Selection of Blue Swimming Crab Meat Suppliers Using The Method Analytical Hierarchy Process (AHP) and Technique For Order Preference By Similarity To Ideal Solution (TOPSIS) In PT XYZ

Adinda CahyaFitriani[1*], Akhmad Wasiur Rizqi[2], Purwanto[3]

[1,2,3]Program Studi Teknik Industri, Fakultas Teknik, Universitas Muhammadiyah Gresik, Jalan Sumatera N0. 101, Gresik Kota Baru (Gkb) , Kabupaten Gresik , Jawa Timur, 61121, Indonesia

Coresponden Author:

Email: Cahyaadinda70@Gmail.Com

Abstract.

PT XYZ is a business entity operating in the marine product processing sector, with pasteurized canned crab meat as its flagship product. Selecting a raw material supplier of crab meat requires the consideration of several criteria to ensure that the chosen supplier can consistently meet the company's raw material requirements. This study aims to identify the criteria and sub-criteria used in supplier selection, calculate the priority weights of each criterion and sub-criterion, and determine the best supplier alternative. A descriptive quantitative approach was employed, combining the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Primary data were obtained through interviews and the distribution of AHP questionnaires to five respondents, namely the finance staff, document controller, QC supervisor, production supervisor, and laboratory/QC staff. The AHP results indicate that the raw material quality criterion obtained the highest weight of 0.3090, followed by capacity and consistency (0.2059), price (0.2029), standard compliance (0.1919), and delivery (0.0903). At the sub-criteria level, organoleptic freshness recorded the highest global weight, at 0.1879. Meanwhile, the TOPSIS calculation results indicate that Supplier 5 achieved the highest preference value of 0.6143, followed by Supplier 4 (0.5012), Supplier 1 (0.4440), Supplier 3 (0.3584), and Supplier 2 (0.3531). Accordingly, Supplier 5 is recommended as the best alternative supplier of raw crab meat material for PT XYZ.

Keywords: *Supplier Selection, Crab Meat Raw Material, AHP and TOPSIS, Multi-Criteria Decision Making.*

I. INTRODUCTION

One of the factors influencing company performance is suppliers. Therefore, selecting the right supplier is a strategic decision that must be carefully made by companies that rely on suppliers to run their business operations.[1]A supplier is defined as an organization that provides raw materials needed by customers, either in the form of goods or services. Supplier selection is primarily aimed at reducing the level of risk faced by the company while increasing added value for consumers.[2]The availability of raw materials that meet a company's needs can impact product quality, production timeliness, cost efficiency, and the sustainability of operational activities.

PT XYZ is a company engaged in the seafood processing sector, specifically canned pasteurized crab meat. This company is a crab cannery manufacturer whose production is based on orders. Therefore, the company is required to produce goods according to a predetermined timeline.[3]. The problem currently facing PT XYZ is the supplier of raw materials for crabs. The difficulties encountered are related to supplier selection, because sometimes deliveries do not meet the expected schedule, making it difficult for the company to meet customer demand and unable to achieve production capacity. In addition, the quality of goods supplied by suppliers has also decreased. Many suppliers send crabs that do not meet the specified specifications, such as many raw materials that are stale when they arrive at the company, causing production to stop and not be in accordance with the schedule. Sometimes working hours are delayed, even to the point of being closed due to a lack of raw materials that meet standards.

This problem can be seen in more detail from the raw material reject data for the period March to May 2026. Based on company data, the total volume of raw materials rejected from all suppliers reached 2,671,073 kg over three months. The highest reject volume occurred in April at 1,605,567 kg, followed by 748,316 kg in March and 317,190 kg in May. Supplier 5 recorded the highest absolute reject volume, namely 562,066 kg in March, 1,494,947 kg in April, and 144,318 kg in May.

The high volume of rejected raw materials shows that the suitability of the quality of raw materials is an important aspect in selecting suppliers.[4]In the conditions of the company studied, rejected raw materials had to be

returned to the supplier, which could lead to raw material shortages, production line shutdowns, and delayed product delivery schedules to customers. This situation demonstrates the need for a more measured supplier evaluation that considers several relevant criteria.In supply chain management, supplier selection is a crucial decision because it involves evaluating a number of interrelated criteria that need to be analyzed simultaneously. [5].

