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Analysis and Prioritization of Beef Suppliers in Meatball Grinding MSMEs Using the Analytical Hierarchy Process (AHP) Method

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Abstract: Analysis and Priority Determination of Beef Suppliers in a Meatball Grinding SME Using the Analytical Hierarchy Process (AHP) Method Competition in the food industry, including bakso (meatball) milling businesses, demands precise decision-making in selecting suppliers for the main raw material, namely meat. Improper supplier selection can negatively impact product quality, operational costs, and business sustainability. The Analytical Hierarchy Process (AHP) method is used in this study to determine the best meat supplier for a meatball milling business at Tiban Market Center. The Analytical Hierarchy Process (AHP) method is used to structure the multi-criteria selection problem hierarchically and conduct pairwise comparison assessments of various criteria, such as availability, price, quality, and delivery timeliness. Three meat suppliers were evaluated as alternatives. Data collection was carried out through interviews, pairwise comparison questionnaires, and observations. The Analytical Hierarchy Process (AHP) analysis results show that the most important criterion is quality (weight 46.58%), followed by Timeliness (27.71%), Price (16.11%), and Availability (9.60%). The consistency test (CR = 0.0146) indicates that the evaluation is valid. Supplier 2 (0.5614) was chosen as the best supplier due to superior quality, although its price was not the lowest. Supplier 2 outperformed Supplier 1 (0.4714) and Supplier 3 (0.2786), respectively. These results provide a data-driven recommendation for the bakso milling business to select the supplier that best aligns with product quality and customer satisfaction.

Keyword: Analytical Hierarchy Process, Supplier Selection, Meatball Milling, Small and Medium Enterprise.

INTRODUCTION

With increasing competition in the industry, supplier selection is a crucial factor influencing the success and sustainability of a business's operations. This is especially true for meatball milling MSMEs, which rely heavily on the availability and quality of their primary raw material, meat. The increasing number of meat suppliers on the market has created intense competition, both in terms of price, product quality, service, and delivery.

Supplier selection cannot be done subjectively or solely based on the lowest price; it requires consideration of various interrelated factors. Without a sound and structured decision-making process, supplier selection risks being suboptimal, which can ultimately lead to production problems such as supply delays, inconsistent meat quality, and increased operational costs.

The Analytical Hierarchy Process (AHP) method has proven efficient in facilitating multi-criteria-based research decision-making.(Mulya, 2021)This approach is highly applicable for evaluating variables such as financial aspects, distribution duration, and supplier service quality. Furthermore, AHP facilitates the systematic determination of importance weights between criteria through pairwise comparison techniques, resulting in a more accurate priority structure.(Setiyawan et al., 2020).

Developed by Thomas L. Saaty in the 1970s, the Analytical Hierarchy Process (AHP) is an analytical technique for solving decision-making problems with multiple criteria. This instrument works by organizing complex problems into a hierarchical structure that includes primary objectives, criteria, sub-criteria,

As well as various alternative options. AHP provides a systematic framework for integrating subjective and objective assessments in the decision-making process. The basic principles of AHP are problem decomposition, comparative assessment, and priority synthesis. Problem decomposition is done by breaking down complex problems into simpler elements and structured in a hierarchical form. Comparative assessment involves pairwise comparisons between elements at the same hierarchical level using a numeric scale of 1–9 developed by Saaty.(Adzaki et al., 2023).

According to(Saputra & Nugraha, 2020)AHP is a structured method that facilitates the analysis of complex decisions through pairwise comparison techniques to determine priorities between alternatives. A significant advantage of this method lies in its ability to combine quantitative and qualitative aspects, as well as its validation feature in the form of a Consistency Ratio (CR). An assessment is considered valid if the CR value does not exceed 0.1. Furthermore, the presence of sensitivity analysis in AHP strengthens the reliability (robustness) of decisions by testing the effect of changes in criteria weights on the final result.

