factors from demographic characteristic variables, degree of fear of triploid food, social trust, and food safety concern, so as to accurately discover consumers' attitudes and cognition of triploid food and promote the sustainable development of new biological breeding technologies.

2. Objects and Methods

2.1. Related Theoretical Basis

Risk theory is based on environmental and technological hazards [38]. Risk [39] is defined as the combination of potential consequences and uncertainties associated with an activity that holds value for human beings within a specific timeframe and environment, representing the probability of a potential loss. Risk perception [40] encompasses an individual's subjective judgment and evaluation of potential health-related risks or hazards, characterized by its intricate and cross-disciplinary nature. It involves a series of cognitive processes triggered by individuals' psychology in response to external risk events, playing a pivotal role in shaping how individuals assess risks, make decisions, and exhibit behaviors [41]. The interconnected relationship between psychology, cognition, and risk perception is illustrated in Figure 1.

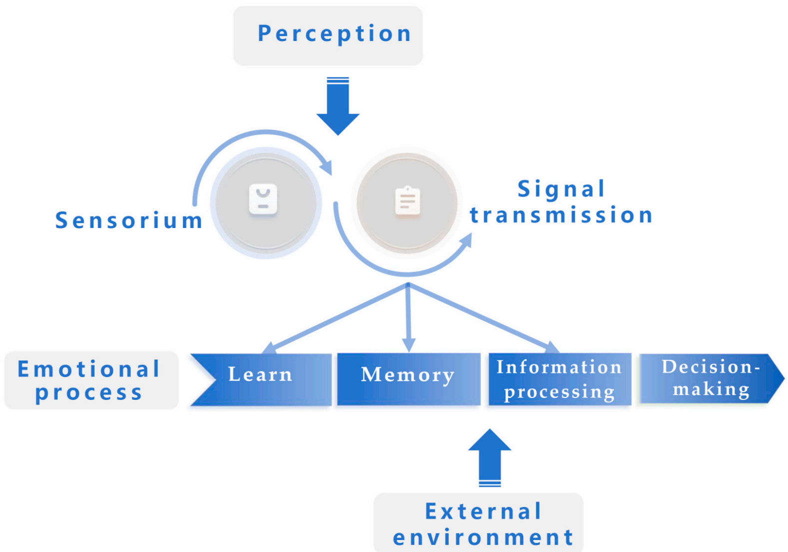

Figure 1. Relationship Diagram between Psychology, Cognition, and Risk Perception.

Ulrich Beck [42] first put forward the concept of "risk society" and pointed out that modern society has become a risk society. Social risk theory reflects a universal anxiety of human society. In crisis events, the biggest risk is people's wrong assessment of risk cognition, not the risk itself. Social risk theory points out that risks in modern society are not only natural disasters that individuals can completely control but also circumstances shaped by social structures and systems. In the field of food, triploid food is regarded as a new type of food, which has certain technical and biological risks and is also influenced by social, cultural, political, and economic factors.

Firstly, the individual's fear of triploid food is influenced by the social risk theory. Socialization of social risks means that food safety is not only an individual problem but also a social problem shaped by social structures and systems. Individuals may be influenced by social information such as media reports, expert opinions, and attitudes of social groups, thus causing fear and anxiety about triploid food. Secondly, individuals' trust in social institutions, experts, and the government may affect their cognition and attitude towards food safety issues. If individuals have a high degree of trust, they may be more inclined to trust the management and evaluation of food safety issues, thus reducing their fear of triploid food. Thirdly, food safety concerns reflect the individuals' concern about food safety issues, including food ingredients, processing technology, production environment, and so on. If individuals are highly concerned about food safety, they may be more sensitive to the risks of new foods, thus increasing their fear of triploid foods.

2.2. Research Hypothesis

Combining psychological, cognitive, and risk perceptions of interrelationships and social risk theory, this study takes demographic variables, fear degree, trust degree, and participation degree as the main influencing factors of triploid food risk cognition and puts forward the following assumptions (Table 1). The research framework is shown in Figure 2.

Table 1. Research Hypothesis Table.

Question	Option
H1	Different demographic variables have significant differences in risk perception of triploid food.
H1 a	Sex has a significant correlation with triploid food risk perception.
H1 b	Age has a significant correlation with triploid food risk perception.
H1 c	Education level has a significant correlation with triploid food risk perception.
H1 d	Employment has a significant correlation with triploid food risk perception.
H1 e	Place of residence has a significant correlation with triploid food risk perception.
H2	The stronger the psychological fear of triploid food, the greater the risk perception.
H3	The stronger the trust in society, the lower the risk perception of triploid food.
H4	The higher the attention to food safety, the greater the risk perception of triploid food.

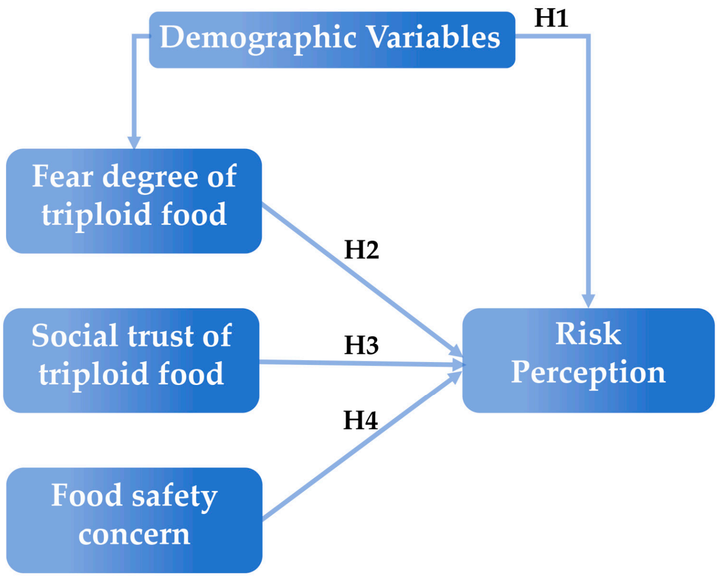

Figure 2. Schematic Diagram of Research Framework.

