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Research Article

Food Quality Safety Evaluation Model in College Canteens Based on the Improved AHP-taking Bengbu College as an Example

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Abstract: Based on the results of investigation and the suggestion from the experts, the factors influencing the college canteen food quality and safety are found and assessment system for university cafeteria food quality and safety is constructed. With the improved Analytic Hierarchy Process (AHP) to the various indexes for the empowerment and the fuzzy comprehensive evaluation method, the university canteen food quality and safety evaluation method is created. Then based on the example from Bengbu College, the solution of the model is provided, thus it is concluded that the process management factors, food factors and environmental factors, make the biggest influence on the canteen food quality and safety. Meanwhile, the extent of the influence of the second level factor on the canteen food quality and safety is identified and further it should be paid a greater attention to the several factors in order to improve the status of the food quality and safety condition.

Keywords: Evaluation, food quality, fuzzy comprehensive evaluation method, improved Analytic Hierarchy Process (AHP), safety, the college canteen

INTRODUCTION

Along with the large-scale enrollment in of the universities, the contradiction of more students, insufficient dining condition appears. In this case, the ministry of education initiated a logistics socialization reform to ease the contradiction. However, with the deepening of the reform of college dining room, the disadvantages of socialization management also became more distinctive (Liang and Wu, 2012). For example, in the course of reform and development, the problems of the staff's technology, dining environment, different consumption idea emerge, which make the university cafeteria food health and safety more and more risky (Li and Hu, 2010). Therefore, it is important to increase the supervision over the canteen food quality and safety, because it is closely related to teachers' and students' health and life safety.

At present, there are more researches on the food quality and safety, such as the potential risk in the dining room (Guan, 2007), to search for the factors to influence the canteen food quality and safety (Hua *et al*., 2011), the establishment of the canteen food safety system (Wang *et al*., 2008). There are also many ways for the research on the food safety evaluation method, such as constructing food safety comprehensive evaluation indicator system with Analytic Hierarchy Process (AHP) (Liu, 2007), evaluation of the safety of children's food packaging design using the fuzzy Analytic Hierarchy Process (AHP) (Wang, 2011), etc. Analytic Hierarchy Process (AHP) is a kind of practical multi-criteria evaluation method, although it has practical, systematic advantages, this method is complicated as it needs consistency check in the calculation of the index weight. In this study, we will construct an assessment system for college cafeteria food quality and safety for the first time based on the practical investigation results and related experts' opinions. With the improved Analytic Hierarchy Process (AHP), the evaluation indicator system of indicators is empowered and a college cafeteria food quality and safety evaluation model is established with the empowerment of fuzzy comprehensive evaluation method. The solution process of the model is thus presented with the case from Bengbu College. The purpose of this study is to analyze the important factors on college canteen food quality and safety evaluation and avoid the tedious consistency check in the traditional Analytic Hierarchy Process (AHP). At the same time, this method can also be helpful to quickly assess the college food quality security situation, thus it is of great significance for the relevant administrative department of university cafeteria food safety supervision and monitoring.

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THE ESTABLISHMENT OF THE MODEL

Setting the index system of evaluation factors: The food quality and safety evaluation systems appear to be the multi-level and multi-attribute decision-making issue. Based on the scientific, comprehensive and level-showing principles, the index evaluation system is established as follows:

Determining the evaluation set: Evaluation set is the collection of the possible results of various evaluations to the objects, which could be indicated by means of various levels. Nowadays, there are many ways to show the levels (Chen *et al*., 2011), as for this study, the evaluation levels are divided into five levels: "Very safe", "Safer", "Safe", "Just-so-so", "Unsafe". Namely, the evaluation set V = {very safe, safer, safe, just-so-so, unsafe}, the assignment V = {95, 85, 75, 65, 55}.

Evaluation of various index weights via improved analysis hierarchy process: The procedure is as follows:

- **To form complementary judgment matrix:** Based on complementary judgment matrix (0-1 dial), 0 shows that A is inferior to B, 0.5 shows that A is equal to B and 1 shows that A is superior to B. Therefore, complementary judgment matrix $F = (f_{ij})_{m\times m}$ can be formed via 0-1 dial method.
- **To build fuzzy coincidence matrix:** Based on conversion formula $r_{ij} = (r_i - r_j)/2m + 0.5$ (*) ($r_i = \sum_{j=1}^{m} f_{ij}$ is named row sum) provided in document (Guan, 2007), complementary judgment matrix can be transformed into fuzzy coincidence matrix $\acute{F} = (\acute{f}_{ij})_{m\times m}$.
- **Evaluation of weight of each factor:** Weight (W) of each factor is often obtained on the basis of analysis hierarchy process (Jiang, 1987; Liu *et al*., 2011; Li *et al*., 2011; Peng, 2012)