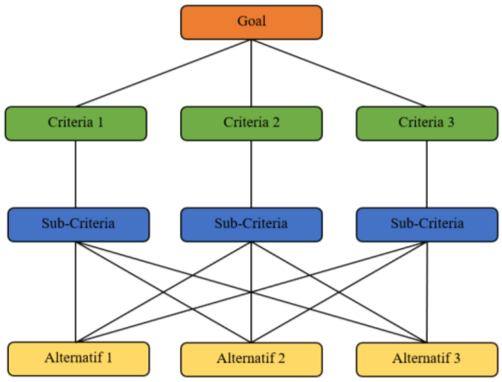
The implementation of the AHP method in the meatball milling industry serves as a strategic tool for evaluating and identifying superior meat suppliers. This analysis covers various crucial indicators, from price and quality to distribution accuracy and service quality. Through this approach, business owners can make more informed decisions to ensure production efficiency and market competitiveness. The output of this study is a prioritized supplier ranking that will help business units meet operational standards and consumer expectations.(Hanifah & Wiranthi, 2021;Setiawan & Hartini, 2022).

METHODS

Research Approach

This study adopts the Analytical Hierarchy Process (AHP) method pioneered by Thomas L. Saaty as a decision-making framework. This approach is applied to unravel complex problems through the development of a hierarchical structure, conducting pairwise comparisons between elements, determining priority weights, and testing the logical consistency of each preference. The AHP was selected based on its ability to integrate qualitative and quantitative variables, resulting in objective and systematic decision recommendations. The operational stages of the AHP in this study consist of:

1. Developing a hierarchical structure: The initial stage is to formulate the main objective (selecting the best supplier), establish the criteria that influence the decision (such as price, quality, timeliness, and availability), and identify alternative meat suppliers in Batam. The hierarchical structure is shown in Figure 1.



Picture1. Hierarchical Structure

2. Making pairwise comparisons: Comparisons are made between criteria and between alternatives for each criterion. Decision makers rate the criteria using a priority scale from 1 to 9 according to the Saaty scale. The importance scale is shown in Table 1.

Table1.Degree of Interest

Intensity of Interest	Information
1	Both elements have the same level of importance.
3	One element is slightly more important than the other elements.
5	One element is considered quite important compared to other elements.
7	One element is considered very important compared to other elements.
9	One element has an extreme level of importance compared to other elements.
2,4,6,8	Values that are between two adjacent assessments.
Reciprocal	If element I has one of the above numbers compared to element J, then element J has the opposite value.

3. Calculating priority weights and consistency: After the pairwise comparison data is obtained, the next step is to calculate the weight or degree of importance for each element tested. To ensure the reliability of the results, a Consistency Ratio (CR) test is performed to validate that the decision maker's assessment has consistent logic. According to applicable standards, assessment results are declared valid and acceptable if the CR value does not exceed the threshold of 0.1.
4. Determining the final result: After all weights are calculated, the scores are aggregated to obtain a final ranking for each supplier alternative. The alternative with the highest weight will be selected as the best meat supplier.

Multi-criteria Decision Making and Analytical Hierarchy Process (AHP)

The problem of supplier selection is inherently multi-criteria, involving the consideration of a variety of factors that are often qualitative and quantitative, and sometimes conflicting (e.g., low price versus high quality). (Ramadhon et al., 2021). To support systematic evaluation of alternatives, an organized Multi-Criteria Decision Making (MCDM) approach is required. (Lubis et al., 2024 ;Sitanggang, 2018). The Analytical Hierarchy Process (AHP), introduced by Thomas L. Saaty in the 1970s, is one of the most widely implemented MCDM techniques. This method facilitates decision makers in decomposing complex problems into a hierarchical model, which includes objectives, criteria, sub-criteria, and available alternative choices. The main advantage of AHP lies in its ability to accommodate qualitative and quantitative data through a pairwise comparison mechanism, where decision makers assess the relative preference between two elements at the same hierarchical level using a numeric scale (Saaty's 1-9 scale). This process produces priority weights for each criterion and an overall score for each alternative, and provides a consistency measure (Consistency Ratio - CR) to evaluate the validity of the assessment (Paliling, 2022).