2.3. Questionnaire Design

This questionnaire is divided into the following two parts:

First of all, based on the existing research [43–46], demographic characteristics are recognized as one of the primary factors influencing consumers' perception of new food risks. For instance, differences in demographic variables such as age, sex, and employment can lead consumers to hold different views on food safety concerns, food additives, regulatory efforts, special labeling, and environmental pollution. Therefore, the first part is a sample collection of demographic variables, as shown in Table 2, including sex, age, education level, employment, and place of residence.

Table 2. Sample Collection of Demographic Variables.

Question	Option
Sex (SEX)	1. Male 2. Female
Age (AGE)	1. 0–14 years old (inclusive): juvenile population 2. 15–64 years old (inclusive): young and middle-aged population 3. 65 years old and above: elderly population
Education Level (EDU)	1. Primary school 2. Junior school 3. High school (including technical secondary school) 4. University (referring to junior college or above)
Employment (EMP)	1. Students (refers to being educated, learning knowledge, and skills in school) 2. Farmers (refers to the work engaged in agricultural production, responsible for planting crops, raising livestock, fishery breeding, or forestry-related work) 3. Public institution personnel or enterprise personnel (refers to work in government agencies, public institutions, or enterprise organizations, engaged in administrative management, technology research and development, sales services, financial management, and other work) 4. Free profession or other (refers to not being employed by a specific employer but being free to engage in work or business)
Place of Residence (PLA)	1. First-tier and new first-tier cities 2. Second and third-tier cities 3. Other cities 4. Villages and towns

Secondly, drawing from relevant research on consumers' risk perception of new technologies applied to food [47–54], this survey analyzed the influencing factors of risk perception regarding triploid food from a psychological perspective. These factors include consumers' risk perception of triploid food, degree of fear, social trust, and food safety concern. Consumers' risk perception of triploid foods encompasses their perception of potential health risks, environmental impacts, and food safety issues. The level of fear refers to the emotional response of consumers to risks associated with triploid food, including the degree of anxiety or fear of potential hazards. Social trust includes consumers' trust in food production and supervision institutions, government, and industry. Food safety concern refers to consumers' general concern about food safety issues, including concerns about food quality, the use of additives, food labeling, and production processes. Therefore, the second part designed a scale for consumers' risk perception of triploid food and its influencing factors, as shown in Table 3. This part is assigned in the form of a five-point Likert scale [55,56].

Table 3. Investigation into Risk Perception of Triploid Food.

Latent Variables	Observed Variables
Consumers' risk perception of triploid food (RP)	Eating triploid food may cause allergic reactions or potential hazards such as certain toxins in its own breeding technology, which will affect human health (RP1).
	Compared with traditional food, the nutritional value of triploid food is lower (RP2). Breeding technology of triploid food will have a negative impact on the agricultural system (RP3).
Fear degree of triploid food (FD)	I am skeptical about the production technology of triploid food (FD1). I am concerned about the potential harm of consuming triploid food (FD2). Since triploid food is not a natural product, I am hesitant to eat it (FD3).

Table 3. *Cont.*

Latent Variables	Observed Variables
Social trust of triploid food (ST)	I don't believe that the government will strictly supervise triploid food technology. (ST1). I don't believe that triploid food enterprises strictly implement relevant policies and regulations (ST2). I don't think the relevant reported information is true and accurate (ST3).
Food safety concern (SC)	When I buy food at ordinary times, I pay great attention to additives in food (SC1). When buying food, I will pay attention to and check the ingredients and food labels (SC2). I will pay more attention to related reports on food safety in my daily life (SC3).

Options: (totally disagree) 1, 2, 3, 4, and 5 (totally agree).

2.4. Sampling Methods

Before the formal release of the questionnaire, we randomly selected sample populations for different demographic variable characteristics to fill out the questionnaire to evaluate the intelligibility and effectiveness of the questionnaire and make the necessary modifications and improvements based on their feedback. In addition, we validated the scientific rigor and applicability of the questionnaire by consulting experts in relevant fields. Finally, we collected a total of 375 questionnaires, of which 353 were valid, and the recovery efficiency was 94.13%.

In order to mitigate selection bias and safeguard respondent privacy, the questionnaire was distributed randomly through online and offline channels. The survey was conducted anonymously by means of online questionnaire submission and face-to-face interviews. For online submission, each user can only complete the questionnaire once to prevent repeated multiple filling. The offline survey is manually entered by the staff to ensure the accuracy of the data. The sampling flow chart is depicted in Figure 3.

