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Decision Support System for Selecting Tofu Dregs Suppliers Using the Analytical Hierarchy Process (AHP) Method

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Abstract: The process of selecting suppliers can be simplified with the aid of a system that offers recommendations for optimal supplier choices. This research aims to develop a decision support system application to assist CV. TJIGOWEK in objectively selecting tofu dregs suppliers while enhancing effectiveness and efficiency in time management. The research methodology employed to facilitate supplier selection is the Analytical Hierarchy Process (AHP). The five fundamental criteria utilized as parameters include quality, quantity, pricing, service, and payment flexibility. The AHP method is employed to determine the weight of each criterion, ultimately generating the optimal alternative ranking. The findings of this study can serve as a valuable reference for making supplier selection decisions aligned with the company's predefined criteria.

Keywords: Decision Support System; Supplier Selection; Analytical Hierarchy Process (AHP).

1. Introduction

The advancements in technology in the modern era have brought significant changes to various aspects of human life, particularly in the business world. According to the results of a survey conducted by the Central Statistics Agency (Badan Pusat Statistik) in 2021, 90.69% of businesses in Indonesia are already utilizing computers [1]. Agriculture, especially in the production of staple food crops, plays a crucial role in Indonesia as it greatly influences the sustenance of the population [2]. One of the well-known domestic food products is "oncom," a traditional Javanese processed food made from fermented soybeans [3]. CV. TJIGOWEK has been involved in the processing of "oncom" and tofu dregs since 2004. In the production of "oncom," the company relies on the supply of tofu dregs from various suppliers. The company requires a significant quantity of tofu dregs daily to produce "oncom," necessitating the involvement of multiple suppliers to ensure an uninterrupted supply of raw materials. Historically, supplier selection has been carried out subjectively. Initially, these suppliers provided satisfactory service, good quality tofu dregs, and competitive prices. However, over time, issues such as the inability of suppliers to meet the company's tofu dregs requirements, subpar quality of the raw materials, and a lack of responsiveness to the company's complaints have arisen. Consequently, the company has had to seek alternative suppliers capable of providing quality tofu dregs and meeting the production needs of "oncom."

Given the existing challenges, a solution is needed—a decision support system that facilitates the company's decision-making by ranking or recommending the best suppliers using the Analytical Hierarchy Process (AHP) method. As per

[4], a decision support system is a computer-based system that aids individuals in finding solutions to problems based on available data and produces output in the form of alternatives. Suppliers are individuals or companies that sell or supply resources to others in the form of raw materials, dividends, or products and services [5]. Amyriki (as cited in Alif, 2020) emphasizes the vital role of suppliers as business partners responsible for ensuring the availability of required raw materials for companies [6]. The Analytical Hierarchy Process (AHP) is an effective mathematical method for evaluating qualitative attributes [7].

In this research, two primary research questions are addressed: firstly, whether the implementation of a decision support system for selecting tofu dregs suppliers facilitates the decision-making process, and secondly, how effective the Analytical Hierarchy Process (AHP) method is in streamlining the selection of tofu dregs suppliers in alignment with the company's specific requirements. The research objectives include the development of a decision support system application encompassing five key criteria: quality, quantity, price, service, and payment tolerance, and the application of the AHP algorithm to enhance efficiency and effectiveness in time management during the assessment and selection of tofu dregs suppliers. Ultimately, the research holds the potential to benefit CV. TJIGOWEK by providing valuable insights that will enable the company to make informed decisions when selecting the most suitable suppliers, thereby ensuring the consistent availability and quality of their products.

2. Research Method

The research methodology can be summarized into a structured process, as depicted in Figure 1. It begins with the researcher identifying the research object, choosing CV. TJIGOWEK as the research location. Subsequently, the research involves problem identification within the company's supplier selection decision-making process. The data and information collection methods employed by the researcher encompass observation, interviews with company leaders to understand supplier selection challenges and criteria establishment, written questionnaires administered to leaders and production department representatives for importance ranking comparisons and alternative assessments, and a comprehensive review of relevant literature, including theses, journals, and articles related to supplier selection using the AHP method. Further steps involve the creation of questionnaires for criteria comparisons and alternative assessments, completed by company leaders and two production department representatives. The method chosen for supplier selection is the Analytical Hierarchy Process (AHP). The subsequent phases encompass designing the model and interface for the decision support system application and determining the system's structure, ensuring the logical flow of each menu within the application. Finally, the decision support system application generates reports on rankings and alternative assessments, providing valuable recommendations for the company's selection of the most suitable supplier.

