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# Research Status and Development of Food Safety Based on Social Network[1]

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**Abstract.** This study aimed to screen periodical studies in the CNKI database from 2003 to 2019 and draw visualization maps using UCINET, NetDraw, and CiteSpace software to analyze the research hotspots, cohesive subgroups, and network structure characteristics to accurately examine the research status and development trend of food safety behavior in China's food enterprises. The study revealed that the research on food safety behavior of the food enterprises in China mainly centered on seven parameters, including "traceability management," "cause of behavior formation," and "government supervision." It showed the characteristics of a concentrated focus, diversified behavior subjects, unsystematic external measures, little summary and research, and unclear interest coordination. The study trend was toward the kernelization of actors, the concretization of behavior objects, and the diversification of behavioral governance. Therefore, the emphasis was placed on strengthening the extent of research on internal management and external environment optimization of enterprises, further studying the science and technology of the food industry, and promoting the realization of social co-governance, thus promoting the research.

**Keywords.** Food enterprises; food safety behavior; research status; social network analysis; trend of development

## 1. Introduction

"Food is the basis of the people, security is the basis of the food." Food safety is related not only to people's lives and health but also to the development of the nation. The food enterprise must be responsible for its behavior as the direct food supplier. Therefore, in 2019, the Food Safety Commission of the State Council of China emphasized that food enterprises were the first stakeholders in food safety. They should control and prevent food safety risks from the source to ensure people's "bite of safety." In this situation, scholars have analyzed food safety behavior from different perspectives, such as the formulation of food safety laws from the country perspective [1][2], collaborative governance from the social perspective [3][4], industry self-discipline from the enterprise perspective [5], and food safety satisfaction from the consumer perspective [6][7][8] Relevant research has been intensified, providing experience and reference for the sustainable development of the Chinese food industry. However, the current relevant

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research results are dispersed to a high degree and lack systematic and comprehensive analysis. Studies have been conducted to summarize the current research status of food safety; however, they are limited to the characteristics of the literature itself, such as the concentrated research objects of the current literature, the fund support of the literature, and the impact factors of the literature. They do little to improve actual food safety. [9][10]11] Therefore, this study used a combination of quantitative and qualitative methods, such as literature metrology, social network analysis, and keyword co-occurrence analysis, with the aid of UCINET and CiteSpace software, to track research outputs about the food safety behavior of food enterprises. We reviewed the newest related studies, providing a basis for the research direction and putting forward practical suggestions for food enterprises to adopt positive food safety behavior.

## 2. Materials and Methods

### *2.1. Data source*

This study used CNKI as the source of statistical analysis to conduct advanced journal retrieval, ensuring that the sample size was expanded and the selected samples could fully reflect the research status of "food safety behavior of food enterprises." The keywords provided highly condensed results in the literature search; hence, we used the keyword "food safety behavior" with the publication time between January 1, 2003, and June 30, 2019. This search resulted in the retrieval of 1036 relevant articles. News reports, meeting notices, and other records unrelated to the food safety behavior of food enterprises were deleted after manual interpretation and data pre-processing. Finally, we retained 320 effective articles for use in this study.

### *2.2. Research methods*

This study mainly used social network visualization analysis to analyze the selected literature statistically to better understand the research status and development trend of food safety behavior in food enterprises. The social network visualization analysis involved the whole knowledge system and knowledge activities as the research object by drawing the knowledge graph and using mathematics, graphics, and data visualization to sort out the development context, hotspots, and future trends of a research field from multiple perspectives. [12]

A "social network" consists of nodes and their relationships. Keywords can be regarded as nodes in the structural network, and the direct relationship between keywords can be identified as co-occurrence between nodes. The co-occurrence phenomenon of keywords can reveal the changes in the research hotspots and structure in a specific field. This study extracted and counted the frequency of keywords in the selected literature to obtain 630 original keywords, eliminating the repeated terms, terms with no practical significance (such as case, single and plural, and abbreviation), and terms with similar meaning (such as food safety and quality safety, food enterprise and enterprise, and government regulation and regulation). A total of 33 effective keywords greater than or equal to 4 in frequency could be used. Then, BibExcel was used to construct a 33 × 33 high-frequency keyword co-occurrence matrix. The co-occurrence matrix was imported into UCINET to form a visual knowledge graph. The current research status could be comprehensively reflected using cohesive subgroup and network feature analysis. The

CONCOR method in UCINET software was used to analyze the cohesive subgroups. The operations in UCINET were as follows: Netdraw–Analytics–Subgroups–Factions. After repeated trials and factions, the fitness reached an inflection point when n=8. Hence, when eight condensed subgroups were selected, the fitness value reached the best, and nodes of the same color belonged to the same condensed subgroup. Finally, CiteSpace was used to make a more intuitive exploration of the research and development trend of the food safety behavior of Chinese food enterprises by analyzing the burst terms.