In an era of globalization and increasingly fierce competition, Supply Chain Management (SCM) has become a crucial element influencing a company's success in maximizing its operational performance. SCM serves not only as a means of managing the flow of goods, information, and finances within the supply chain, but also as a strategy to increase a company's efficiency and competitiveness.[5].

*Supply Chain Management*is a system of organizations that focuses on production and services provided to consumers. This chain describes a network between organizations that have the same goals and are connected in managing logistics or distribution of goods to customers.[6]The Multi-Criteria Decision Making (MCDM) model is a method for determining a decision by simultaneously considering several criteria through a process of evaluating and selecting available alternatives. Each alternative considered in this multi-criteria decision-making process can be described using various types of criteria, both qualitative and quantitative.[7].

The MCDM approach used in this study is a combination of the AHP and TOPSIS methods.[8]The AHP method is used to determine the weight of each criterion, while the TOPSIS method is applied for the ranking stage.[9]. The application of AHP in problems involving several levels of criteria is also used by[10]to determine the weighting of performance attributes in supply chain performance measurement using the SCOR model. The weighting results are used to determine the priority of performance attributes that need to be improved. The application of the integration of the AHP and TOPSIS methods in determining alternative priorities is also carried out by[11].In this study, the AHP approach is applied to obtain values for each criterion, which will later be used as input in the TOPSIS calculation process to determine the priority of choices based on how close they are to the positive and negative ideal solutions.

Various previous studies have shown that combining AHP and TOPSIS techniques can improve the supplier assessment process, making it more objective, planned, consistent, and can be clearly measured in the decision-making process. [12][8][13].To maintain a focused and directed analysis, this study establishes a number of specific problem limitations. This study specifically evaluates and selects suppliers for crab meat raw materials at PT XYZ using the AHP and TOPSIS approaches, which consider a number of criteria including quality, price, delivery time, capacity, as well as supply consistency and compliance with established standards. The purpose of this study is to establish criteria and priority weights in the process of selecting crab meat raw material suppliers, while identifying the best alternative supplier options through the application of the AHP and TOPSIS methods.

II. RESEARCH METHODS

*Approach*Study

The method applied in this study is descriptive quantitative with a case analysis on the process of selecting suppliers of raw materials for crab meat at PT XYZ. Through this approach, the assessment and determination of alternative suppliers are carried out in a structured manner by applying MCDM, namely combining the AHP and TOPSIS methods. The descriptive quantitative approach is also used by[14]In Industrial Engineering research, the aim is to systematically describe the condition of the research object based on numerical data and determine improvement priorities. Data in this study were obtained through observation, interview, and questionnaire methods, in accordance with the approach used by[15]to obtain information regarding the condition of the research object and user needs as a basis for analysis. The overall research process flow is depicted in Figure 1.