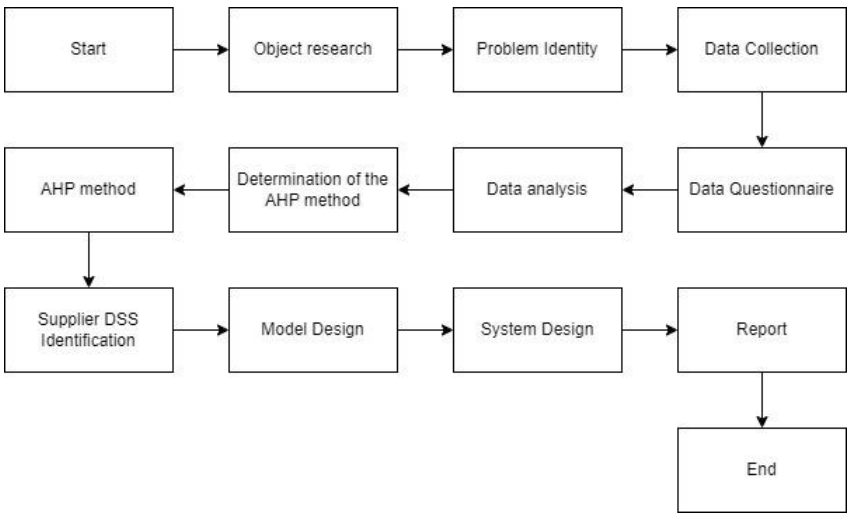

Figure 1. Research Stages

Within the AHP method for resolving the tofu dregs supplier selection issue, the following steps are undertaken.

1) Hierarchy Formation: The initial step in any AHP analysis involves a careful definition of the situation, incorporating relevant details. This is followed by the construction of a hierarchical model comprising several levels of detail, including the problem focus, criteria, and alternatives.

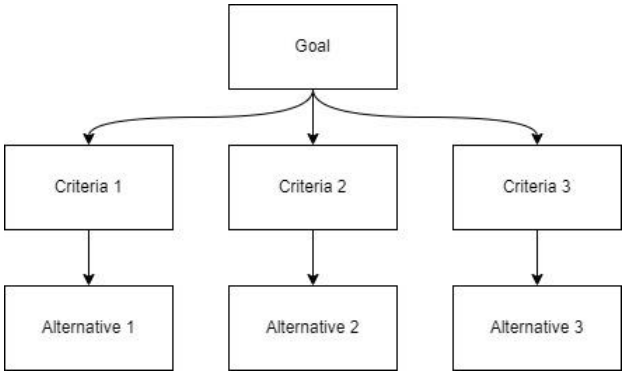

Figure 2. Hierarchical Structure

2) Pairwise Comparison of Criteria and Alternatives: Evaluation of the importance of comparisons among factors is based on Saaty's pairwise comparison scale. This scale assigns values from 1 to 9 to express preferences.

Table 1. Comparison Rating Scale

Intensity of Interest	Information
1	Both elements are equally important
3	One element is a little more important than other elements
5	One element is more important than other elements
7	One element is clearly more important than other elements
9	One element is more important than the elements oOther
2, 4, 6, 8	Values between two adjacent consideration values If activity i gets one point compared to activity j, then i has the opposite value compared to activity j, then i has a value. The opposite compared to i.

Source: (Kurniawan et al., 2020) [8].

3) Priority Determination: Each criterion and alternative undergoes pairwise comparisons to calculate weights and priorities. Decision-makers adjust the comparison values to ensure a systematic approach.
4) Logical Consistency: Ensuring consistency in comparisons is vital. This aspect involves categorizing similar objects based on uniformity and relevance and assessing the level of relationships among objects based on specific criteria [8].

These methodological steps provide a systematic and comprehensive framework for conducting the research and developing the decision support system for supplier selection, especially in the context of tofu dregs procurement.

3. Result and Discussion

3.1 Results

3.1.1 Problem Identification

The company faced a pressing need for swift decision-making in selecting suppliers. The production of oncom, a traditional Indonesian fermented food, demanded a substantial quantity of tofu dregs as a primary ingredient. As a result, the company required suppliers capable of consistently providing the necessary raw materials to avoid disruptions in the on-coming production process. Additionally, other issues surfaced, such as suppliers' reluctance to address complaints and subpar service quality. These issues had the potential to damage the company's relationships with its suppliers, leading to conflicts or undesired termination of partnerships.

