

Research on Supplier Selection of Fresh Food Supermarkets under New Retail Mode

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Abstract: Under the new retail mode, the market competition in the fresh produce industry is fierce. Optimizing the procurement of fresh agricultural products and selecting high-quality suppliers are conducive to reducing costs and enhancing market competitiveness of fresh supermarkets under the new retail mode. This paper constructs a supplier selection index system for fresh produce supermarkets, uses hierarchical analysis and entropy weight method to determine the comprehensive weight of the indexes, and establishes the TOPSIS supplier selection model with gray correlation improvement. And the model is applied to A fresh food supermarket under the new retail mode, and the best supplier is selected for this supermarket from four strawberry suppliers.

Keywords: Supplier Selection, Gray TOPSIS Method, Fresh Produce.

1. Introduction

In recent years, the new retail industry is becoming more and more mature, and scholars in China have launched relevant research on the connotation, characteristics, motivation and development trend of new retail [1, 2]. Generally speaking, the research system of "new retail" has been initially formed, but not yet mature, and will be in the new normal of change for a long time. However, at present, many fresh food enterprises under the new retail model have not formed a complete evaluation system, and the quality of fresh food problems are endless, which restricts the development of the industry. The choice of suppliers determines the cost and quality of goods and the stability of fresh supermarket operations. Therefore, scientific and reasonable selection of suppliers for fresh supermarkets is of great significance to the development of fresh supermarkets under the new retail model.

The main methods of supplier selection are hierarchical analysis method [3, 4], mathematical planning method [5, 6], gray correlation analysis method [7, 8], fuzzy comprehensive evaluation method [9, 10] and so on. In the supplier selection of fresh agricultural products, Zhu Xue Zhen uses hierarchical analysis to construct the supplier selection model of agricultural products, and comprehensively evaluates the strength of agricultural products suppliers [11], however, the hierarchical analysis method has more human factors and is more subjective when determining the weights. Thus, scholars began to use a combination of subjective and objective weights to determine the weights of indicators, and combined with the TOPSIS method to construct the supplier selection model of fresh produce. Song Bao'e comprehensively used the hierarchical analysis method and entropy value method to determine the index weights, and combined with the TOPSIS method to construct the fresh food supplier selection model for supermarkets to select long-term strategic partners [12]. Su Zong Rong constructed a fresh food supplier selection index system for Metro and combined the TOPSIS method to build a model to solve Metro's dilemma under new retail [13]. Feng Meng jie used the rooting theory to generalize an evaluation system containing 17 factors

influencing the selection of fresh food e-commerce enterprises, and used the entropy weight-TOPSIS method to select the best suppliers for fresh food e-commerce platforms and realize the procurement of farmers by e-commerce platforms [14]. There are many indicators and complex data for fresh produce supplier selection, while TOPSIS method can normalize the data and eliminate the influence between multiple indicators. However, the single TOPSIS method focuses on selecting the program with the optimal level of synthesis when evaluating the target program, and it will ignore the relationship between the internal indicators and cannot reflect the level of each indicator dimension. Therefore, this study applies gray correlation to improve the TOPSIS method to select the best supplier of fresh food supermarket [15].

2. Fresh Supermarket Supplier Selection Index System

2.1. Selection of Supplier Selection Indicators for Fresh Food Supermarkets

It is known through literature research that the basic guidelines for supplier selection are quality, price, delivery capability, technical level, and service capability. Combined with the reality of the fresh food industry for targeted analysis, the quality indicators are refined into quality rating system, product quality pass rate, food traceability rate, freshness. Refine the price into, unit product price, distribution costs. Delivery capacity is refined into on-time delivery rate, continuous supply capacity, and average delivery period. For meat products, aquatic products, fruits and vegetables and other fresh commodities are easy to rot and deteriorate, not fresh, time-sensitive requirements are very strong characteristics. Fresh product suppliers have to ensure product freshness and reduce the loss rate, so the technical level is refined into three secondary indicators: cold chain transportation capacity, distribution cold storage facilities, and loss rate of transported products. In addition, in order to reduce procurement costs, the fresh food platform must increase the proportion of direct purchases, with high demand and the need for stable supply, so the volume discount rate

indicator is incorporated into the price, and the order fulfillment rate is incorporated into the delivery capacity. Finally, considering the characteristics of fresh food new retail and consumer demand response, the service ability is

refined into two secondary indicators: customer satisfaction rate and ability to handle customer complaints. The supplier selection index system of fresh produce supermarket is constructed, as shown in Table 1:

Table 1. Indicator system for supplier selection in fresh food supermarkets

Level 1 indicators	Secondary indicators	Description of indicators
Quality (A1)	Quality level (A11)	Scoring by experts based on the quality characteristics of the product, such as appearance, flavor, nutrition and other indicators, ten-point system
	Product quality pass rate (A12)	Test the content of bacteria, viruses, pesticides, additives, etc. in commodities with reference to the Food Sanitation Law, the Agricultural Products Quality and Safety Law, the Pesticide Regulations, etc., and test the number of qualified food categories/total number of food categories
	Food traceability (A13)	Number of traceable fresh produce types/total fresh produce types
	Freshness (A14)	Supermarkets receive deliveries of freshness, scored by the receiving clerk based on experience, ten-point system
Price (A2)	Price per unit of product (A21)	Quotation per unit of fresh produce
	Volume discount rate (A22)	Discount rates available from suppliers for bulk orders
	Distribution costs (A23)	Additional charge per unit of fresh produce when suppliers make deliveries
Delivery capacity (A3)	On-time delivery rate (A31)	Examining the ability of each supplier to deliver products from a time perspective, number of orders arriving on time/total number of orders over time
	Continuity of supply (A32)	Scoring by experts based on suppliers on a ten-point scale
	Average delivery time (A33)	Time taken from acceptance of order to delivery by supplier
	Order fulfillment rate (A34)	Ability to deliver according to actual demand, number of products actually supplied by the supplier/original order quantity
	Level of technology (A4)	Cold chain transportation capacity (A41)
	Distribution cold storage facilities (A42)	Whether the cold storage area and other types of equipment are complete
	Wear and tear rate of transportation products (A43)	Number of fresh produce spoiled and bumped during transportation/total number of fresh produce
Service capacity (A5)	Customer satisfaction rate (A51)	Feedback on customer evaluations of fresh products after suppliers have supplied the products
	Ability to handle customer complaints (A52)	Ability of fresh food suppliers to deal with problems arising after supply, number of after-sales satisfaction/number of customer complaint problems

2.2. Determination of Weights of Supplier Selection Indicators for Fresh Supermarkets

In existing studies related to supplier selection indicators, the hierarchical analysis method and entropy weight method are often used to determine indicator weights. Scholars often use the combination method to determine the indicator weights, which can make up for the subjectivity of the hierarchical analysis method, but also avoid the entropy weight method to produce indicator weight values that are different from the actual, further improving the accuracy of the conclusions.

2.2.1. Entropy Weighting Method to Determine Objective Weights

Entropy weight method is a mathematical method used to determine the degree of discrete of a certain indicator, can be based on the degree of difference between the indicators, the use of information entropy, calculated the weight of each indicator. There are m suppliers, n evaluation indicators, each supplier's evaluation indicator values form a matrix X the values of the evaluation indicators of each supplier form a matrix. x_{ij} is the first i of the supplier. j The value of the indicator of the supplier is the first value of the supplier.

(1) Standardization of raw data Data are standardized using the extreme value method, and since there are benefit-type indicators and cost-type indicators, evaluation indicators with different attributes need to be handled differently:

Benefit-based indicators:

$$y_{ij} = \frac{x_{ij} - \min\{x_{ij}\}}{\max\{x_{ij}\} - \min\{x_{ij}\}} \quad (i = 1, 2, \dots, m; j = 1, 2, \dots, n) \quad (2-1)$$

Cost-based indicators:

$$y_{ij} = \frac{\max\{x_{ij}\} - x_{ij}}{\max\{x_{ij}\} - \min\{x_{ij}\}} \quad (i = 1, 2, \dots, m; j = 1, 2, \dots, n) \quad (2-2)$$