Fuzzy comprehensive assessment: Fuzzy comprehensive assessment may be conducted as follows:

- **Evaluation of decision matrix judgment of each single factor:** A panel of experts on judgment composed of n members successively evaluates each index based on fixed evaluation rating standard, then works out the numbers of n_1, n_2, n_3, n_4, n_5 which separately represent High Security, Relatively High Security, Security, Intermediate Security and Less Security. The membership (n_1/n, n_2/n, n_3/n, n_4/n, n_5/n) of unifactor can be obtained by means of normalization, with $n = \sum_{i=1}^{5} n_i$. In this case, decision matrix judgement R_i (i = 1, 2, 3, 4, 5) of each single factor in all the sub aggregates can be respectively obtained.
- **Evaluation of the result of food quality security assessment of university canteen:** The result of food quality security assessment of university canteen is gained eventually by decision matrix judgment of sub aggregate via multi-layer comprehensive evaluation method in document (Yu and Fu, 2004).

APPLICATION SAMPLE

Based on the improved AHP and taking the canteen of Bengbu College for example, the study analyses the fuzzy comprehensive assessment course of food quality security evaluation of university canteen.

Determination of various index weights:
To form complementary judgment matrix: In this study, first class index food is illustrated to determine the determination of various index weights of its subordinate three second-class indexes called physical plus chemical factors and biotic factor. For this purpose, relevant experts are invited to compare the correlation importance among different level factors to form complementary judgment matrix:

$$F_{B_2-C} = \begin{pmatrix} 0.5 & 0 & 1 \\ 1 & 0.5 & 1 \\ 0 & 0 & 0.5 \end{pmatrix}$$

To build fuzzy coincidence matrix: Based on formula (*), the above complementary judgment matrix can be transformed into fuzzy coincidence matrix:

$$F'_{B_2-C} = \begin{pmatrix} 0.5 & 0.33 & 0.67 \\ 0.67 & 0.5 & 0.83 \\ 0.37 & 0.17 & 0.5 \end{pmatrix}$$

Evaluation of weight of each factor: Based on analysis hierarchy process in document (Chen *et al*., 2011), weights of the first-class index of food with three second-class indexes can be obtained:

$$W_{B_2-C} = (0.33, 0.45, 0.22)$$

In the same manner, the weights correlation between general index and first-class and the correlation between other three first-class indexes called staff index, management index with environment index and their respective subordinates second-class indexes can be obtained as follows:

$$W_{A-B} = (0.17, 0.27, 0.30, 0.26)$$

$$W_{B_1-C} = (0.29, 0.19, 0.23, 0.29)$$

$$W_{B_3-C} = (0.21, 0.29, 0.22, 0.28)$$

$$W_{B_4-C} = (0.52.0.48)$$

Table 1: The index system of food quality and safety evaluation in college canteens

First-class index	Second indexes	Evaluation set					Combination index
		Very safe	Safer	Safe	Just-so-so	Unsafe	
Person B_1 (0.17)	Safety consciousness C_{11} (0.29)	0.3	0.5	0.1	0.1	0	0.049
	Physiological health C_{12} (0.19)	0.3	0.4	0.2	0.1	0	0.032
	Professional quality C_{13} (0.23)	0.2	0.3	0.4	0.1	0	0.039
	Ideological and political quality C_{14} (0.29)	0.3	0.5	0.1	0.1	0	0.049
Food B_2 (0.27)	Physical and chemical factors C_{21} (0.33)	0.2	0.5	0.2	0.1	0	0.089
	Biological factors C_{22} (0.45)	0.2	0.5	0.3	0.0	0	0.122
	Other factors C_{23} (0.22)	0.1	0.4	0.3	0.1	0.1	0.059
Management B_3 (0.30)	Safety education C_{31} (0.21)	0.3	0.4	0.2	0.1	0	0.063
	Safety inspection C_{32} (0.29)	0.5	0.2	0.1	0.1	0.1	0.087
	Safety organization C_{31} (0.22)	0.4	0.2	0.2	0.1	0.1	0.066
	Rules and regulations C_{32} (0.28)	0.2	0.4	0.3	0.1	0	0.084
Environment B_4 (0.26)	Working environment C_{41} (0.52)	0.1	0.3	0.2	0.2	0.2	0.135
	Work area layout C_{42} (0.48)	0.3	0.4	0.1	0.1	0.1	0.125

That is, the figures in brackets of Table 1.