AHP Application in Supplier Selection

The AHP method has been widely applied in various supplier selection contexts across various industries. Numerous studies have demonstrated the effectiveness of AHP in ranking suppliers based on multi-criteria evaluation. (Latif & Wahyuning, 2024)For example, AHP is used to select suppliers of crab raw materials with ARAS integration. (Mulya, 2021), as well as the selection of suppliers of retail products and consumer goods using the AHP approach (Syahputra et al., 2024). Some studies also integrate AHP with other MCDM methods such as Simple Additive Weighting (SAW), Additive Ratio Assessment (ARAS), or Multi-Factor Evaluation Process (MFEP) to overcome certain limitations or utilize the advantages of each method.(Diana & Achadiani, 2022). Consistently, these studies highlight AHP's ability to structure problems, accommodate decision-maker preferences, and produce more objective supplier recommendations.

Supplier Selection Criteria in the Food Industry

Selecting the right criteria is a fundamental step in the AHP process. In the food industry context, some common criteria often considered important include price, product quality, delivery reliability or timeliness, supply capacity or availability, and customer service. Raw material quality is often a top priority because it directly impacts the safety, taste, and perception of the final product by consumers. In the food supply chain, factors such as response time, ability to meet demand, and communication systems are also crucial. This study adopted the criteria of Price, Quality, Timeliness, and Availability, which align with common criteria found in relevant literature for the food industry and MSME contexts.

Data collection technique

The data used in this study were obtained through:

1. interviews with employees of meatball milling MSMEs to identify important criteria in selecting beef suppliers based on their experience and views.
2. completing a paired comparison questionnaire to assess the level of importance of each criterion and alternative.
3. field observations to understand market conditions and the quality of raw materials offered by suppliers.

With this approach, the research results are expected to provide accurate and applicable recommendations in making decisions regarding the optimal selection of meat suppliers.

Calculation of Weight and Consistency in the AHP Method

Calculating weights and consistency is a crucial step in the AHP method, determining the validity and reliability of decision-making results. Weighting in AHP is carried out through a series of systematic steps, starting with compiling a pairwise comparison matrix, normalizing the matrix, and calculating the eigenvectors, which represent the priority weights of each element. This process allows decision-makers to quantify subjective preferences into numerical values that can be used in further analysis.(Joss & Cahyaningtyas, 2025;Dean of Putri & Kurniadi, 2025).

The first step in calculating weights is to construct a pairwise comparison matrix based on the decision maker's assessment using the Saaty scale of 1-9. The pairwise comparison matrix A with elements in this matrix indicates how important criterion or alternative i is compared to criterion or alternative j, usually using the nine-point Saaty scale, where a value of 1 means equally important and a value of 9 means very important. Pairwise Comparison Matrix (A) Representation: A pairwise comparison matrix is a square matrix where each entry represents a relative comparison value between element i and element j.$A = [a(i,j)]A = [a(i,j)]$

1. $a_{ij}$where is the comparative value of element i to element j.
2. $a_{ji}$is the comparison value of element j to element i. In AHP, relationships apply $a_{ij} = {}^{1}/_{a_{ji}}$
3. $a_{ii}$is the comparative value of an element with itself, which is always 1.

The next step after constructing the pairwise comparison matrix is to normalize the matrix. This process is performed by dividing each element's value in column j by the total of all values in the same column. The normalized matrix R with elements r_ij can be calculated using the formula:

$$r_{ij} = {}^{a_{ij}}/_{\sum a_{ij}} \quad , i = 1, 2, 3, \ldots, n \qquad (1)$$