(2) Normalize the data:

$$p_{ij} = \frac{y_{ij}}{\sum_{i=1}^m y_{ij}} \quad (2-3)$$

(3) Calculate the information entropy:

$$H_j = -\frac{1}{\ln m} \sum_{i=1}^n p_{ij} \ln p_{ij} \quad (j = 1, 2, \dots, n) \quad (2-4)$$

The coefficient of variation h_j For:

$$h_j = 1 - H_j \quad (2-5)$$

(4) Calculate entropy weights:

$$\omega_j = \frac{h_j}{\sum_{j=1}^n h_j} \quad (2-6)$$

2.2.2. Hierarchical Analysis to Determine Subjective Weights

Hierarchical analysis is a decision-making method that breaks down the factors that are always relevant to decision-making into levels such as objectives, guidelines, and programs, on the basis of which qualitative and quantitative

analyses are conducted. In this paper, we use e_j denote the subjective weight of the j th evaluation index obtained by the hierarchical analysis method. Its calculation steps are as follows:

(1) Establishment of a hierarchical model. Generally when the decision-making problem is transferred to a hierarchical structural model for analysis, the goals and considerations of the decision are divided into the goal level, the guideline level and the program level.

(2) Construct judgment matrix. The factors at the same level are compared between the two, and the judgment matrix is established by using the nine-scaled method to assess the rank according to the degree of importance.

(3) Calculate the relative weights. Calculate the relative weight of the factors on the level relative to the factors on the upper level, the commonly used methods are square root method, sum and product method and eigenvalue method, etc., and this paper adopts the sum and product method to calculate the weight.

(4) Consistency test. Calculation of consistency indicators CI :

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (2-7)$$

λ_{max} is the largest eigenvalue of the judgment matrix, calculate the test coefficient CR :

$$CR = \frac{CI}{RI} \quad (2-8)$$

RI is a random consistency indicator, which can be obtained from the random consistency indicator table, when $CR \leq 0.1$ when, the judgment matrix is considered to have satisfactory consistency.

2.2.3. Geometric Averaging to Determine Composite Weights

The weights obtained from entropy weighting and hierarchical analysis were combined using geometric averaging to obtain a composite weight of θ_j :

$$\theta_j = \sqrt[n]{e_j \times \omega_j} \quad (j = 1, 2, \dots, n) \quad (2-9)$$

3. Gray-based TOPSIS Modeling

The TOPSIS method, also known as the Approximate Ideal Solution Ranking Method, is a multi-objective decision-making method. By calculating the relative closeness of alternative suppliers to the positive and negative ideal solutions, the suppliers are ranked and the best alternative is selected comprehensively. However, the TOPSIS method cannot reflect the level of each index dimension when evaluating suppliers, and it may appear that two suppliers have equal distance to the positive and negative ideal solutions. Gray correlation analysis is mainly used to rank the solutions through the shape or similarity with the ideal solution, to react to the trend of change within the sample and the difference between the sample and the target sample, and to emphasize the correlation between the internal elements of the project, and it is used to improve TOPSIS, which can reflect the status of the change of the indicators within the suppliers, and also the deviation between the suppliers and the target solution. The calculation steps are as follows:

(1) Raw data standardization the raw data are first normalized and then standardized:

$$Z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (3-1)$$

(2) Construct the weighted standardized decision matrix using the indicator weights calculated in Equation 2-9 θ_j the weighted decision matrix is calculated by using the weights of the indicators calculated in Eq. 2-9. B_{ij} (b) Construct the weighted standardized decision matrix:

$$B_{ij} = \theta_j z_{ij} \quad (3-2)$$

(3) Determine the positive and negative ideal solutions:

$$B^+ = (\max_i B_{ij} | j \in J_1), (\min_i B_{ij} | j \in J_2), | i = 1, 2, \dots, m \quad (3-3)$$

$$B^- = (\min_i B_{ij} | j \in J_1), (\max_i B_{ij} | j \in J_2), | i = 1, 2, \dots, m \quad (3-4)$$

Among them: J_1 and J_2 are sets of benefit and cost indicators, respectively.