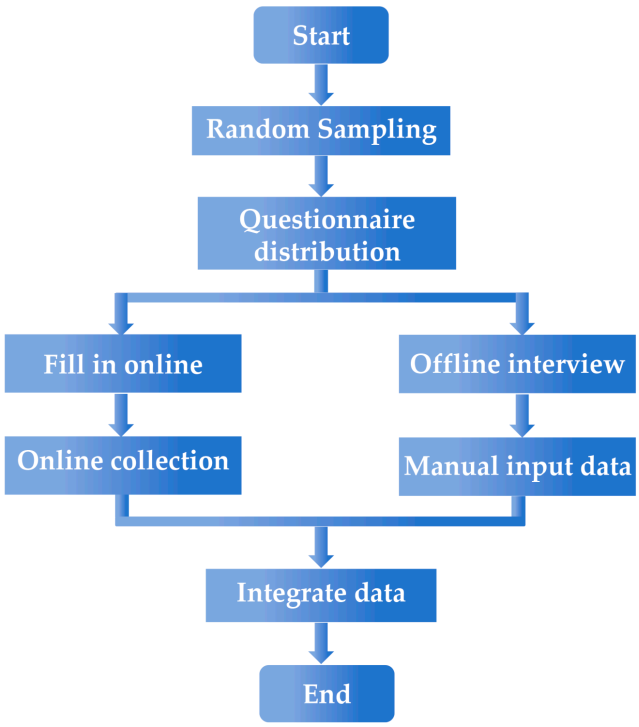

Figure 3. Sampling Flow Chart.

2.5. Sample Description

In this questionnaire survey, the total number of valid samples was 353. The specific distribution of samples is shown in Table 4. The sex distribution is 51.84% male and 48.16% female, indicating a relatively balanced gender ratio, which is basically in line with the national gender ratio. Regarding age distribution, 5.95% were aged 0–14 years, 64.87% were aged 15–64 years, and 29.18% were over 65 years old. In view of the fact that most consumers belong to the young and middle-aged group aged 15–64, this age group accounts for a large proportion of our sample. Furthermore, the distribution of respondents' education level, occupation, and residence covers a wide range of scenarios, ensuring comprehensive coverage across various demographics.

Table 4. Statistical Table of Demographic Variables (N = 353).

Variable	Description	Frequency	Proportion
Sex (SEX)	Male	183	51.84%
	Female	170	48.16%
Age (AGE)	0–14 years old	21	5.95%
	15–64 years old (inclusive)	229	64.87%
	65 years old and above	103	29.18%
Education Level (EDU)	Primary school	28	7.93%
	Junior school	85	24.08%
	High school	149	42.21%
	University	91	25.78%
Employment (EMP)	Students	60	17.00%
	Farmers	119	33.71%
	Public institution personnel or enterprise personnel	84	23.80%
	Free profession or other	90	25.50%
Place of Residence (PLA)	First-tier and new first-tier cities	34	9.63%
	Second- and third-tier cities	62	17.56%
	Other cities	134	37.96%
	Villages and towns	123	34.84%

2.6. Statistical Analysis Methods

Analysis of variance (ANOVA) [57] is a statistical test used to detect the difference in the mean of the test group when there is a parameter-dependent variable and one or more independent variables. Common analysis of variance includes one-way analysis of variance, two-way analysis of variance, multi-factor analysis of variance, and covariance analysis, and analysis of variance is usually followed by multiple comparisons to determine which group means are different from each other. The basic hypothesis of variance analysis needs to pass the normality test and the homogeneity of variance test, but in practical applications, if the sample size is large enough and the number of subjects in each group is equal, it is usually not strictly required.

Structural equation model (SEM) [58,59] is a comprehensive statistical modeling tool for analyzing multivariate data analysis of complex relationships between structures and indicators, including measurement models and structural models. Factor analysis is a technique that assumes that the correlation between a set of observed variables can be modeled by a set of smaller unobserved or latent variables (called factors), which is divided into two forms: exploratory and confirmatory [60]. Since this study has designed a mature scale based on relevant literature when designing the questionnaire and constructed the basis of the theoretical model, the confirmatory factor analysis method was selected [61]. The confirmatory factor analysis (CFA) model can be directly incorporated into the general structural equation model (SEM) [62]. By evaluating the degree of fit between the specific model and the data and estimating the factor load, the variance and covariance of the factor, and the residual variance of the observed variables [60], the relationship between a factor and the corresponding measure can be tested to determine whether the relationship between the items conforms to the theoretical relationship designed by the researchers, and the structural validity of the scale can be more effectively tested. The structural equation model (SEM) allows potential variables to draw paths between them through their influence on observable variables [61].

To sum up, it can be summarized in the following Table 5.

Table 5. Statistical Analysis Methods.

Description	Analysis of Variance	Structural Equation Model
Concept	A method for studying the relationship between one or more categorical independent variables and a numerical dependent variable.	Multivariate data analysis for analyzing complex relationships between structures and indicators, including measurement models and structural models.
Model Construction	Determine the research question. Collect data. Choose the appropriate analysis of the variance method. Set assumptions. Conduct variance analysis. Interpretation of the results.	Assume theoretical model. Build SEM model. Evaluation model and data fitting. Correct the theoretical model.
Application Aims	Based on the comparison of sample mean and variance, determine whether there is a significant difference in the overall mean. This paper is used to explore the difference in consumers' demographic variables in their risk perception of triploid food.	It is used to explore and verify the complex relationship between variables and provides a flexible method to analyze multivariate data. This paper is used to analyze the comprehensive influence of consumers' fear of triploid food, social trust, and food safety concern on risk perception.

3. Results

3.1. Descriptive Statistics

Firstly, the five-point Likert scale was used to assign the observed variables that affect consumers' risk perception of triploid food, and the assignment scores were 1, 2, 3, 4, and 5 points, respectively. Then, descriptive statistics were made on the maximum, mean, standard deviation, and variance of the observed variables. The specific results are shown in the following Table 6.

Table 6. Descriptive Statistical Analysis Results.