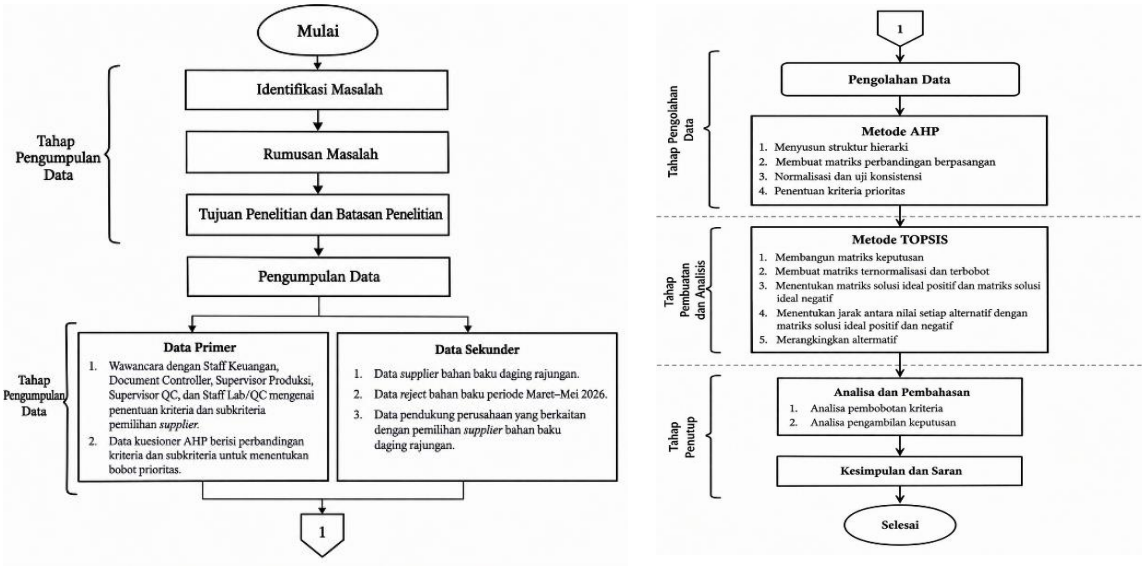


Fig. e1. Research Flow

Data collection

This study utilizes two categories of data, namely primary data and secondary data.Primary data was obtained through interviews and questionnaires distributed to sources familiar with the supplier selection process, including finance staff, document controllers, quality control supervisors, production supervisors, and lab/quality control staff. Observation, interviews, and questionnaires were also used as data collection techniques.[16]in obtaining research data. The data collected included criteria, sub-criteria, and an assessment of five alternative suppliers of crab meat raw materials.On the other hand, secondary data was obtained through company documents and information related to suppliers of crab meat raw materials.

Data processing

The data processing procedure in this study was carried out in stages by combining AHP and TOPSIS techniques.Using Microsoft Excel, AHP was applied to obtain the importance weights for each criterion and subcriteria, as well as the priority values for each supplier.The results of the AHP calculation will be used as data to calculate TOPSIS so that preference values and supplier priority order can be obtained.The resulting ranking serves as the basis for determining the most appropriate supplier of crab meat raw materials for PT XYZ.

1. AHP method

AHP is a method for decision-making that involves various criteria, proposed by Thomas L. Saaty, and can be used to solve decision-making problems that involve qualitative and quantitative elements.[17]. The application of AHP is carried out to determine the priorities of various criteria and alternatives by forming a hierarchical structure involving criteria and sub-criteria within it.[18]. Assessment between elements in the hierarchy is carried out using pairwise comparison as a basis for obtaining the priority value of each element.[19]The weighting results can then be used to determine alternative priorities and to test the consistency of the assessments given.[18],[19].

The AHP method is processed through several stages as follows:

a. Define the priority levels of criteria and sub-criteria by referring to the assessments given by respondents.

b. Conduct a comparison between each criterion and subcriteria using a pairwise method based on the AHP importance scale ranging from 1 to 9.

c. A normalized comparison matrix is used to obtain the priority weights of each criterion and subcriteria.

d. The results of the pairwise comparisons are then tested for consistency to ensure the accuracy and consistency of the assessment.[19],[20].

The values used in pairwise comparisons are determined based on the AHP importance intensity scale, ranging from 1 to 9, as developed by Saaty. The importance intensity scale can be seen in Table 1.[21]:

Table1. Pairwise comparison rating scale

Intensity of Interest	Information
1	These two factors have a comparable impact.
3	Experience and evaluation usually focus more on one aspect than others.
5	Based on experience and evaluation, there is often a tendency to give more focus to one aspect than another.
7	An element is highlighted and appears dominant when compared to comparable elements.
9	An element is proven to have a much higher level of popularity compared to other elements, with the strongest level of confidence.
2,4,6,8	This occurs when there is doubt in the assessment between two very similar assessments.
The opposite	If activity i has a certain value when compared with activity j, then the value obtained by activity j is the inverse (reciprocal) of that value.