(4) Calculate the distance from the supplier to the positive and negative ideal solutions:

$$d_i^+ = \sqrt{\sum_{j=1}^n (B_{ij} - B_j^+)^2} \quad (3-5)$$

$$d_i^- = \sqrt{\sum_{j=1}^n (B_{ij} - B_j^-)^2} \quad (3-6)$$

(5) Determine the gray correlation coefficient:

$$s_{ij}^+ = \frac{\min_i \min_j |B_j^+ - B_{ij}| + \rho \max_i \max_j |B_j^+ - B_{ij}|}{|B_j^+ - B_{ij}| + \rho \max_i \max_j |B_j^+ - B_{ij}|} \quad (3-7)$$

$$s_{ij}^- = \frac{\min_i \min_j |B_j^- - B_{ij}| + \rho \max_i \max_j |B_j^- - B_{ij}|}{|B_j^- - B_{ij}| + \rho \max_i \max_j |B_j^- - B_{ij}|} \quad (3-8)$$

(6) Determination of relevance:

$$s_i^+ = \frac{1}{n} \sum_{j=1}^n s_{ij}^+ \quad (3-9)$$

$$s_i^- = \frac{1}{n} \sum_{j=1}^n s_{ij}^- \quad (3-10)$$

(7) Normalization of Euclidean distance and grey correlation:

$$M = M_i / \max M_i \quad (3-11)$$

Where M_i , which can be expressed as d_i^+ , and d_i^- , and s_i^+ , and s_i^- .

(8) Combining normalized Euclidean distance and gray correlation:

$$f_i^+ = \lambda_1 d_i^- + \lambda_2 s_i^+ \quad (3-12)$$

$$f_i^- = \lambda_2 d_i^+ + \lambda_1 s_i^- \quad (3-13)$$

Among them: λ_1 and λ_2 denote the degree of preference of the decision maker for location and shape, and satisfy $\lambda_1 + \lambda_2 = 1$.

(9) Determine the relative closeness of the gray correlation for each alternative supplier D_i :

$$D_i = \frac{f_i^+}{f_i^- + f_i^+} \quad (3-14)$$

D_i The larger the value, the closer the candidate program is to the ideal value.

4. Example Analysis

4.1. Data Sources

Supermarket A, in order to promote the development of fresh food operation under the new retail model and improve its market competitiveness, needs to choose the strongest one among the four strawberry fresh produce suppliers S1, S2, S3, S4 as a strategic partner. According to the information collection of the four suppliers, combined with the scoring of qualitative indicators by experts, the indicator data of the alternative suppliers are collated, see Table 2:

Table 2. Alternative supplier raw data statistics

norm	S1	S2	S3	S4
A11	10	8	8	10
A12	97.90%	98.21%	98.54%	98.9%
A13	100%	100%	100%	98%
A14	8.89	8.33	9.22	9.42
A21	20	19	18	21
A22	1.32	1.29	1.26	1.34
A23	0.25	0	0	0.2
A31	98%	96.7%	99.8%	96.4%
A32	8.42	7.89	9.41	7.42
A33	0.5	1	1	1.5
A34	70%	75%	79%	68%
A41	9.21	9.45	9.33	9.44
A42	8.2	8.97	8.34	8.42
A43	20%	25%	22%	23%
A51	98%	99%	97%	99%
A52	96%	97.8%	98%	99.2%

4.2. Calculation of indicator weights

Calculation of objective weights of indicators
Normalization matrix from Eqs. 2-1 and 2-2