Latent Variables	Observed Variables	Maximum Value	Minimum Value	Average Value (AV)	Standard Deviation (SD)	Variance (V)
RP	RP1	5	1	3.011	0.872	0.761
	RP2	5	1	3.023	0.67	0.448
	RP3	5	1	2.898	0.927	0.859
FD	FD1	5	1	3.091	0.922	0.85
	FD2	5	1	3.082	0.909	0.826
	FD3	5	1	3.079	0.904	0.818
ST	ST1	5	1	2.875	0.867	0.751
	ST2	5	1	2.994	0.905	0.818
	ST3	5	1	2.983	0.859	0.738
SC	SC1	5	1	2.921	0.904	0.818
	SC2	5	1	2.895	0.916	0.838
	SC3	5	1	2.932	0.933	0.87

3.2. Reliability Analysis and Validity Analysis

For the scale sample in the questionnaire, it is necessary to test its reliability and validity to ensure that the sample is reliable and the design of the questionnaire topic is reasonable. Reliability measures consistency and validity measures accuracy [63]. In this paper, the Cronbach α coefficient is used to test the reliability of the scale, and the reliability coefficient is 0.931 (Table 7), exceeding 0.9, so the reliability of the research data is very good. And even if any items are deleted, the reliability coefficient will not be significantly improved, which indicates that deleting items has no significant effect on the reliability coefficient. In addition, the CITC values of all the analyzed items are greater than 0.5, which means that there is a strong correlation between the analyzed items, which proves once again that the reliability level is high and the internal consistency is good. The validity of the scale is evaluated by the KMO and Bartlett spherical test (Table 8), and the KMO value is 0.927, which shows that the evaluation scale has good validity and is suitable for factor analysis. Therefore, this research scale passed the reliability and validity test.

Table 7. Cronbach Reliability Analysis.

Latent Variables	Observed Variables	Corrected Item-Total Correlation (CITC)	Cronbach's α If Item Deleted	Cronbach's α Coefficient
RP	RP1	0.863	0.919	0.931
	RP2	0.568	0.93	
	RP3	0.649	0.927	
FD	FD1	0.793	0.921	
	FD2	0.739	0.924	
	FD3	0.778	0.922	
ST	ST1	0.674	0.926	
	ST2	0.646	0.927	
	ST3	0.659	0.927	
SC	SC1	0.666	0.927	
	SC2	0.704	0.925	
	SC3	0.67	0.927	

Table 8. Inspection of KMO and Bartlett Test.

KMO	Bartlett Test		
	Approx. Chi-Squared	df	p Value
0.927	2903.524	66	<0.0001

In this study, a multi-dimensional discussion was combined with existing related research, and each dimension was further refined to make the designed questionnaire more comprehensive. Although the reliability and validity both exceeded the high level of 0.9, through further analysis, it can be found that this may be because the cognitive level of most respondents with the same demographic characteristics is similar. Therefore, the data collected by this questionnaire are effective, reliable, and interpretable in practical application and can be further analyzed.

3.3. Analysis of Variance

In order to facilitate the further analysis of variance on the characteristics of demographic variables, the score of the potential variable RP is calculated by the standardized load coefficient in the factor analysis. The calculation formula is as follows, and the specific values of the observed variables are (X1, X2, X3).

$$\text{RP\_Score} = 0.923 \times \text{X1} + 0.645 \times \text{X2} + 0.65 \times \text{X3} \quad (1)$$

Sex, age, education level, employment, and place of residence were used as independent variables, and a one-way analysis of variance was performed on risk perception. The results of the analysis of variance are shown in Table 9. Table 10 shows the results of multiple comparisons between variables with significant differences in the analysis of variance.

Table 9. Results of Variance Analysis.

Variable	Variable Value	Mean Value	Standard Deviation	F	*p*
SEX	Male	6.705	1.559	1.352	0.246
	Female	6.513	1.534		
AGE	0–14 years old	5.165	1.455	39.588	0.000 ***
	15–64 years old	6.321	1.216		
	65 years old and above	7.557	1.737		
EDU	Primary school	8.537	1.99	41.92	0.000 ***
	Junior school	7.185	1.619		
	High school	6.535	0.857		
	University	5.613	1.43		
EMP	Students	5.793	1.388	22.418	0.000 ***
	Farmers	6.153	1.375		
	Public institution personnel or enterprise personnel	6.977	1.318		
	Free profession or other	7.426	1.592		
PLA	First-tier and New First-tier Cities	7.104	2.152	6.801	0.000 ***
	Second and Third Tier Cities	6.737	1.939		
	Other Cities	6.872	1.18		
	Villages and Towns	6.132	1.37		

*** represent the significance levels of 1%.

Table 10. Multiple Comparisons.

	(I) Name	(J) Name	Difference (I-J)	*p*
AGE	0–14 years old	15–64 years old	−1.156	0.001 ***
	0–14 years old	65 years old and above	−2.393	0.000 ***
	15–64 years old	65 years old and above	−1.237	0.000 ***
EDU	Primary school	Junior school	1.352	0.000 ***
	Primary school	High school	2.001	0.000 ***
	Primary school	University	2.924	−0.000 ***
	Junior school	High school	0.649	0.002 ***
	Junior school	University	1.571	0.000 ***
	High school	University	0.922	0.000 ***
EMP	Students	Farmers	−0.361	0.380
	Students	Public institution personnel or enterprise personnel	−1.184	0.000 ***
	Students	Free profession or other	−1.634	0.000 ***
	Farmers	Public institution personnel or enterprise personnel	−0.824	0.000 ***
	Farmers	Free profession or other	−1.273	0.000 ***
	Public institution personnel or enterprise personnel	Free profession or other	−0.449	0.162
PLA	First-tier and new first-tier cities	Second- and third-tier cities	0.367	0.667
	First-tier and new first-tier cities	Other cities	0.232	0.854
	First-tier and new first-tier cities	Villages and towns	0.972	0.005 ***
	Second- and third-tier cities	Other cities	−0.134	0.939
	Second- and third-tier cities	Villages and towns	0.605	0.051 *
	Other cities	Villages and towns	0.739	0.001 ***

