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Research Article

Analysis of the Comprehensive Evaluation about College Campus Food Safety Satisfaction Based on Fuzzy AHP

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Abstract: This study uses the sample data of college campus food safety satisfaction and applies the theories and methods of fuzzy mathematics and analytic hierarchy process to the evaluation of college campus food safety satisfaction study. We divide the evaluation system of food safety satisfaction into a number of indicators according to need combined with the survey data, which includes factor set, evaluation set, membership function and weight set, in order to achieve the level of comprehensive evaluation on the campus food safety satisfaction and explore its influencing factors and weakness. This research obtains those conclusions as following: the food safety in university campus is "not satisfied" overall. For example, they are not satisfied with the license certification, relevant laws, content of pesticide, food packaging, brand production and the supervision system. Based on this, the paper puts forward those suggestions: Strengthen the information transparency of food and establish the food safety information release platform; propagate the "Food Safety Law" and popularize the knowledge of food safety; strengthen the punishment of food safety problems and legal sanctions to punish.

Keywords: Analytic hierarchy process, college students, fuzzy comprehensive evaluation, food safety, satisfaction

INTRODUCTION

Carrying out the evaluation of food safety satisfaction and putting the words to the urban residents are benefit not only for understanding the social conditions and public opinion, enhancing their awareness of rights, but for the increasing of self-discipline consciousness for businesses. Therefore, evaluation of food safety satisfaction as the government closer to the people's livelihood, listen to the voice of the people, the effective way to understand the social conditions and public opinion, has an important role in improving the food safety supervision work.

The concept of food safety written in "World Food Security Committee" was first put forward by the UN Food and Agriculture Organization (FAO) in 1974. This definition focused on food in quantity, which can meet the demand of people. In 1980s later, the concept of food safety has been changed from focusing on quantity to focusing on quality. Codex Committee on food hygiene (CAC) defines the food safety as: the activities of food planting, breeding, processing, packaging, storage, transportation, sales, consumption and other activities in accordance with the national mandatory standards and requirements are not possible toxic and harmful substances to human health damage or threat to lead consumers to death or endanger consumers and risks for future generations. Therefore, food security includes both production safety and operation safety; both the results of security and process safety; both the real security and future security.

Because of the difference of perspectives, methods and objects, different scholar has slightly different conclusion on satisfaction of food safety. The research results mainly concentrate in two aspects.

First, Study on the evaluation system of food safety:

Food Security Index (FSI): in the form of index to reflect the basic situation of food safety related information. Xu *et al*. (2008) constructed the food safety index through a survey of food experts.

The Customer Satisfaction Index (CCSI): the overall evaluation of the customer of a product or a service provider so far all consumer experience, is a kind of accumulation of customer satisfaction. Li Xiaoping (2010) built the customer satisfaction model structure using the food safety case of Suguo supermarket, through the evaluation of customer satisfaction, the model was empirically tested.

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Food Security Early Warning System (FSAS): the prediction and control of alarm. Tang (2005) designed the general police food safety index and the corresponding quantity security, quality security index, index of sustainable security index depending on the perspective of food safety early-warning requirements, which includes four layers of structure of a total of 18 warning condition indexes (Tang, 2005).

Second, An empirical study on the food safety satisfaction:

Evaluation method: Scholars generally using the research methods of econometric analysis to empirical research on food safety satisfaction. For example, for the empirical studies of food safety satisfaction. Wang *et al*. (2013) used the gray connection model, Su *et al*. (2012) used structural equation model, Wei and Li (2012) applied the method of regression analysis and classification of two party inspection Logistics card, Zhang (2012) applied multiple linear regression analysis method.

The selection of evaluation index: Liang *et al*. (2010) according to the factors that may affect the food safety chooses 20 single indexes and put forward to 5 common factors including governance, production and processing, harmful substances, quality status, social supervision exploratory (Liang *et al*., 2010).