The priority weight (w_i) for each element i is then calculated by averaging the values in row i of the normalized matrix:

$$w_i = \frac{(\sum r_{ij})}{n} \quad , i = 1, 2, 3, \ldots, n \qquad (2)$$

The next stage involves consistency testing to ensure that the preferences set by decision makers have an adequate level of reliability. This validation procedure is implemented by calculating the Consistency Index (CI) and Consistency Ratio (CR). To calculate the CI, first calculate the maximum eigenvalue (λ_max) using the formula:

$$\lambda max = \Sigma\left(\frac{\Sigma(a_{ij} \times w_j)}{n}\right), i, j = 1, 2, \ldots, n \qquad (3)$$

Or with another approach:

$$\lambda max = \Sigma\left(\frac{\Sigma(AW_i)}{n \times w_i}\right), i = 1, 2, \ldots, n \qquad (4)$$

Where *AWi*is the i-th element of the vector resulting from multiplying matrix A by the weight vector W.*Consistency Index*(CI) is then calculated using the formula:

$$CI = \frac{\lambda max - n}{n-1} \qquad (5)$$

Where n is the number of elements being compared. *Consistency Ratio*(CR) is calculated by dividing CI by*Random Index*(RI) which is a random consistency index whose value depends on the size of the matrix n:

$$CR = \frac{CI}{RI} \quad (6)$$

The RI values for various matrix sizes n can be seen in Table 2.

Table2.Random Consistency Index

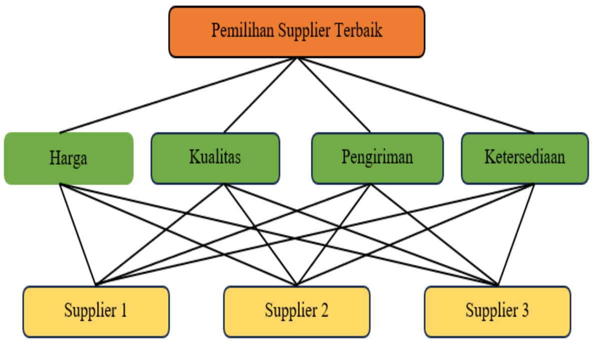
N	1.2	3	4	5	6	7	8	9	10	11	12	13	14	15
Republic of Indonesia	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Novrisal and Fazriah (2023)states that the level of assessment consistency is considered adequate if the Consistency Ratio (CR) does not exceed 0.1 or 10%. If this figure exceeds the specified limit, the decision maker is required to evaluate and revise the assessment until it reaches the required consistency standard. The validity and reliability of the final decision depend heavily on this consistency, as inconsistent assessments risk producing incorrect priority weights and suboptimal decisions.

RESULTS AND DISCUSSION

Hierarchical Structure Compilation

The first step in implementing the AHP method is identifying criteria. These criteria are determined based on the conditions and problems encountered in the meatball milling process, namely price, quality, timeliness, and availability. Next, a hierarchical structure is created based on the problems, as shown in Figure 2.



Picture2.Hierarchical Structure Compilation

Calculation of Weight Comparison and Consistency

Next, a weight comparison is performed to determine weight and consistency. The pairwise comparison matrix for the criteria is compiled as shown in Table 3.

From this comparison, the weight (eigenvector) of each criterion is calculated using the normalization matrix approach.

Table3.Degree of Importance

Criteria	Price	Quality	Delivery	Availability
Price	1	0.333	0.5	2
Quality	3	1	2	4
Delivery	2	0.5	1	3
Availability	0.5	0.25	0.333	1
total	6.5	2,083	3,833	10

Source: Processed data, 2025

Table4.Criteria Value Matrix

Criteria	Price	Quality	Delivery	Availability	Amount	Weight	Eigenvalue
Price	0.153846	0.16	0.130435	0.2	0.644281	0.16107	1.046957
Quality	0.461538	0.48	0.521739	0.4	1.863278	0.46582	0.970457
Delivery	0.307692	0.24	0.260870	0.3	1,108562	0.27714	1.062372
availability	0.076923	0.12	0.086957	0.1	0.383880	0.09597	0.959699
Total	1	1	1	1	4	1	4,039484