e. Consistency test

To measure the level of consistency of assessments in the pairwise comparison matrix, a consistency test is performed. The initial step is to multiply the pairwise comparison matrix by the weighted priority vector to obtain the Weighted Sum value. Next, the Eigenvalue for each criterion is determined by dividing the Weighted Sum value by the priority weight of each criterion. This value is then used to calculate the maximum eigenvalue (λ_max)[22],[23]. Calculationλ_maxdone using the following formula:

$$\lambda_{max} = \frac{\sum_{i=1}^{n} \lambda_i}{n} \quad (1)$$

Information:

λ_max :highest eigenvalue

λ_i : Eigenvalue value for each criterion

n :the number of criteria being compared

f. CI calculation is done using the following formula[24]:

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

Information**:**

CI : Consistency Index

λ_{max} :highest eigenvalue

n : total elements compared in the matrix

g. The Consistency Ratio (CR) is then calculated. The comparison matrix is said to be consistent if the CR is ≤ 0.1. If the value is greater, the pairwise comparison process needs to be reviewed.[25].

$$CR = \frac{CI}{IR} \quad (3)$$

Information :

CR : Consistency Ratio

IR : Random Consistency Index

IR values can be seen in Table 2:

Table2. Consistent random index values

Matrix	1.2	3	4	5	6	7	8	9	10	11	12	13	14
R-value	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57

2. TOPSIS method

The TOPSIS method is a strategy for making decisions that involves many criteria, with the aim of determining the best choice among the various options available, based on previously determined criteria.[26]The TOPSIS method was introduced by Yoon and Hwang in 1981 as an approach to multicriteria decision-making. This method determines the best alternative based on its proximity to the positive ideal solution and its distance from the negative ideal solution.[27]. The AHP method in this study functions to determine the priority weight of each criterion and sub-criteria, while the TOPSIS method functions to sort

supplier alternatives according to the weights generated through the AHP method.[28]. There are several steps for the TOPSIS method according to[29]:

a. Calculate the normalized decision matrix using the formula listed in equation (4):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (4)$$

b. Weighted matrix normalization

To obtain a weighted normalized matrix, the normalized value is multiplied by the weight of each subcriterion.

$$y_{ij} = w_j \times r_{ij} \quad (5)$$

c. Calculating the value(A^+) and (A^-).

The determination of the positive ideal solution (A^+) and the negative ideal solution (A^-) is done by using the values from the weighted normalized matrix. Since all research subcriteria include benefit attributes, the highest value for each subcriteria is used to form the positive ideal solution, while the lowest value is used as the negative ideal solution.[30].

$$A_j^+ = \max_i (y_{ij}) \quad (6)$$
$$A_j^- = \min_i (y_{ij})$$

d. Determine the distance of each alternative

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (y_{ij} - A_j^+)^2} \quad (7)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij} - A_j^-)^2} \quad (8)$$

Information:

D_i^+ :*Supplier*i-th ideal solution +

D_i^- :*Supplier*i-th ideal solution -

e. Determining preference values

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (9)$$

III. RESULTS AND DISCUSSION

In this study, a hierarchical decision structure was constructed by placing the supplier selection objective as the first level, while subsequent levels consist of a number of criteria and sub-criteria that are used as considerations in evaluating suppliers. Characters were determined based on the results of interviews and questionnaires with five respondents, including finance staff, document controllers, production supervisors, quality assurance supervisors, and laboratory/QC staff. Based on the data analysis that has been conducted, there are five criteria and ten sub-criteria that are used as guidelines in determining suppliers of raw materials for crab meat at PT XYZ. Details regarding these criteria and sub-criteria can be found in the table below:

Table3Criteria and sub-criteria

Criteria	Subcriteria
Raw Material Quality (K1)	Organoleptic Freshness (Smell, Color, Texture) (SK 1.1)
	Crab Grade / Size (SK 1.2)
Price (K2)	Price per Kg (SK 2.1)
	Price Stability (SK 2.2)

Shipping (K3)	Timeliness of Delivery (SK 3.1)
	Distance from Supplier to Factory (SK 3.2)
Capacity & Consistency (K4)	Consistent Supply Volume (SK 4.1)
	Ability to Meet Order Surge (SK 4.2)
Standard Compliance (K5)	HACCP / SNI Compliance (SK 5.1)
	Antibiotic Residue Free (SK 5.2)

Based on established criteria and sub-criteria for evaluating crab meat raw material suppliers, this study used five alternative suppliers deemed capable of meeting the company's raw material needs. These five alternatives consist of Supplier 1, Supplier 2, Supplier 3, Supplier 4, and Supplier 5. Supplier codes are used to maintain the confidentiality of each supplier's identity.