The empirical results: A survey in Beijing showed that, the average score of food safety satisfaction on a five point scale is 2.76 (Cheng, 2011).

To sum up, for the research of food safety satisfaction literature, as the angles, methods, objects and samples are different; the conclusions are not the same. There are those main problems:

- The maneuverability of the evaluation model is poor due to those reasons as following: from the aspects of the selection of index system, the index is too simple or too cumbersome and for the food safety and satisfaction of comprehensive evaluation, the index system is not perfect enough.
- For the investigation, it lacks of representation to just choose a united group as the research object. For example, Su *et al*. (2012) just chooses the college students as the object of investigation.
- For the perspective of research approaches, the reliability of simple frequency statistics is lower. As the weight of index level of the grey evaluation method must be made by the experts to judge, so it includes some subjective factors that reliability also be affected.

In summary, this study does the satisfaction assessment on food safety of College students by applying the fuzzy hierarchy comprehensive evaluation method.

MATERIALS AND METHODS

Analytic hierarchy process: The sample data can be approximated as from a normal or near-normal distribution:

Determine the objectives and evaluation factors: P evaluation indexes: $u = \{u_1, u_2, \ldots\ldots, u_p\}$.

Construct judgment matrix: The element values of judgment matrix reflect our understanding of the relative importance of each element. And we usually use the numbers of 1 to 9 and their reciprocal to scale it. But when the importance of each factor could be reflected by the real ratio, we use this ratio to be the element values of corresponding judgment matrix in general. Then the judgment matrix is obtained. $S = (u_{ij})_{p\times p}$.

Calculate the judgment matrix: Calculate the greatest characteristic root λ_{max} of the judgment matrix S and the feature vector A correspondingly which is the order of the importance of each evaluation factor. A is also named the right of distribution coefficient.

The consistency test: We should to calculate the consistency index $CI = \frac{\lambda_{\max} - n}{n-1}$ and the average random consistency index *RI* to check the consistency of judgment matrix. It needs to construct 500 sample matrixes using the method of stochastic. The sample matrixes should be obtained by filling the sample matrix on the main diagonal triangle with the scaling and their reciprocal randomly. That is to say the main diagonal of the numerical value is always 1 and the reciprocal of corresponding transposed position is adopted the corresponding position of the random number. Then we need to calculate the consistency index value for each random sample matrix. Average those values *CI* and then obtain the mean random consistency index value *RI*. These levels of consistency analysis of sequencing results are satisfactory when the random consistency ratio $CR = \frac{CI}{RI} < 0.10$, that is to say the right of distribution coefficient is reasonable. Otherwise we need to adjust the judgment matrix element values and distribute the coefficient values again (Hu and He, 2000).

The fuzzy comprehensive evaluation method and steps: Fuzzy comprehensive evaluation is constructed through grade fuzzy subset to quantify fuzzy index to reflect the rated things (that is, determine membership) and then use fuzzy comprehensive transformation principle of each index. The evaluation step as following:

Determine factor theory domain of the evaluation object: P evaluation indexes $u = \{u_1, u_2 \ldots u_p\}$.

Determine reviews level domain: Determine the class set $v = \{v_1, v_2 \cdots v_p\}$. Each level may correspond to one fuzzy subset.

Establish the fuzzy relation matrix: We need to quantify the rated objects one by one from each factor u_i $(i = 1,2 \cdots p)$ after constructing hierarchical fuzzy subset. That is to say, from the single factor, determine the hierarchical fuzzy subset's degree of membership $(R|u_i)$ of rated things. Finally obtain the fuzzy relation matrix:

$$R = \begin{bmatrix} R|\ u_1 \\ R|\ u_2 \\ \cdots \\ R|\ u_p \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix}_{p.m}$$

The element r_{ij} in row i column j of matrix R shows one rated things on the v_j level of fuzzy subset membership from the factor u_i. Describe a rated thing's performance in a factor u_i through the fuzzy vector $(R|u_i) = (r_{i1}, r_{i2}, \cdots\cdots, r_{im})$. While in other evaluation methods is by an index to depict the actual value. Therefore, from this point of view fuzzy comprehensive evaluation needs more information (Yang, 2000).