Source: Processed data, 2025

From this comparison, the weight (eigenvector) of each criterion is calculated using a normalization matrix approach. Based on Table 4, the following results are obtained:

$$CI = \frac{\lambda max - n}{n - 1}$$

$$CI = \frac{4{,}039484 - 4}{4 - 1}$$

$$CI = \frac{4{,}039484 - 4}{4 - 1}$$

$$CI = 0{,}013161464 \qquad (7)$$

Meanwhile, to determine the Consistency Ratio (CR), the Consistency Index (CI) / Random Consistency Index (RI) formula is used. Based on Table 1, consistency testing ensures that the data provided is not random and meets the principles of logical consistency. The calculation results are as follows:

$$CR = \frac{CI}{IR}$$

$$CR = \frac{0{,}013161464}{0{,}90}$$

$$CR = 0{,}014623849 \text{ (Consistent)} \qquad (8)$$

Because CR < 0.1, the data is declared consistent, and the criteria weights can be used for further evaluation.

Data Processing Results

Referring to the results of the analysis using the AHP method, a weighting value has been obtained for each criterion in the context of supplier selection for meatball grinding MSMEs as presented in Table 5.

Table5.Criteria Comparison Matrix

Criteria	Weight
Price	16.11%
Quality	46.58%

Delivery	27.71%
Availability	9.60%

Source: Processed data, 2025

Next, convert these to alternative weights based on the supplier data obtained during the interviews. After obtaining the priority weights for each criterion, the next step is to assess the weighting of the three suppliers based on qualitative data converted to a quantitative scale using the AHP approach. Table 6 shows the results of the alternative weightings for each supplier against each criterion.

Table6. Weighting Results for Each Criteria

Criteria	Alternative	Weight
Price	Cheap	0.7014
	Reasonable	0.2132
	Expensive	0.0853
Quality	Very good	0.5869
	Good	0.3230
	Not good	0.0893
Delivery	On time	0.6690
	Sometimes Right Sometimes Not	0.2572
	Late	0.0738
Availability	Very Complete	0.7120
	Complete	0.2299
	Incomplete	0.0581

Source: Data processed from interview results, 2025

Observation

Table 7 This paper presents the final synthesis results of supplier selection using the Analytical Hierarchy Process (AHP) method based on four main criteria: price, quality, delivery, and availability. The total score for each alternative is the result of aggregating the criteria weights with the priority weights for each supplier.

Table7.The final result

Criteria (Weight)	*Supplier*1	*Supplier*2	*Supplier*4
Price (0.16107)	0.1129	0.0343	0.0343
Quality (0.46582)	0.1509	0.2733	0.1509
Shipping (0.27714)	0.1855	0.1855	0.0713
Availability (0.09597)	0.0221	0.0683	0.0221
Total score	0.4714	**0.5614**	0.2786
Ranking	2	1	3

Source: Processed Data, 2025

The calculation results show that Supplier 2 obtained the highest score of 0.5614, placing it in first place. Supplier 1 was in second place with a score of 0.4714, while Supplier 4 obtained a score of 0.2786, placing it in third place. Based on these results, Supplier 2 is recommended as the best alternative in the supplier selection process.

CONCLUSION

This study successfully applied the Analytical Hierarchy Process (AHP) method to assist decision-making in selecting the best beef supplier for a meatball milling business in Tiban Centre Market. Based on a pairwise comparison analysis of the criteria of price, quality, on-time delivery, and availability, it was found that Quality (weighted at 46.58%) was the most prioritized factor for business managers, followed by Timeliness (27.71%). The results of the global weight calculation showed that supplier 2 (score 0.5614) was the best alternative, outperforming supplier 1 (0.4714) and supplier 3 (0.2786), mainly due to its consistency in providing high-quality meat even though the price was not the cheapest. The application of AHP was proven to provide a systematic and objective framework for evaluating various criteria simultaneously, thus helping the meatball milling business in making more strategic and data-driven supplier selection decisions, which ultimately supported the quality of the final product and customer satisfaction.

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