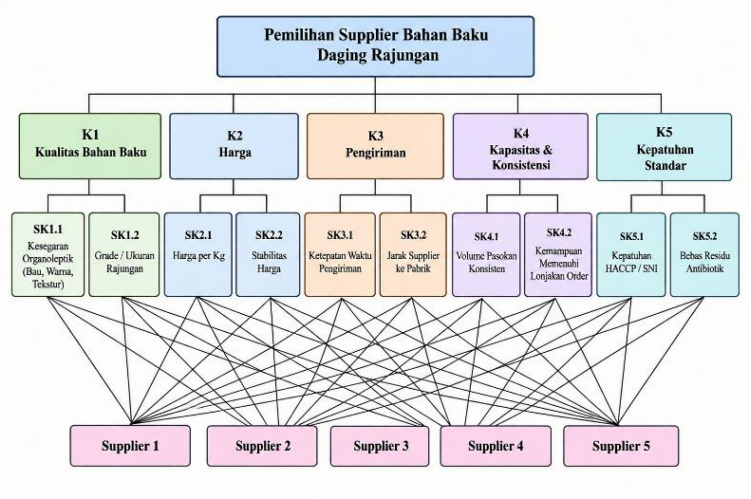


Fig. 2. Hierarchical structure

The questionnaire data from five respondents was then processed using pairwise comparisons to determine the importance of the main criteria in selecting a supplier for crab meat. The results of this comparison are shown in the table below:

Table4. Pairwise comparison matrix between criteria

Criteria	K1	K2	K3	K4	K5
K1	1,0000	1.6438	5,1940	1,1076	1,3797
K2	0.6084	1,0000	1.6829	1.3875	1.0845
K3	0.1925	0.5942	1,0000	0.3309	0.6310
K4	0.9029	0.7207	3,0219	1,0000	0.8706
K5	0.7248	0.9221	1,5849	1.1487	1,0000
Amount	**3.4286**	**4,8808**	**12,4837**	**4,9747**	**4,9657**

The next step is to normalize the pairwise comparison matrix, dividing each element in a column by the total value of the column. Next, each row is averaged to obtain the priority weights for each criterion. These weights are then used to calculate the weight sum vector and consistency vector, as part of the consistency testing phase of the pairwise comparison matrix.

Table5. Matrix normalization, priority weights, and criteria consistency

Criteria	K1	K2	K3	K4	K5	Amount	Priority Weight	Vector Consistency	Rank
K1	0.2917	0.3368	0.4161	0.2226	0.2778	1,5450	0.3090	5,1923	1
K2	0.1774	0.2049	0.1348	0.2789	0.2184	1.0144	0.2029	5,1095	3
K3	0.0561	0.1217	0.0801	0.0665	0.1271	0.4516	0.0903	5,0886	5
K4	0.2633	0.1477	0.2421	0.2010	0.1753	1,0294	0.2059	5,2025	2
K5	0.2114	0.1889	0.1270	0.2309	0.2014	0.9596	0.1919	5,1200	4
Amount	1,0000	1,0000	1,0000	1,0000	1,0000	5,0000	1,0000	**25,7129**	

Afterward, the reliability of the previously generated priority weights is verified. This test is performed by multiplying the pairwise comparison matrix by the priority weights of each criterion to obtain the Weighted Sum value. The eigenvalue (λ) is then calculated by dividing the Weighted Sum value of each criterion by its relevant priority weight.

$$\lambda_i = \frac{WS_i}{W_i}$$

Table6. Results of the Eigenvalue calculation

Criteria	*Weighted Sum*	Priority Weight	*Eigenvalue*
K1	1.6044	0.3090	5,1921
K2	1,0367	0.2029	5,1092
K3	0.4596	0.0903	5,0893
K4	1,0711	0.2059	5,2019
K5	0.9826	0.1919	5,1203