## 3. Research status of food safety behavior in Chinese food enterprises

### *3.1. Research hotspots*

A research hotspot is the focus of a particular discipline in a certain period, which is represented by the emergence of a large amount of literature and academic thoughts on a subject [13]. Table 1 shows some high-frequency keywords, which basically can reflect the research hotspot in the field of food safety behavior.

**Table 1.** High-frequency keywords in the literature search on food safety behavior of Chinese food enterprises (word frequency ≥ 4, unit: time)

| High-frequency keywords | Frequency | High-frequency keywords | Frequency |
|---|---|---|---|
| Food safety | 139 | Core enterprises | 12 |
| Food safety behavior | 87 | Evolutionary game | 12 |
| Food enterprises | 62 | Government supervision | 12 |
| Farmers | 31 | Farm products | 11 |
| Quality safety of agricultural products | 29 | Food | 10 |
| Influencing factors | 27 | Cognition | 9 |
| Food supply chain | 18 | Game | 9 |
| Enterprise social responsibility | 18 | Consumers | 8 |
| Raisers | 16 | Logit mode | 8 |
| Food safety traceability system | 15 | Supermarket | 7 |

We performed the social network visualization analysis to further analyze the relationship between keywords. As shown in Figure 1, the obtained social network visual structure map of high-frequency keywords was an undirected network graph, where square symbols represented keywords nodes and the square size represented the frequency of keywords. The line of two nodes represented the occurrence of keywords in the same study, the thickness of the line represented the frequency of occurrence, and the density of the line represented the degree of correlation between words. Nodes such as “food safety,” “food safety behavior,” “food enterprises,” and “factors” were located in the center of the network. Relatively dense connections with surrounding nodes were present, indicating that the current studies focused on the factors of food safety behavior of food enterprises.

**Figure 1.** Social network visualization structure map of high-frequency keywords.

### *3.2. Cohesive subgroup*

Cohesive subgroup analysis can accurately observe the characteristics of subgroup members to intuitively and comprehensively reflect the research status. [14] As shown in Figure 2, the nodes of the same color belonged to the same cohesive subgroup. The results were combined with the corresponding studies for in-depth analysis to accurately explore the implicit interaction relationship in the research on the food safety behavior of food enterprises. The research on "food safety behavior of food enterprises" in China could be categorized into seven groups (Table 2).

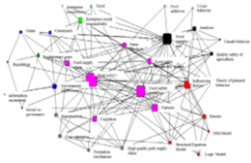

**Figure 2.** Cohesive co-occurrence map of high-frequency keywords.

**Table 2.** Classification of cohesive subgroups

| Serial number | Subgroups | Keywords |
|---|---|---|
| 1 | Traceability management | Food safety; food safety behavior; food supply chain; cognition; food safety traceability system; farmers; farm products; theory of planned behavior |
| 2 | Cause of behavior formation | Formation mechanism; high-quality pork supply chain; core enterprise; supermarket |
| 3 | Government supervision | Government supervision; consumer; game; information asymmetry |
| 4 | Enterprise behavior management | Food enterprises; analysis; quality safety of agricultural products; unsafe behavior; food additives; usage behavior |
| 5 | Factors of willingness to implement | Factors; raisers; structural equation model; logit model; interpretative structural model |
| 6 | Corporate social responsibility | Enterprise social responsibility; business management; food |
| 7 | Social supervision | Social co-governance; regulation; evolutionary game |

- Traceability management. This subgroup included keywords such as "food safety behavior," "quality and safety traceability system," and "farmers." It was

seen that the current research not only focused on the food safety control behavior of food enterprises but also paid more attention to the food safety production behavior of specific actors in each link, such as farmers and raisers. Food enterprises first started participating in information transmission traceability to ensure safe and reliable delivery. It could not only effectively solve the problem of information asymmetry in the food supply chain but also effectively reduce the cost of a food recall. [15][16] Food safety involved many links and factors, but the source was agricultural products, the foundation was agriculture, and the key was farmers. Since the 18th National Congress of the Communist Party of China, the agricultural departments across the country persistently carried out comprehensive law enforcement to ensure the quality and safety of agricultural products to control the safety risks of edible agricultural products at the source. [17] Therefore, researchers focused more on the combination of food safety behavior in food enterprises with agriculture, industrialization, and other fields.