*** and * represent the significance levels of 1% and 10%, respectively.

3.4. Structural Equation Model

In this paper, AMOS 26.0 is used to model the first-order confirmatory factor analysis of the sample data and analyze whether it is reasonable. In the measurement model, the relationship between the observed variables and the latent variables is tested by the standardized load coefficient. The large load coefficient indicates that the correlation between the two is stronger. The factor load coefficient table (Table 11) shows that the p value between all observed variables and latent variables is less than 0.05, the result is significant, and the standardized load coefficient values are all greater than 0.6, which indicates that the measured variables meet the factor requirements, and it has enough of a variance interpretation rate to show that each variable can be displayed on the same factor, that is, there is a strong correlation between the observed variables and the latent variables.

Table 11. Factor Load Coefficient Table.

	Variable	Unstandardized Factor Loading	Standardized Factor Loading	z	S.E.	p
RP	RP1	1	0.923	-	-	-
	RP2	0.536	0.645	14.127	0.038	0.000 ***
	RP3	0.748	0.65	14.307	0.052	0.000 ***
FD	FD1	1	0.899	-	-	-
	FD2	0.899	0.82	20.455	0.044	0.000 ***
	FD3	0.946	0.866	22.714	0.042	0.000 ***
ST	ST1	1	0.831	-	-	-
	ST2	0.987	0.786	16.153	0.061	0.000 ***
	ST3	0.974	0.817	16.906	0.058	0.000 ***
SC	SC1	1	0.856	-	-	-
	SC2	0.99	0.837	18.441	0.054	0.000 ***
	SC3	0.956	0.793	17.169	0.056	0.000 ***

*** represents a significance level of 1%.

The model evaluation in Table 12 shows the results of model AVE and CR indicators. Average variance extracted (AVE) is a statistic to test the internal consistency of structural variables in statistics, and construct reliability (CR) is structural reliability, which reflects whether all items in each latent variable consistently explain the latent variable. In general, an AVE higher than 0.5 or CR higher than 0.7 indicates higher convergent validity. Therefore, the extraction degree of the measurement indexes in the factors of this study is excellent.

Table 12. Model Evaluation.

Factor	AVE Value	CR Value
RP	0.579	0.795
FD	0.744	0.897
ST	0.657	0.852
SC	0.686	0.868

In the process of model fitting, it is necessary to evaluate the fitting indexes. The commonly used indexes include the chi-squared freedom ratio, goodness of fit index (GFI), root-mean-square error of approximation (RMSEA), root-mean-square error (RMR), comparative fit index (CFI), normed fit index (NFI), and non-normed fit index (NNFI). The results in Table 13 show that χ^2/df = 2.458, GFI = 0.96, RMSEA = 0.064, RMR = 0.024, CFI = 0.976, NFI = 0.96, and NNFI = 0.967 in the confirmatory factor analysis fitting index. The values of each index have passed the test, and the model data are well fitted and can be effectively verified [64–66].

Table 13. Model Fitting Index.

Index	χ^2/df	GFI	RMSEA	RMR	CFI	NFI	NNFI
Criterion	<3	>0.9	<0.10	<0.05	>0.9	>0.9	>0.9
Value	2.458	0.96	0.064	0.024	0.976	0.96	0.967

Moreover, according to the covariance analysis table of pairwise pairing between factors, the correlation between factors can be analyzed by standard coefficients. The results of the factor covariance analysis are shown in Table 14, and it can be found that there is also a strong correlation between the factors.

Table 14. Factor Covariance Table.

Factor A	Factor B	Non-Standard Estimation Coefficients	Standard Error	Standard Estimated Coefficient	z	*p*
RP	**FD**	0.6	0.053	0.901	11.329	0.000 ***
RP	**ST**	0.483	0.047	0.836	10.327	0.000 ***
RP	**SC**	0.5	0.049	0.804	10.273	0.000 ***
FD	**ST**	0.43	0.046	0.722	9.388	0.000 ***
FD	**SC**	0.481	0.049	0.752	9.78	0.000 ***
ST	**SC**	0.319	0.041	0.573	7.843	0.000 ***

*** represents a significance level of 1%.

Through the above confirmatory factor analysis, the overall goodness of fit test of the model was passed, and the standard of the marked load coefficient was met. The structural equation model can be further constructed to test the path coefficient between the latent variables. From the model path coefficient table (Table 15), it can be seen that the *p* value of all path significance is 0.000 ***, which is significant at the level, and the path is effective, indicating that there is an influence relationship between variables. The influence efficiency can be analyzed in depth through standardized path coefficients. In addition, the results of covariance analysis (Table 16) show that the covariance relationship between FD and ST, FD and SC, and ST and SC is significant, there is a certain correlation, and the higher the standard estimation coefficient between the two factors, the stronger the correlation.

Table 15. Model Regression Coefficient Table.

Factor (Latent Variable)	→	Analysis Item (Explicit Variable)	Non-Normalized Coefficients	Standardized Coefficient	Standard Error	z	*p*
FD	→	**RP**	0.423	0.435	0.064	6.652	0.000 ***
ST	→	**RP**	0.413	0.37	0.058	7.165	0.000 ***
SC	→	**RP**	0.276	0.266	0.055	5.028	0.000 ***

*** represents a significance level of 1%.

Table 16. Path Node Covariance Relationship Table.