After obtaining the Eigenvalue for each criterion, the next step is to determine the λ_max value, which is calculated based on the average value of all existing Eigenvalues.

$$\lambda_{max} = \frac{\sum_{i=1}^{n} \lambda_i}{n}$$ n = 5, then $$\lambda_{max} = \frac{5,1921+5,1092+5,0893+5,2019+5,1203}{5} = 5,1426$$

The next step is to calculate the Consistency Index (CI) as an indicator to evaluate the level of inconsistency in the pairwise comparison matrix. The index is calculated using the following equation:

$$CI = \frac{\lambda_{max}-n}{n-1}$$ n=5, then $$CI = \frac{5,1426-5}{5-1} = 0,0356$$

The next step is to calculate the CR value using the RI value. Since the number of criteria applied is n=5, the RI value used is 1.12. The process of calculating the Consistency Ratio value is carried out using the following equation:

$$CR = \frac{CI}{RI}$$ so $$CR = \frac{0,0356}{1,12} CR = 0,0318$$

Since the CR value obtained is 0.0318, which is lower than 0.10, the pairwise comparison matrix between the main criteria is consistent. This indicates that the priority weights obtained can be used as a guideline in the next AHP calculation process, namely determining the weights of the subcriteria.

The next stage of data processing is determining the weight of each sub-criteria using the AHP method. To find the global weight, multiply the criterion weight and the sub-criteria weight. The summary of the criterion, sub-criteria, and global weights is displayed in the following table.

Table7. Global Weight Recapitulation

Criteria	Criteria Weight	Subcriteria	Subcriteria Weight	Global Weight
K1	0.3090	SK1.1	0.6081	0.1879
		SK1.2	0.3919	0.1211
K2	0.2029	SK2.1	0.4836	0.0981
		SK2.2	0.5164	0.1048
K3	0.0903	SK3.1	0.6217	0.0562
		SK3.2	0.3783	0.0342
K4	0.2059	SK4.1	0.7974	0.1642
		SK4.2	0.2026	0.0417
K5	0.1919	SK5.1	0.3975	0.0763
		SK5.2	0.6025	0.1156
Total	1,0000			1,0000

Based on the overall weight summary obtained by the AHP method, these weights are then used as weights for the subcriteria in the TOPSIS calculation. The results of the priority order of each supplier across all subcriteria obtained through the AHP process are then used to form values in the TOPSIS decision matrix.

Thus, the decision matrix in the TOPSIS stage utilizes the results of the AHP, which are then normalized to determine supplier rankings. The decision matrix used in this study can be seen in Table 8.

Table8. Supplier selection decision matrix

Subcriteria	*Supplier*1	*Supplier*2	*Supplier*3	*Supplier*4	*Supplier*5
SK 1.1	0.2797	0.1132	0.2313	0.1810	0.1948
SK 1.2	0.1774	0.1271	0.1600	0.2154	0.3202
SK 2.1	0.2537	0.3380	0.1704	0.1266	0.1113
SK 2.2	0.2180	0.2748	0.1678	0.1783	0.1612
SK 3.1	0.2738	0.2659	0.1556	0.1858	0.1189
SK 3.2	0.1348	0.3054	0.2490	0.1688	0.1420
SK 4.1	0.1060	0.1475	0.1467	0.2706	0.3291
SK 4.2	0.1483	0.1507	0.1048	0.2257	0.3705
SK 5.1	0.1263	0.1937	0.1295	0.2662	0.2843
SK 5.2	0.1486	0.1618	0.1926	0.2317	0.2653

After the decision matrix is obtained, the next step is to normalize the value of each alternative for each sub-criterion using formula (4). The normalized value is then multiplied by the global weight of each sub-criterion according to formula (5), thus obtaining a weighted normalized matrix. This step aims to consider the level of importance of each sub-criterion in the evaluation process for each supplier alternative. The results of the weighted normalized matrix calculation are presented in the following table.