- Causes of behavior formation. This subgroup included four keywords: "high-quality pork supply chain," "formation mechanism," "core enterprises," and "supermarkets." According to relevant statistics, 57.14% of food safety incidents from 2008 to 2017 were caused by human factors. Human factors were mostly caused by improper behavior. [6] Therefore, recent studies focused more on the formation mechanism of food safety behavior in food enterprises. The pork supply chain was the focus of current research. It was mainly because the diet structure had become more reasonable and balanced with the improvement in people's living standards. Pork has become an indispensable food in people's daily life.
- Government regulation. This subgroup included "consumers," "game," "information asymmetry," and other keywords. China's food safety supervision is in a complex environment with many uncertain factors, and each subject's behavior in the food supply chain mainly causes food safety problems. [18] The government regulation must effectively ensure check-and-balance among the stakeholders and their interests. Therefore, most studies combined the consumption behavior of consumers and adopted the evolutionary game method to study government regulation. The study of the food safety behavior of food enterprises under government regulation should not only focus on the selection rules of food safety behavior of enterprises but also on the effectiveness of the government's food safety management in "getting twice the result with half the effort."

- Enterprise behavior management. This subgroup included keywords such as "usage behavior" and "food additives." Illegal behaviors in the information asymmetry situation were the main components of enterprise behavior management research. For example, evil enterprises used the information to cheat consumers and abuse food additives. On October 1, 2015, the Food Safety Law, which is considered the strictest law ever, was revised and implemented in China. It clearly states that food producers and operators should ensure good faith management, [19] strictly control the process of production and operation, and improve the relevant food safety management system. [20] The excessive content of illegal substances caused by fake food additives was a major food

safety risk. Food additives should better reflect the efforts of food enterprises to control food safety behavior in food production and operation.

- Factors of willingness to implement. This subgroup included the "structural equation model," "logit model," "ISM model," and other keywords. It was found that most of the studies adopted quantitative research methods. Food enterprises would consider both internal and external motivations when implementing food safety behavior with the continuous improvement in consumer requirements for food quality. Therefore, the research on the willingness of food enterprises to implement food safety behavior mainly focused on implementation motivation factors. [21] The Food Safety Law clearly states that the food safety governance principle of "risk management is focused on prevention " should be upheld. The food safety incidents that have occurred are the external manifestations of the existing food safety risks. [22] It is necessary to further realize the transformation of food enterprise behavior from "post management" to "pre-prevention" mode at the source of risk by reducing the risk and taking precautionary steps.
- Corporate social responsibility. This subgroup was related to "business management," "food," and other keywords. The study of food safety behavior based on corporate social responsibility does not rely only on market regulation to ensure food safety. The motivation for changing food safety behavior mainly comes from the sense of social responsibility. It also relies on government intervention and other enforcement regulations through legislation. [23] The research on food corporate social responsibility met the needs of the development of the food industry and was also an indispensable part of building a healthy China.
- Social supervision. The research on the social supervision subgroup mainly included keywords such as "social co-governance" and "evolutionary game." The current research status reflects the increasing attention of all sectors of society to food safety issues and the change in food safety cognition. Research methods such as evolutionary games can enrich the research content of food safety behavior of food enterprises from the perspective of social co-governance. [24] At the same time, it is inevitable for the whole society to participate in supervising the food safety behavior of food enterprises, and it is also a necessary way to achieve food safety governance.

### *3.3. Network structure characteristics*

The structural characteristics of social networks can be quantitatively analyzed and studied according to the characteristic relationships between network nodes. These are generally characterized by three indexes: degree centrality, betweenness centrality, and closeness centrality. [25]

#### *3.3.1. Degree centrality*

As presented in Table 3, the degree centrality of "food safety," "food safety behavior," and "food enterprises" are at the top three positions and far more significant compared with those of other nodes, indicating that these three degree centralities were at the core

of the network and played a leading role in the overall situation. The average degree centrality was 28.970, and eight keywords were at a higher degree of centrality than the average, such as "farmers" and "raisers," indicating that the recent studies on food safety behavior of food enterprises were more focused on the agricultural field. This could also reflect the state's focus on the supervision of food enterprises.