Factor (Latent Variable)	↔	Analysis Item (Explicit Variable)	Non-Normalized Coefficients	Standardized Coefficient	Standard Error	z	*p*
FD	↔	**ST**	0.43	0.722	0.046	9.388	0
FD	↔	**SC**	0.48	0.752	0.049	9.778	0
ST	↔	**SC**	0.319	0.573	0.041	7.843	$4.440892098500626 \times 10^{-15}$

Based on the above analysis, the structural equation model of the influencing factors of consumers' risk perception of triploid food was well verified. The weighted structural equation model path diagram is as follows (Figure 4):

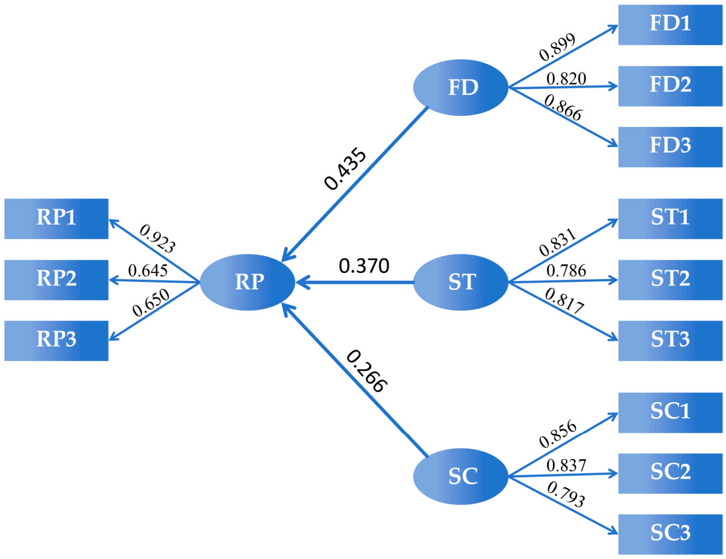

Figure 4. Structural Equation Model Path Diagram.

In order to further optimize the model and reduce possible deviations, some demographic statistical variables with significant differences found in variance analysis were added to the model as control variables. The analysis results are as follows (Figure 5, Table 17):

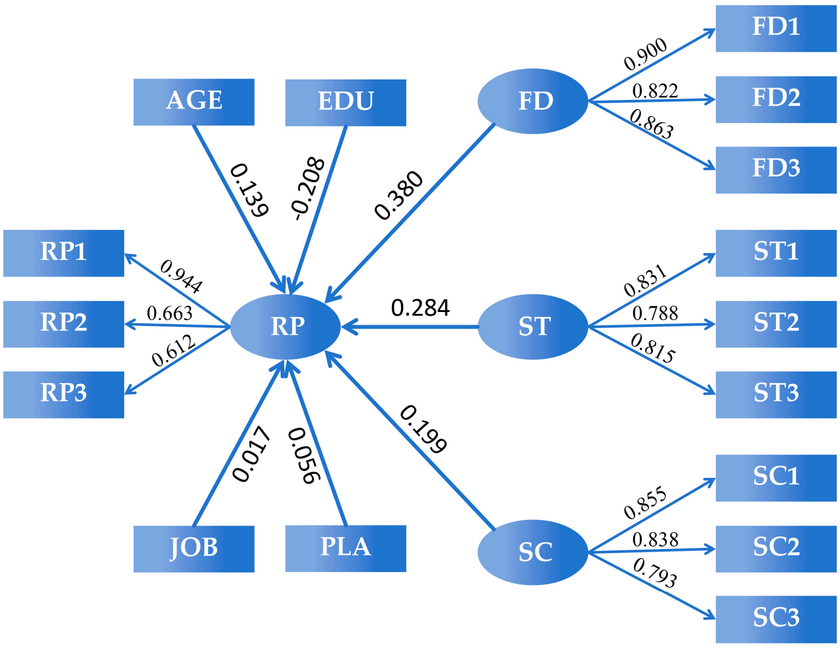

Figure 5. Improved Structural Equation Model Path Diagram.

Table 17. Improved Model Fitting Index.

Index	χ^2/df	**GFI**	**RMSEA**	**RMR**	**CFI**	**NFI**	**NNFI**
Criterion	<3	>0.9	<0.10	<0.05	>0.9	>0.9	>0.9
Value	2.222	0.943	0.059	0.028	0.970	0.947	0.970

4. Discussion

4.1. Analysis of the Descriptive Statistics

From the survey results, it is evident that consumers hold a generally high level of risk perception regarding triploid food. In terms of risk perception, the mean and standard deviation of RP1 are A = 3.011 and SD = 0.872; the mean and standard deviation of RP2 are A = 3.023 and SD = 0.67; the mean and standard deviation of RP3 are A = 2.898 and SD = 0.927. This indicates that respondents' concerns about triploid food mainly revolve around health risks, with relatively lower perceptions of ecological risks. They were more consistent and almost neutral in their fear of triploid foods, probably because they lacked sufficient information or understanding to make clear judgments and attitudes. In terms of social trust, consumers exhibit less confidence in enterprises' strict adherence to relevant policies and regulations, which indicates the need to further strengthen the regulatory policies and industry standards of relevant enterprises. Concerning food safety, consumers express heightened apprehension about reports related to food safety. This suggests that consumers' risk perception is largely affected by the availability of information, and they may be more inclined to choose trustworthy food brands or products. Therefore, media outlets should strive for more objective reporting on food safety issues, aiming to furnish consumers with reliable and accurate information while avoiding sensationalism to prevent undue panic.