Combination weights calculation: As showed in Table 1, by multiplying each first class index weight and corresponding second-class index weight, comprehensive weights which reflects how each sub-factor affects food quality security can be made.

Implement of comprehensive assessment: Implement process of comprehensive assessment is still illustrated with first-class index food.
Judgment matrix on the index food is shown below:

$$R_2 = \begin{pmatrix} 0.2 & 0.5 & 0.2 & 0.1 & 0 \\ 0.2 & 0.5 & 0.3 & 0 & 0 \\ 0.1 & 0.4 & 0.3 & 0.1 & 0.1 \end{pmatrix}$$

Second-class weight sets are shown below:

$$A_2 = (0.33, 0.45, 0.22)$$

Consequently, comprehensive assessment on the index food by experts can be obtained:

$$B_2 = A_2 \cdot R_2 = (0.33, 0.45, 0.22) \cdot \begin{pmatrix} 0.2 & 0.5 & 0.2 & 0.1 & 0 \\ 0.2 & 0.5 & 0.3 & 0 & 0 \\ 0.1 & 0.4 & 0.3 & 0.1 & 0.1 \end{pmatrix}$$

$$= (0.2, 0.45, 0.3, 0.1, 0.1)$$

By means of normalization, $\widetilde{B_2}$ = (0.17, 0.39, 0.26, 0.09, 0.09)

Similarly, by means of normalization, assessment result of staff index, management index and environment index can be successively made as follows:

$$\tilde{B}_1 = (0.32, 0.32, 0.25, 0.11, 0)$$

$$\tilde{B}_3 = (0.28, 0.27, 0.27, 0.10, 0.10)$$

$$\tilde{B}_4 = (0.23, 0.31, 0.15, 0.15, 0.15)$$

In conclusion, comprehensive assessment of food quality security condition in the canteen of Bengbu College can be obtained:

$$B = A \cdot R = (0.17, 0.27, 0.30, 0.26) \cdot \begin{pmatrix} 0.32 & 0.32 & 0.25 & 0.11 & 0 \\ 0.17 & 0.39 & 0.26 & 0.09 & 0.09 \\ 0.28 & 0.27 & 0.27 & 0.10 & 0.10 \\ 0.23 & 0.31 & 0.15 & 0.15 & 0.15 \end{pmatrix}$$

$$= (0.28, 0.27, 0.27, 0.15, 0.15)$$

By means of normalization:

$$B = (0.25, 0.24, 0.24, 0.13, 0.13)$$

Evaluation score: By formula Z = B.VT, the ultimate comprehensive evaluation score of food quality and safety for Bengbu College Refectory should be:

$$Z = (0.25, 0.24, 0.24, 0.13, 0.13) \cdot (95, 85, 75, 65, 55)^T$$
$$= 78.39$$

From the calculation, the 'safest' degree of food quality and safety for Bengbu College Refectory is 0.25, the safer 0.24, the safe 0.24, the Just-so-so 0.13, the unsafe 0.13. Judging from the maximum 0.25, the degree of food quality and safety for Bengbu College Refectory is safe.

RESULTS AND DISCUSSION

As can be seen from the Table 1:

- Among the first-degree factors in affecting food quality and safety, management, foodstuff and surroundings are the most important covering respectively 30, 27 and 26%, respectively.

- Among the second-degree factors in affecting food quality and safety, safety consciousness with Ideological and political quality, biological factors, safety supervision and working conditions counts much against the first-degree, covering 29, 45, 29 and 52% in each.
- On the impact from the second-degree factors against food quality and safety, working conditions, working site, biotic factors and physics and chemical factors covered 13.5, 12.5, 12.2, 8.9%, respectively separately.

Therefore, in order to improve food quality and safety in refectory, these factors should be concerned.

CONCLUSION

When assessing the operation system for food quality and safety in college canteens, this is to empower every index by the way of the improved Analytic Hierarchy Process with comprehensive evaluation method which enables to qualify the qualitative analysis from the supervisors and experts digitizing the imprecise expression and process so as to get reasonable judgment. Meanwhile, in this scoring model, the proportion of the factors and single factor evaluation matrix firmly rely on the practical operation systems. With the result on the basis of the widely collective wisdom and quantitative research, the mode lowers arbitrariness in evaluation with the result objective and highly creditable. The overall level of food quality and safety for college canteen can be raised by utilizing this model of evaluation so as to detect the potential accidents and vulnerable segments. The supervision and rectification can be strengthened as well.

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