**Table 3.** Partial data on degree centrality

| Keywords | Degree centrality | NrmDegree | Share |
|---|---|---|---|
| Food safety | 178.000 | 20.602 | 0.186 |
| Food safety behavior | 133.000 | 15.394 | 0.139 |
| Food enterprises | 94.000 | 10.880 | 0.098 |
| Farmers | 61.000 | 7.060 | 0.064 |
| Factors | 56.000 | 6.481 | 0.059 |
| Quality safety of agricultural products | 36.000 | 4.167 | 0.038 |
| Raisers | 31.000 | 3.588 | 0.032 |
| Enterprise social responsibility | 29.000 | 3.356 | 0.030 |

### *3.3.2. Betweenness centrality*

The betweenness centrality of "food safety" was the biggest at 141.495 (Table 4), indicating that the studies on food safety behaviors of food enterprises paid more attention to food safety, and "food safety" also played an important mediating role in the network. The average betweenness degree was 11.758. Five keywords were more frequent than the average. Besides the "food enterprise," the rest of the keywords belonged to subgroups 1 and 5. It illustrated that the traceability management and factors of willingness to implement were in the middle of a link to guarantee food safety, which could be used to correlate research hotspots in different regions.

**Table 4.** Partial data on betweenness centrality

| Keywords | Betweenness centrality | Degree |
|---|---|---|
| Food safety | 141.495 | 28.527 |
| Food enterprises | 78.498 | 15.826 |
| Food safety behaviors | 61.438 | 12.387 |
| Factors | 25.075 | 5.055 |
| Farmers | 21.785 | 4.392 |

### *3.3.3. Closeness centrality*

"Food safety" had the smallest closeness centrality, indicating that it was in the core position in the network (Table 5). The average closeness centrality value of all keywords was 55.515, and 12 keywords had a closeness centrality value less than 55.515, indicating that it was easily influenced and controlled by other nodes and easy to integrate with other nodes. The keywords with a lower value of closeness centrality were consistent

with the analysis results of degree centrality and betweenness centrality. These keywords were all of the high frequency (Table 1), indicating a high degree of fit between them and the frequency of the keywords.

**Table 5.** Partial data on closeness centrality

| Keywords | Farness | Closeness |
|---|---|---|
| Food safety | 35.000 | 91.429 |
| Food enterprises | 40.000 | 80.000 |
| Food safety behavior | 40.000 | 80.000 |
| Factors | 47.000 | 68.085 |
| Farmers | 48.000 | 66.667 |
| Food safety traceability system | 53.000 | 60.377 |
| Enterprise social responsibility | 53.000 | 60.377 |
| Cognition | 53.000 | 60.377 |
| Food supply chain | 53.000 | 60.377 |
| Government supervision | 54.000 | 59.259 |
| Agricultural products | 54.000 | 59.259 |
| Analysis | 55.000 | 58.182 |

## 4. Development trend of food safety behavior of Chinese food enterprises

Burst terms analysis refers to the detection of words with a high-frequency change rate among a large number of subject words in a certain period based on word frequency statistics. These words may be used as one of the critical criteria to measure the research frontier issues. CiteSpace econometric analysis software was used to conduct an econometric analysis of 320 studies. The CiteSpace burst detection analysis result is shown in Table 6. The table shows the high-quality pork supply chain, enterprise social responsibility, and five other burst terms. The keywords of research frontiers in the food safety behavior of food enterprises in China were obtained, reflecting its development trend.

**Table 6.** CiteSpace burst detection

| Stage | Burst terms | Strength |
|---|---|---|
| 2011–2012 | High-quality pork supply chain | 1.6669 |
| 2012–2013 | Enterprise social responsibility | 3.4309 |
| 2013–2014 | Core enterprise | 2.8802 |
| 2014–2015 | Game | 1.4611 |
| 2015–2016 | Quality safety of agricultural products | 1.2362 |
| 2016–2017 | Evolutionary game | 2.4398 |
| 2017–2018 | Social co-governance | 1.9054 |

### 4.1. Kernelization of actors

"Corporate social responsibility" and "core enterprise" research will continue to become a hot topic. In the food supply chain network, the core enterprises are in a central position, which master scarce resources other enterprises do not have and control the efficiency and rhythm of the whole supply chain network. Besides undertaking social responsibility, they should also shoulder the responsibility of managing, supervising, and guiding the upstream and downstream food enterprises to implement food safety behavior. However, in China, the consumers' legal rights and interests are sacrificed, and social morality and conscience are abandoned due to excessive competition between food enterprises. They pursue profit maximization blindly, and food safety incidents occasionally occur. Therefore, further studies are needed to establish the social responsibility consciousness among food enterprises so that they operate with honesty.

### 4.2. Concretization of behavior objects

The research on the "high-quality pork supply chain" has become important. China is the world's largest pork producer and consumer. However, widespread safety hazards exist in pork quality resulting from the Chinese pork farming pattern, that is, "small-scale production and huge demand." The issue that the pork quality is not up to standard is not only a problem of the pork supply chain but also involves the behavior of each subject in the supply chain. The behavior of actors is not standard, and the quality information is asymmetric, leading to the instability of the whole pork supply chain and, at times, becoming uncontrollable and collapsing. Therefore, how to promote the coordination of various actors in the pork supply chain to ensure the quality and safety of pork from breeding farms to the dining table has become an urgent topic for further studies.