Table9. Weighted Normalized Matrix

Subcriteria	*Supplier*1	*Supplier*2	*Supplier*3	*Supplier*4	*Supplier*5
SK 1.1	0.1133	0.0458	0.0937	0.0733	0.0789
SK 1.2	0.0456	0.0327	0.0411	0.0553	0.0823
SK 2.1	0.0512	0.0683	0.0344	0.0256	0.0225
SK 2.2	0.0500	0.0630	0.0385	0.0409	0.0369
SK 3.1	0.0329	0.0319	0.0187	0.0223	0.0143
SK 3.2	0.0098	0.0221	0.0180	0.0122	0.0103
SK 4.1	0.0358	0.0498	0.0496	0.0914	0.1112
SK 4.2	0.0125	0.0127	0.0088	0.0191	0.0313
SK 5.1	0.0205	0.0314	0.0210	0.0431	0.0460
SK 5.2	0.0375	0.0409	0.0487	0.0585	0.0670

Once the weighted normalized matrix is obtained, the next step is to determine the positive ideal solution (A^+) and the negative ideal solution (A^-). Since all sub-criteria used are of the benefit type, the highest value for each sub-criterion is used to form the positive ideal solution, while the lowest value is used to determine the negative ideal solution. The results of the calculations for both ideal solutions can be seen in the following description.

Table10. Positive ideal solution and negative ideal solution

	SK1.1	SK1.2	SK2.1	SK2.2	SK3.1	SK3.2	SK4.1	SK4.2	SK5.1	SK5.2
Positive (A+)	0.1133	0.0823	0.0683	0.0630	0.0329	0.0221	0.1112	0.0313	0.0460	0.0670
Negative (A-)	0.0458	0.0327	0.0225	0.0369	0.0143	0.0098	0.0358	0.0088	0.0205	0.0375

In the next step, the distance between each supplier alternative and the positive ideal solution (A^+) and the negative ideal solution (A^-) is calculated to identify the alternative's level of proximity to the ideal solution. The results of these distance calculations are then used to obtain preference values for each alternative, which form the basis for determining supplier rankings. Details of the distance values, preferences, and alternative rankings are presented in Table 11.

Table11. Alternative supplier ranking results

Alternative	Distance to Positive Ideal Solution (D+)	Distance to Negative Ideal Solution (D-)	Preference Value	Rank
*Supplier*1	0.0976	0.0779	0.4440	III
*Supplier*2	0.1096	0.0598	0.3531	V
*Supplier*3	0.0965	0.0539	0.3584	IV
*Supplier*4	0.0739	0.0743	0.5012	II
*Supplier*5	0.0667	0.1061	0.6143	I

Based on the results of data processing using the TOPSIS method, there are differences in preference values among the five alternative suppliers. The highest preference value was obtained by supplier 5, which was 0.6143, which placed it in the top ranking. Next, supplier 4 was in second place with a value of 0.5012, followed by supplier 1 with a value of 0.4440. Supplier 3 obtained a value of 0.3584, while supplier 2 obtained a value of 0.3531. From these results, supplier 5 can be concluded as the best alternative recommended for procurement of raw materials for crab meat at PT XYZ.

IV. CONCLUSION

The results of data processing and analysis using the AHP method show that raw material quality (K1) is the criterion with the highest level of importance in selecting crab meat suppliers, with a weight of 0.3090. Followed by the capacity and consistency criteria (K4) with a weight of 0.2059, price (K2) of 0.2029, standard compliance (K5) of 0.1919, and delivery (K3) of 0.0903. At the sub-criteria level, organoleptic freshness (SK1.1) was recorded as having the highest global weight of 0.1879, making it the most emphasized aspect in the evaluation of crab meat raw material suppliers. Furthermore, the calculation using the TOPSIS method revealed that supplier 5 obtained the highest preference value, namely 0.6143, and was ranked first, then there was supplier 4 (0.5012) in second place, supplier 1 (0.4440) in third place, supplier 3 (0.3584) in fourth place, and supplier 2 (0.3531) in fifth place. Therefore, supplier 5 was considered the most appropriate alternative to be recommended to PT XYZ in procuring raw materials for crab meat, considering its highest level of proximity to the ideal solution based on all the subcriteria applied.

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