$$Y = \begin{bmatrix} 1.0000 & 0.0000 & 0.0000 & 1.0000 \\ 0.0000 & 0.3100 & 0.6400 & 1.0000 \\ 1.0000 & 1.0000 & 1.0000 & 0.0000 \\ 0.5138 & 0.0000 & 0.8165 & 1.0000 \\ 0.3333 & 0.6667 & 1.0000 & 0.0000 \\ 0.7500 & 0.3750 & 0.0000 & 1.0000 \\ 0.0000 & 1.0000 & 1.0000 & 0.2000 \\ 0.4706 & 0.0882 & 1.0000 & 0.0000 \\ 0.5025 & 0.2362 & 1.0000 & 0.0000 \\ 1.0000 & 0.5000 & 0.5000 & 0.0000 \\ 0.1818 & 0.6364 & 1.0000 & 0.0000 \\ 0.0000 & 1.0000 & 0.5000 & 0.9583 \\ 0.0000 & 1.0000 & 0.1818 & 0.2857 \\ 1.0000 & 0.0000 & 0.6000 & 0.4000 \\ 0.5000 & 1.0000 & 0.0000 & 1.0000 \\ 0.0000 & 0.5625 & 0.6250 & 1.0000 \end{bmatrix}$$

The entropy weight of each indicator is calculated from Equations 2-4 to 2-6 as:

$$\omega_1 = (0.105, 0.059, 0.044, 0.049)$$

$$\omega_2 = (0.057, 0.054, 0.069)$$

$$\omega_3 = (0.088, 0.067, 0.053, 0.070)$$

$$\omega_4 = (0.050, 0.083, 0.054)$$

$$\omega_5 = (0.050, 0.049)$$

Calculation of subjective weights for indicators the

judgment matrix for the first-level indicators is shown in Table 3:

Table 3. Judgement matrix for Tier 1 indicators

Level 1 indicators	A ₁	A ₂	A ₃	A ₄	A ₅
A ₁	1	3	2	3	5
A ₂	1/3	1	1/3	1/3	4
A ₃	1/2	3	1	1/2	3
A ₄	1/3	3	2	1	2
A ₅	1/5	1/4	1/3	1/2	1

The weights of the level 1 indicators were calculated by the sum and product method:

$$e_0 = (0.393, 0.125, 0.195, 0.221, 0.066)$$

$$\lambda_{max} = \frac{1}{5} \times \left(\frac{2.151}{0.392} + \frac{0.650}{0.125} + \frac{1.070}{0.195} + \frac{1.240}{0.221} + \frac{0.350}{0.066} \right) = 5.4$$

Final consistency check.

$$CI = \frac{\lambda_{max} - n}{n - 1} = \frac{5.4 - 5}{5 - 1} = 0.1$$

$$CR = \frac{C.I.}{R.I.} = \frac{0.1}{1.12} = 0.089 < 0.10$$

Inspection passed.

According to the above steps, the judgment matrix and solution of the secondary indicators are shown in Table 4 to Table 8:

Table 4. Judgment matrix for secondary indicator A₁

indicators	A ₁₁	A ₁₂	A ₁₃	A ₁₄	consistency test
A ₁₁	1	2	1	3/2	$\lambda_{max} = 4.09$ $CI = 0.03$ $CR = 0.03 < 0.10$
A ₁₂	1/2	1	1/2	3/4	
A ₁₃	3/4	2	1	2/3	
A ₁₄	2/3	4/3	2/3	1	

Table 5. Judgment matrix for secondary indicator A₂

indicators	A ₂₁	A ₂₂	A ₂₃	consistency test
A ₂₁	1	5/6	5/8	$\lambda_{max} = 3.08$ $CI = 0.04$ $CR = 0.06 < 0.10$
A ₂₂	6/5	1	3/4	
A ₂₃	8/5	5/3	1	

Table 6. Judgment matrix for secondary indicator A₃

indicators	A ₃₁	A ₃₂	A ₃₃	A ₃₄	consistency test
A ₃₁	1	3/2	3/2	6/5	$\lambda_{max} = 4.03$ $CI = 0.01$ $CR = 0.01 < 0.10$
A ₃₂	2/3	1	1	4/5	
A ₃₃	2/3	6/7	1	4/5	
A ₃₄	7/8	5/4	5/4	1	

Table 7. Judgment matrix for secondary indicator A₄

Secondary indicators	A ₄₁	A ₄₂	A ₄₃	consistency test
A ₄₁	1	9/10	9/10	$\lambda_{max} = 3.04$ $CI = 0.02$ $CR = 0.03 < 0.10$
A ₄₂	10/9	1	10/9	
A ₄₃	9/8	1	1	