### 4.3. Diversification of behavioral governance

"Game" and "social co-governance" have become the forefront of studies to encourage people to participate in food safety supervision. Food safety issues involve all sections of society, and hence all sections of society need to participate in food safety governance. In China, a consensus on social co-governance has been reached. However, many issues persist in its actual implementation. The responsibilities and powers between various food enterprises and other relevant subjects must be clarified. The government is prone to corruption from food enterprises, and the supervisory effect of other social forces is weakened, resulting in the failure of co-governance. Hence, it will continue to become a social hotspot until a balance between all relevant subjects is maintained in terms of achieving co-governance via evolutionary game research from the perspective of food safety behavior of food enterprises.

## 5. Conclusions and Recommendations

### 5.1. Main conclusions

The current research can be logically divided into internal management, external analysis, and intermediary food enterprises based on the density of connections between nodes.

The structural relationship thus formed is shown in Figure 3. Based on the results of this study, we arrived at the following conclusions.

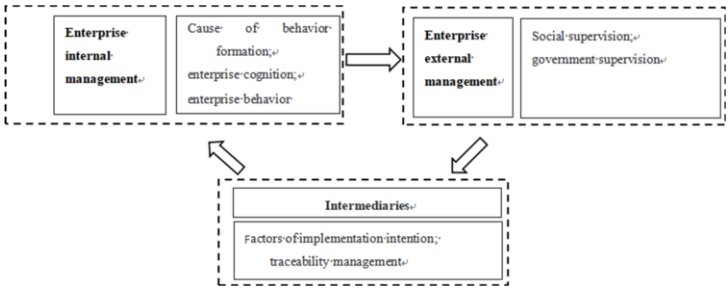


**Figure 3.** Structural relation diagram of food enterprises and food safety behavior

*5.1.1. The research focus is concentrated, and the actors are diversified.*

The focus of research on food safety is gradually concentrated and the behavior subjects of research are diversified at present, which is related to the behavior analysis of farmers, raisers, and other microcosmic bodies, and involves the behavior studies of circulation enterprises such as supermarkets and wholesale markets for agricultural products. Nevertheless, the selection of research subjects in food enterprises needs to be improved in terms of representation. Only a few studies have focused on the food safety behavior of farmers' markets, restaurants, and canteens, representing a chaotic and weak stretch in China's food safety supervision. [19] Therefore, further studies are needed to address a broader and more comprehensive subject behavior.

*5.1.2. The external measures are not systematic, and the search summary and outcomes are few.*

At present, the research perspective about the external factors of regulating food safety enterprises involves "government regulation" and "social work." Also, the study content is biased toward a theoretical overview, emphasizing insufficient participation from the government and all sectors of society in food safety regulation; few co-governance schemes exist with the practical value extracted from the deficiencies. This is also a hotspot that needs to be conserved via further studies.

*5.1.3. The interest coordination between different subjects is not clear.*

As shown in Figure 3, the food safety behavior of food enterprises is affected by internal, external, and intermediary factors. One of the critical problems is with the food supply chain "from the fields to the table" involving different interest subjects; how other stakeholders of food enterprises implement incentive and supervision mechanisms has become the key to the development of Chinese food security system reform.

### 5.2. Policy recommendations

- The internal structure of the enterprise should be strengthened, responsibility awareness should be enhanced, and food safety behavior should be standardized. The safety behavior of food enterprises plays a leading role in food safety management. Food business operators should conscientiously fulfill social responsibility and abandon old ideas that profit is the only goal to achieve long-term interests. Further, food enterprises should strengthen the social responsibility awareness of internal employees to effectively ensure food safety. Also, enterprises should give importance to morality and establish a customer-centered service philosophy to build an honest and trustworthy enterprise culture.
- Advances in science and technology directly impact food safety and result in significant overall changes. China should apply its excellent experience and introduce advanced technologies into research based on the food enterprises' willingness to implement food safety behavior so as to provide the scientific and technological impetus to upgrade the Chinese food industry.
- The external environment should be optimized, and the power of supervision should be with all sections of society. First, the government should improve the legal and policy system to create mandatory protective barriers for food safety. The government should also steadily promote the supervision of food safety behaviors of food enterprises. Further, the consumers should fully play the supervisory role and improve self-protection awareness abilities as prominent participants in food safety management. Finally, news media should be attentive and play a role in guiding public opinion and spreading public awareness toward food safety and transparency. News media should timely and efficiently expose illegal business behaviors.

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