4.2. Analysis of the Influencing Factors of Demographic Variables on Risk Cognition

Based on the results of single-factor analysis of variance and multiple comparisons, the analysis of variance of specific demographic variables and risk perception is as follows:

(1) Sex

Most studies [67–71] suggest that women may express greater concern about food safety issues, possibly due to their traditional role in the family, where they typically bear more responsibility for food shopping and preparation. In addition, women may show a higher level of fear in psychological characteristics, making them more sensitive to potential food risks. However, this study found that there was no significant difference in consumers' perception of triploid food risk between genders. This could be attributed to the evolving roles of men and women in modern society, where they assume more diverse responsibilities both at home and in the workplace. Women are gradually entering the workplace, and the responsibilities of men and women in family affairs are more equally shared. It is essential to note that individual food risk perception is a multifaceted phenomenon shaped by numerous factors, and gender is not the exclusive or primary determinant.

(2) Age

There are significant differences in the risk perception of triploid food among consumers of different age groups. Previous studies [72–76] have found that age is a crucial factor influencing consumers' perceptions of food safety and risk. Older individuals tend to exhibit heightened concern regarding food safety issues, likely due to their increased focus on health-related foods and heightened sensitivity to health risks associated with food. Additionally, their limited understanding of digital technology may make them suffer from the digital divide, which may lead them to rely more on traditional information channels such as television, newspapers, and radio. This preference for traditional channels may restrict their access to information. The combination of these factors leads to a higher level of risk perception of triploid foods among the elderly.

(3) Education Level

Consumers with lower levels of education tend to exhibit significantly higher risk perceptions of triploid foods compared to those with higher levels of education. In the group with a lower education level, the understanding of genetically modified food may be relatively less comprehensive and profound than that of the highly educated group. Individuals with lower levels of education lack a thorough comprehension of triploid technology, resulting in an inadequate scientific foundation for assessing food risks. This deficiency contributes to heightened misunderstandings of potential risks and magnifies the perception of risk associated with triploid food. Our results are consistent with the existing research results [75–77], further emphasizing how differences in educational attainment can engender cognitive dissonance in food risk perception.

(4) Employment

Students typically exhibit the lowest risk perception regarding triploid food. On the one hand, students are good at collecting information related to triploid food by using the Internet. On the other hand, the school curriculum is comprehensive, providing students with relevant knowledge of the principle of triploid food. Secondly, growers view triploid crops favorably due to their superior characteristics and potential for greater benefits, making it relatively easier for farmers to embrace triploid foods. Professionals in public institutions and enterprises may prioritize life and health concerns due to the nature of their work. Freelancers, unlike traditional office workers who rely on company-provided food services, are more concerned about the source and safety of their food. They often purchase ingredients and pay close attention to their familys' health, rendering them more sensitive to food safety risks [35,77].

(5) Place of residence

The perception of triploid food risk varies among residents in different regions, likely influenced by a multitude of factors. These differences may be partially attributed to variations in residents' education levels and access to information channels. Several studies indicate that urban residents tend to have a higher risk perception of food [35,78,79]. Consumers residing in urban areas often possess higher levels of education and have access to a wider array of information sources. Consequently, they are more likely to access richer and more comprehensive food safety information, thereby enhancing their awareness of the risks associated with triploid foods. Conversely, in rural areas, residents tend to exhibit lower levels of risk awareness regarding triploid food. This can be attributed to factors such as lower economic status, limited access to information, and inadequate attention to food safety issues. In some rural regions, residents may prioritize economic benefits over food safety concerns. Additionally, many rural residents may have farming experience or may be directly involved in food production, which can lead to a diminished perception of food risks.

4.3. Analysis of Multi-dimensional Influencing Factors of Risk Cognition

Within the structural equation model, the path coefficients between the variables all pass the significance test, indicating that consumers' risk perception of triploid food has a certain relationship with the degree of fear of triploid food, social trust, and food safety concern. The specific relationship is as follows:

(1) The stronger the consumers' psychological fear of triploid food, the greater the risk perception.

The path coefficient between consumers' psychological fear of triploid food and risk perception of triploid food is 0.435. Previous studies [80–83] have demonstrated that psychological factors influence consumers' risk perception, and consumers' emotions significantly impact their perception and attitudes toward food. Therefore, these findings further reinforce the conclusions of earlier research, suggesting that consumers' psychological fear of triploid food may heighten their risk perception, subsequently influencing their attitudes and behaviors toward such food. On the one hand, when consumers lack sufficient understanding of the production process and other information about triploid foods, they may instinctively magnify the uncertainties associated with triploid foods, leading to more negative judgments and inclinations. On the other hand, individuals' emotional responses and psychological effects can further intensify the perception of potential risks. If consumers develop a negative impression upon exposure to triploid foods, this impression may overshadow their perception, resulting in excessive concern about risks. Emotional uneasiness and fear may make individuals more inclined to accept negative information, thus strengthening the negative perception of food, which in turn leads to the enhancement of risk perception.

(2) The more consumers trust the government, enterprises, and other relevant departments, the lower the risk perception of triploid food.

The path coefficient of consumers' social trust and triploid food risk perception is 0.370. Previous studies [50,84–86] have found that consumers' trust in government, enterprises, and other relevant departments is closely associated with their perception and attitude toward food safety. The governments' supervision of food processing, transportation, sales, and packaging, as well as corresponding laws, regulations, and publicity, will change consumers' wishes. If consumers have confidence in the regulatory system of the government and relevant entities and believe in their ability to effectively supervise the food industry and ensure product safety and compliance, they may be more inclined to trust that the production and sale of triploid foods are properly regulated. Moreover, if enterprises strictly follow and implement food safety regulations and standards, and the government effectively supervises them and punishes non-compliance behaviors, this will further enhance consumers' trust in products and reduce concerns about potential risks. In addition, the past experience of governments and enterprises in successfully dealing with food safety issues, as well as the ability to effectively respond to crises, may also increase public trust in them, thereby reducing the perception of food risks.