Table 8. Judgment matrix for secondary indicator A₅

Secondary indicators	A ₅₁	A ₅₂	consistency test
A ₅₁	1	7/5	$\lambda_{max} = 2$ $CR = 0 < 0.10$
A ₅₂	5/7	1	

The calculation gives the weights of the secondary

indicators:

$$e_1 = (0.328, 0.199, 0.254, 0.219)$$

$$e_2 = (0.255, 0.306, 0.439)$$

$$e_3 = (0.317, 0.211, 0.204, 0.268)$$

$$e_4 = (0.306, 0.352, 0.342)$$

$$e_5 = (0.583, 0.417)$$

The combined weights are derived from Equation 2-9, see Table 9:

Table 9. Combined weights of indicators

norm	Subjective weight e_j	objective weighting ω_j	$e_j \times \omega_j$	Combined weights θ_j
A ₁₁	0.328	0.105	0.186	0.085
A ₁₂	0.199	0.059	0.108	0.049
A ₁₃	0.254	0.044	0.105	0.048
A ₁₄	0.219	0.049	0.104	0.047
A ₂₁	0.255	0.057	0.121	0.055
A ₂₂	0.306	0.054	0.129	0.059
A ₂₃	0.439	0.069	0.174	0.079
A ₃₁	0.317	0.088	0.167	0.076
A ₃₂	0.211	0.067	0.119	0.054
A ₃₃	0.204	0.053	0.104	0.047
A ₃₄	0.268	0.070	0.137	0.062
A ₄₁	0.306	0.050	0.124	0.056
A ₄₂	0.352	0.083	0.171	0.078
A ₄₃	0.342	0.054	0.136	0.062
A ₅₁	0.583	0.050	0.171	0.078
A ₅₂	0.417	0.049	0.143	0.065

4.3. Gray TOPSIS-based Model Solving

According to Equations 3-1 and 3-2, each indicator is weighted after standardization, and then according to Equations 3-3 and 3-4, the positive ideal solution is calculated B^+ and negative ideal solution B^- which are shown in Table 10:

Table 10. Weighted normalized matrices and positive and negative ideal solutions

norm	S ₁	S ₂	S ₃	S ₄	B ⁺	B ⁻
A ₁₁	0.0469	0.0375	0.0375	0.0469	0.0469	0.0375
A ₁₂	0.0244	0.0245	0.0245	0.0246	0.0246	0.0244
A ₁₃	0.0241	0.0241	0.0241	0.0236	0.0241	0.0236
A ₁₄	0.0233	0.0218	0.0241	0.0247	0.0247	0.0218
A ₂₁	0.0147	0.0294	0.0441	0.0000	0.0441	0.0000
A ₂₂	0.0299	0.0292	0.0285	0.0303	0.0303	0.0285
A ₂₃	0.0000	0.0553	0.0553	0.0111	0.0553	0.0000
A ₃₁	0.0381	0.0376	0.0388	0.0375	0.0388	0.0375
A ₃₂	0.0273	0.0256	0.0305	0.0241	0.0305	0.0241
A ₃₃	0.0384	0.0192	0.0192	0.0000	0.0384	0.0000
A ₃₄	0.0297	0.0318	0.0335	0.0288	0.0335	0.0288
A ₄₁	0.0276	0.0283	0.0279	0.0282	0.0283	0.0276
A ₄₂	0.0377	0.0412	0.0383	0.0387	0.0412	0.0377
A ₄₃	0.0503	0.0000	0.0302	0.0201	0.0503	0.0000
A ₅₁	0.0389	0.0393	0.0385	0.0393	0.0393	0.0385
A ₅₂	0.0319	0.0325	0.0326	0.0330	0.0226	0.0319