Determine the weight vector of evaluation factors: Determine the weight vector of evaluation factors in the fuzzy comprehensive evaluation: $A = \{a_1, a_2 \ldots a_p\}$. The element a_i of the weight vector A is essentially a factor of u_i sub fuzzy membership degree. The analytic hierarchy process to determine the relative order of importance among evaluation indexes is used in this study to determine the weight coefficient and normalized before synthesis. That is:

$$\sum_{i=1}^{p} a_i = 1\ ,\ a_i \geq 0\ ,\ i = 1,2 \cdots n$$

The comprehensive evaluation of synthetic fuzzy vector: Using appropriate operator composes a and the rated things R and then get the result of fuzzy comprehensive evaluation vector B of each rated thing. That is:

$$A \circ R = (a_1, a_2, \cdots\cdots, a_p) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix} = (b_1, b_2, \cdots\cdots, b_m) = B$$

Among them b_i is obtained by counting the column j of A and the column j of R, which is rated on the grade of membership degree of fuzzy subset v_j of things on the whole (Xie and Liu, 2000).

Analyze the results of comprehensive evaluation of fuzzy vector: The most commonly used method in practice is the principle of maximum degree of membership, but in some cases the use of it is very reluctant. It could loss a lot of information and even obtains the unreasonable evaluation results. Use the method proposed weighted average grade of membership and order multiple rated things according to its rank position.

RESULTS AND DISCUSSION

Data source: This study evaluated in the college campus food safety satisfaction of Tangshan City as an example. Let those undergraduate students and school staffs of schools in Tangshan City to be the investigation objects. Data were collected using self-administered questionnaire. Design a questionnaire depending on the relevant evaluation index of college campus food safety satisfaction (Wang, 2005). Then use stratified sampling method and give out those questionnaires to the persons under investigation. Let them work out the questionnaires themselves. Then check the validity of each questionnaire. Questionnaires were sent to 370, recovery of 370, recovery of 100%, effective questionnaire 365, effective rate was 98.6%. Of the students surveyed girls also have a boy, from different levels, different age stages. The students surveyed were girls and boys. They are from different levels and different age stages.

The questionnaire designed Likert scale format, constitute the evaluation index system of food safety satisfaction set consists of 5 first level indexes and 20 two level indexes, index measurement method using special scale Likert scale, using semantics are divided into 5 grades: very satisfied, satisfied with the measurement, in general, not satisfied, not satisfied with the extreme. For the convenience of calculation, this study will quantify the semantics standard subjective evaluation of the degree and in turn the value 5, 4, 3, 2 and 1. Subjective measurement uses level five semantics scaling. Quantitative evaluation of standard design is shown in Table 1.

Show the application of fuzzy comprehensive evaluation based on AHP in this area by means of

Table 1: Quantitative evaluation of grading standards

The evaluation value	Comment	Grading
x_i>4.5	Very satisfied	E1
3.5<x_i≤4.5	Satisfied	E2
2.5<x_i≤3.5	In general	E3
1.5<x_i≤2.5	Not satisfied	E4
x_i≤1.5	Not satisfied with the extreme	E5

Table 2: Two grades of evaluation factors of campus environment quality and weighting