(3) The higher the consumers' attention to food safety, the greater the risk perception.

The path coefficient of consumers' attention to food safety and risk perception of triploid food is 0.266. Nowadays, food safety issues are widely discussed on social media platforms. In particular, consumers who are highly concerned about food safety tend to pay attention to and trust media reports and related information. Related research [52,87–89] has also found that social media attention has a great impact on the publics' perception of food safety risks. For example, food safety incidents such as product recalls and food pollution may arouse the vigilance of consumers who are highly concerned about food safety. The rapid spread of social media information may exaggerate or emphasize some food safety risks, make consumers more exposed to negative information, and increase risk perception.

5. Conclusions

In this study, consumers' risk perception of triploid food was studied in many dimensions. The results show the following:

Consumers primarily focus on health concerns when considering the risks associated with triploid foods, with relatively less attention given to their ecological implications. Their fear of triploid foods remains relatively stable and neutral. Concerning social trust, consumers often exhibit skepticism regarding the effective enforcement of regulations and the accuracy of information provided. Moreover, consumers tend to express heightened apprehension regarding reports related to food safety. This collective perception underscores the intricate interplay between individuals' health concerns, trust in regulatory systems, and attention to food safety information.

Through analysis of variance and multiple comparisons, it was found that consumers' risk perception of triploid food is significantly different under different demographic characteristics (age, education level, place of residence, and employment). Through the structural equation model, confirmatory factor analysis, standard load analysis, and path test analysis, the results show that consumers' fear of triploid food, social trust, and food safety concerns play an important role in the whole process of food risk perception. Specifically, we find that the higher the consumers' fear of triploid food, the lower their social trust, and the higher their attention to food safety, resulting in an increase in their perceived risk level. This conclusion highlights the combined effects of personal emotions, social trust, and food safety concerns on food risk perception.

6. Suggestions

Through the above research conclusions, some suggestions are given as follows:

1. Strengthen government supervision of triploid food and formulate relevant policies.

The government should implement strict supervision measures and establish a perfect supervision system to ensure comprehensive and effective safety evaluation and product quality supervision of triploid technology. Formulate clear policies and regulations and conduct regular spot checks on triploid foods on the market based on scientific evidence to ensure the safety, feasibility, and sustainability of new food technologies and protect consumers' rights and interests. This also encourages close cooperation and exchanges between enterprises, scientific research institutions, and government departments, strengthens the ability of technological innovation and popularization, and promotes the food industry to make greater progress in scientific and technological innovation.

2. Organize knowledge popularization activities about triploid and raise consumers' awareness.

Conducting specialized lectures and seminars can significantly enhance consumer awareness. These events, strategically organized in schools, research institutions, enterprises, and communities, serve to captivate the publics' interest, encouraging active participation and addressing their concerns. Furthermore, using social media platforms is an efficient way to spread information. Specialized social media can regularly publish popular science articles, videos, and pictures about triploid food. By interacting with the public, answering their questions, and explaining related concepts, the publics' cognition and understanding of triploid food can be improved. It is worth noting that special educational activities can be carried out in community centers and other places for the elderly over 65 who rarely use the Internet to popularize knowledge about triploid food.

3. Enhance the transparency of triploid technology and mobilize consumers' rational judgment.

A special organization or department can be set up to be responsible for the information transparency of the new technology of triploid food, to provide consumers with scientific, objective, and comprehensive information, and to improve consumers' knowledge and understanding of the new food technology. This institution can be responsible for collecting, sorting out, and publishing information such as scientific research results, safety assessment reports, and regulatory policies related to triploid technology. By establishing a unified information platform, consumers can easily obtain the latest and most reliable information so as to better understand and evaluate the advantages and risks of new food technologies. Through the open and transparent regulatory and assessment results, consumers can better understand and evaluate the advantages and risks of triploid food technology, reduce unnecessary panic and misunderstanding so as to mobilize consumers' rational judgment, improve risk awareness, and encourage innovation and research and development of triploid food technology.

7. Prospect

With the development of the social economy, the influence of demographic variables on the risk perception of triploid food may change, so it is necessary to further analyze it. In future research, the role of demographic variables in food risk perception can be re-examined to understand their changing trends in different social contexts. Such in-depth analysis is expected to reveal the dynamic impact of socio-economic factors on consumers' risk perception of triploid food.

Furthermore, a limited number of variables of different dimensions were selected in this study, and all possible influencing factors could not be included, which has certain limitations in the selection of variable dimensions. In future research, we can consider expanding the research field and introducing more multi-dimensional variables to more comprehensively understand consumers' perceptions of triploid food risks. This expansion can make the research results more detailed, comprehensive, and convincing.

In addition, according to the actual situation of consumers, we can further expand the research on the influencing factors of triploid food risk perception and set more scientific and reasonable observation variables. Through in-depth exploration of consumers' needs, attitudes, and behaviors, we can better understand their perception of triploid foods and thus more accurately characterize the key factors affecting risk perception.

Finally, in order to better guide consumers' cognition of triploid food, relevant management suggestions can be further improved. At the institutional level, a sounder regulatory system can be established to ensure that the production and sales of triploid foods meet safety standards. In terms of risk management mechanisms, the transmission of food safety information can be strengthened to improve the publics' understanding of triploid food. These measures should be closely combined with consumers' risk perception to promote the further optimization of food safety management.

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