Calculated from equations 3-5 and 3-6:

$$d_i^+ = (0.0630, 0.0569, 0.0296, 0.0797)$$

$$d_i^- = (0.0657, 0.0657, 0.0797, 0.0251)$$

Calculated according to equations 3-7 and 3-8:

$$s_{ij}^+ = \begin{bmatrix} 1.0000 & 0.3333 & 0.3333 & 1.0000 \\ 0.3333 & 0.4202 & 0.5814 & 1.0000 \\ 1.0000 & 1.0000 & 1.0000 & 0.3333 \\ 0.5070 & 0.3333 & 0.7315 & 1.0000 \\ 0.4286 & 0.6000 & 1.0000 & 0.3333 \\ 0.6667 & 0.4444 & 0.3333 & 1.0000 \\ 0.3333 & 1.0000 & 1.0000 & 0.3846 \\ 0.4857 & 0.3524 & 1.0000 & 0.3333 \\ 0.5013 & 0.3956 & 1.0000 & 0.3333 \\ 1.0000 & 0.5000 & 0.5000 & 0.3333 \\ 0.3793 & 0.5789 & 1.0000 & 0.3333 \\ 0.3333 & 1.0000 & 0.5000 & 0.9231 \\ 0.3333 & 1.0000 & 0.3793 & 0.4118 \\ 1.0000 & 0.3333 & 0.5556 & 0.4545 \\ 0.5000 & 1.0000 & 0.3333 & 1.0000 \\ 0.3333 & 0.5333 & 0.5714 & 1.0000 \end{bmatrix}$$

$$s_{ij}^- = \begin{bmatrix} 0.3333 & 1.0000 & 1.0000 & 0.3333 \\ 1.0000 & 0.6173 & 0.4386 & 0.3333 \\ 0.3333 & 0.3333 & 0.3333 & 1.0000 \\ 0.4932 & 1.0000 & 0.3798 & 0.3333 \\ 0.6000 & 0.4286 & 0.3333 & 1.0000 \\ 0.4000 & 0.5714 & 1.0000 & 0.3333 \\ 1.0000 & 0.3333 & 0.3333 & 0.7143 \\ 0.5152 & 0.8500 & 0.3333 & 1.0000 \\ 0.4987 & 0.6792 & 0.3333 & 1.0000 \\ 0.3333 & 0.5000 & 0.5000 & 1.0000 \\ 0.7333 & 0.4400 & 0.3333 & 1.0000 \\ 1.0000 & 0.3333 & 0.5000 & 0.3429 \\ 1.0000 & 0.3333 & 0.7333 & 0.6364 \\ 0.3333 & 1.0000 & 0.4545 & 0.5556 \\ 0.5000 & 0.3333 & 1.0000 & 0.3333 \\ 1.0000 & 0.4706 & 0.4444 & 0.3333 \end{bmatrix}$$

Calculated from equations 3-9 and 3-10:

$$s_i^+ = (0.5709, 0.6142, 0.6762, 0.6359)$$

$$s_i^- = (0.2445, 0.5765, 0.5282, 0.6406)$$

When taking $\lambda_1 = \lambda_2$ When it is taken, it can be obtained according to Eqs. 3-11 to 3-13:

$$f_i^+ = (0.8345, 0.8663, 1.0000, 0.6276)$$

$$f_i^- = (0.5857, 0.8069, 0.5976, 1.0000)$$

The relative closeness of each alternative supplier is calculated according to Equation 3-14:

$$D_i = (0.5876, 0.5177, 0.6259, 0.3856)$$

From the results, it can be seen that the relative closeness of gray correlation for the four alternative suppliers results in: $D_3 > D_1 > D_2 > D_4$, therefore supplier S₃ is the best choice.

5. Conclusion

Under the new retail model, selecting high-quality suppliers and cooperating with them in depth is conducive to fresh produce supermarkets to solve various problems of retail terminals, such as product quality, food safety, and customer satisfaction and so on, and to improve their own competitiveness. Through literature research, expert interviews and other methods, we constructed a supplier selection index system for fresh supermarkets consisting of 5 primary indicators and 16 secondary indicators. The entropy

weight method and hierarchical analysis method are used to determine the comprehensive weights of the indicators to overcome the defects of the single weight solving method. The TOPSIS model improved by gray correlation analysis is constructed, which considers the correlation between indicators and makes the results more scientific and reasonable. The example application shows that the method is easy to operate, the selection results are intuitive, and it provides a reference for the selection of fresh supermarket suppliers.

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