Comprehensive index	Evaluation index	Weight
Management supervision A (0.275)	Technical certification	0.183
	The relevant laws	0.128
	Law enforcement	0.210
	The supervision system	0.174
	Government policy	0.199
	License certification	0.106
Production and processing B (0.211)	Food production source	0.203
	storage and transportation	0.281
	machining process	0.185
	food packaging	0.161
	brand production	0.170
Harmful substances C (0.203)	The content of heavy metals	0.482
	The use of additive	0.405
	The content of pesticide	0.113
Quality status D (0.202)	Nutritional composition	0.217
	quality status	0.285
	The fresh degree	0.246
	Health degree	0.252
Social supervision E (0.109)	The media supervision	0.474
	The evaluation of public opinion	0.526

sample survey data. Determine the evaluation object factor set (determine the evaluation index). Now we consider it from the following several aspects: the construction of index system including 5 first grade indicators, those are corporate governance, production and processing, harmful substances, quality status, social supervision and 20 class two environment evaluation indexes. Environmental indicator systems are shown in Table 2.

The index weight by AHP steps solve: Determine the evaluation object set:

P = The food safety satisfaction for university campus.

Construct the evaluation factor set:

$$\mu = \{\mu_1, \mu_2, \mu_3, \mu_4, \mu_{51}\}$$

Determine reviews level domain:

That is to say to establish the evaluation set *v*:

$$v = \{v_1, v_2, v_3, v_4\}$$

= {very satisfied, satisfied, in general, not satisfied, not satisfied with the extreme}

Calculate the first class of index weight: There are five the first class of indexes. We calculate the index weight by the analytic hierarchy process. Construct judgment matrix $S = (u_{ij})_{p\times p}$. That is:

$$S = \begin{bmatrix} 1 & \frac{4}{3} & \frac{5}{4} & 1 & \frac{9}{5} \\ \frac{3}{4} & 1 & \frac{9}{10} & \frac{8}{9} & \frac{7}{5} \\ \frac{4}{5} & \frac{10}{9} & 1 & \frac{4}{5} & \frac{3}{2} \\ 1 & \frac{9}{8} & \frac{5}{4} & 1 & 2 \\ \frac{5}{9} & \frac{5}{7} & \frac{2}{3} & \frac{1}{2} & 1 \end{bmatrix}$$

Calculate the greatest characteristic root $\lambda_{\max} = 5.00289$ of the judgment matrix S using the software mathematic. For the test of consistency of judgment matrix, we need to calculate the consistency index:

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{5.0289-5}{4} = 0.007225$$

Average the random consistency indexes *RI* = 1.24. Random consistency ratio:

$$CR = \frac{CI}{RI} = \frac{0.007225}{1.24} == 0.00582 < 0.10$$

So the level of consistency analysis of sequencing results is satisfactory. That is to say the right of distribution coefficient is very reasonable. The corresponding feature vector is:

A_0 = (0.33, 0.2532, 0.2436, 0.2424, 0.1308)

Then do normalization:

A = (0.275, 0.211, 0.203, 0.202, 0.109)

Calculation the two level index weight: Similarly, this study still uses analytical hierarchy process to calculate the index weight. Construct the judgment matrix separately for each of two level indexes. Calculate the greatest characteristic root and check the consistency by Mathematic. Then get the weight coefficient and reasonable.

The weight for management supervision:

(0.183, 0.128, 0.210, 0.174, 0.199, 0.106)

The weight for production and processing:

(0.203, 0281, 0.185, 0.161, 0.170)

The weight for harmful substances:

(0.482, 0.405, 0.113)

The weight for quality status:

(0.217, 0.285, 0.246, 0.252)

The weight for social supervision:

(0.474, 0.526)

The multilevel fuzzy comprehensive evaluation of college campus food safety satisfaction: Weighted average college campus food safety satisfaction fuzzy comprehensive evaluation.

Combine A and R and then obtain the result vector B of fuzzy comprehensive evaluation using the weighted average fuzzy synthesis operator $M(\bullet,\oplus)$. When the factors are more, max min algorithm commonly used in fuzzy comprehensive evaluation makes those factors which have been given weights often small. In the fuzzy synthetic operation, the information is often lost and it often leads the result not easy to distinguish and unreasonable (That is, the model failure). So the weighted average fuzzy synthesis operator is used in this study in view of the above problems. The formula is:

$$b_i = \sum_{i=1}^{p}\left(a_i \cdot r_{ij}\right) = \min\left(1, \sum_{i=1}^{p} a_i \cdot r_{ij}\right), j = 1, 2, \cdots, m$$

In the formula,

b_j : The membership belonging to the class j

a_j : The weight of the i evaluation index

r_{ij} : The degree of membership for the i evaluation indexes belonging to the j class.

Substitute the statistical data which is from a sample survey in the established model. Calculate vectors at all levels of the fuzzy comprehensive evaluation. Management supervision evaluation vector is calculated as follows:

$A_1 = a \circ R$ = (0. 15011, 0.386472, 0.26719, 0.086752, 0.109842)

Comprehensive evaluation of the normalized vector:

A1= (0.150, 0.386, 0.267, 0.086, 0.111)

Production process for evaluation vector:

B1= (0.084, 0.226, 0.399, 0.168, 0.123)

Harmful substance evaluation vector:

C1= (0.035, 0.270, 0.411, 0.084, 0.2)

Quality status evaluation vector:

D1= (0.032, 0.179, 0.201, 0.444, 0.144)

Evaluation vector for social supervision:

E1= (0.027, 0.300, 0.3926, 0.184, 0.0964)

Comprehensive evaluation vector: Then normalize:

(0.075, 0.278, 0.324, 0.185, 0.138)

Rate for the comprehensive score:

VA = 5*0.150+4*0.386+3*0.267+2*0.086+1*0.111 = 3.378
VB = 5*0.084+4*0.226+3*0.399+2*0.168+1*0.123 = 2.98
VC = 5*0.035+4*0.270+3*0.411+2*0.084+1*0.2 = 2.856
VD = 5*0.032+4*0.179+3*0.201+2*0.444+1*0.144 = 2.511
VB = 5*0.027+4*0.300+3*0.3926+2*0.184+1*0.0964 = 2.9572

By the above calculation and contrasting the evaluation classification of Table 1 we can know that the evaluation results of "management supervision" is "in general", which belongs to the class E3. The evaluation results of other 4 indexes both are "dissatisfied", which belongs to the class E4. Order those evaluation results depending on the size of each index grade. Among them we find that the evaluations of "harmful substances" and "quality status" are lower then others. But the comprehensive evaluation of the overall score is:

V = 5*0.075+4* 0.278+3* 0.324+2* 0.185+1* 0.138 = 2.97

CONCLUSION

The campus food safety satisfaction of university students is an important food safety index. It reflects the objective food safety state to a certain extent. This study establishes 20 food safety satisfaction evaluation indexes by the method of questionnaire investigation. And calculate the weight of one class index. Those weights of "management supervision", "production and processing", "harmful substances", "quality status" and "social supervision" are 0.275, 0.211, 0.203, 0.202 and 0.109 respectively. From a single index, the content of pesticide and license certification obtain the lowest score, they are 0.113 and 0.106 respectively, which reflect the concerns of students in the governance and oversight, production and processing and other harmful

substances. Comprehensive analysis shows that the average score of college students in Tangshan City food safety satisfaction on a five point scale is only 2.97.

Because the food involves safety problems from the breeding, production and processing, transportation, sales and consumption, we should improve the food safety of residents' satisfaction. To do this study, from the government level, first of all, the government should implement the "food safety law", supervise the food enterprises to implement the quality safety responsibility, improve the food standard production process through each quarter corporate self-examination once every six months, the field verification of a careful renewal and the implementation of the system, do a good job for the raw material procurement link management, establish and perfect inspection system, carry out additive using management regulations strictly (Wang, 2012). Secondly, strengthen the supervision of law enforcement and punishment of the illegal food production and processing enterprises, small workshops and undocumented food production units. Finally, carry out the food quality and safety market access system strictly. And do the dynamic management for the food production enterprises.

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