3.1.2 Problem Resolution

Having identified these challenges, the author sought a solution by developing a decision support system to facilitate the selection of tofu dregs suppliers. This system was designed to evaluate and prioritize potential suppliers based on predefined criteria, employing the Analytical Hierarchy Process (AHP) methodology. The outcomes generated by this application served as a valuable reference in the supplier selection process.

3.1.3 Algorithm

An explanation of the manual supplier selection calculations using the Analytical Hierarchy Process (AHP) is as follows:

1) Determine Criteria and Alternatives

Table 2. Criteria

Criteria	Information
K01	Quality
K02	Quantity
K03	Price
K04	Service
K05	Payment Tolerance

Table 3. Alternative

Alternative	Information
S01	Eka Factory
S02	Factory 568
S03	SS Ratu Jaya Factory
S04	CSR Factory

2) Comparison Data Between Criteria

The results of each respondent's questionnaire are used as a single data unit to continue calculating the AHP. For every comparison of the same criteria in the results of the three pairwise comparisons between the criteria in tables 4 to table 5, the geometric average will be calculated using the formula:

$$Geometric\ mean\ = N\sqrt{X_1}xX_2x\ \dots x\ X_n$$

Information:
x = Pairwise comparison results per criterion
n = Total number of respondents

Table 4. Geometric Mean Calculation

Comparison Criteria	Respondent 1	Respondent 2	Respondent 3	Weighting
K01-K02	4,000	2,000	4,000	3,175
K01-K03	3,000	0,500	3,000	1,651
K01-K04	2,000	3,000	2,000	2,289
K01-K05	0,500	4,000	0,500	1,000
K02-K03	0,500	0,333	0,500	0,437
K02-K04	0,333	2,000	0,333	0,606
K02-K05	0,200	3,000	0,200	0,493
K03-K04	0,500	4,000	0,500	1,000
K03-K05	0,250	5,000	0,250	0,679
K04-K05	0,333	2,000	0,333	0,606

3) Comparative Data on Supplier Assessment Alternatives for Each Criteria

Determine the assessment for alternative comparisons with 4 suppliers who are assessed based on these criteria. Assessment of alternative suppliers according to quality criteria.

Table 5. Assessment of Alternative Suppliers According to Quality Criteria

Supplier Comparison	Respondent 1	Respondent 2	Respondent 3	Weighting
S01 – S02	4,000	2,000	2,000	2,520
S01 – S03	3,000	0,333	0,333	0,693
S01 – S04	7,000	3,000	3,000	3,979
S02 – S03	0,333	0,250	0,250	0,275
S02 – S04	3,000	2,000	2,000	2,289
S03 – S04	4,000	5,000	5,000	4,642

Table 6. Assessment of Alternative Suppliers According to Quantity Criteria

Supplier Comparison	Respondent 1	Respondent 2	Respondent 3	Weighting
S01 – S02	4,000	2,000	2,000	2,520
S01 – S03	3,000	3,000	0,250	1,310
S01 – S04	5,000	4,000	5,000	4,642
S02 – S03	0,333	2,000	0,200	0,511
S02 – S04	2,000	4,000	3,000	2,884
S03 – S04	5,000	4,000	6,000	4,932

Table 7. Assessment of Alternative Suppliers According to Price Criteria

Supplier Comparison	Respondent 1	Respondent 2	Respondent 3	Weighting
S01 – S02	2,000	2,000	3,000	2,289
S01 – S03	0,250	0,333	0,333	0,303
S01 – S04	0,333	4,000	5,000	1,882
S02 – S03	0,143	0,250	0,200	0,193
S02 – S04	0,200	2,000	3,000	1,063
S03 – S04	3,000	5,000	7,000	4,718

Table 8. Assessment of Alternative Suppliers According to Service Criteria

Supplier Comparison	Respondent 1	Respondent 2	Respondent 3	Weighting
S01 – S02	3,000	2,000	3,000	2,621
S01 – S03	5,000	0,333	0,333	0,822
S01 – S04	7,000	4,000	5,000	5,192
S02 – S03	2,000	0,250	0,200	0,464
S02 – S04	5,000	2,000	3,000	3,107
S03 – S04	2,000	5,000	7,000	4,121

Table 9. Assessment of Alternative Suppliers According to Payment Tolerance Criteria

Supplier Comparison	Respondent 1	Respondent 2	Respondent 3	Weighting
S01 – S02	5,000	0,200	3,000	1,442
S01 – S03	0,500	0,500	5,000	1,077
S01 – S04	5,000	3,000	7,000	4,718
S02 – S03	0,200	3,000	3,000	1,216
S02 – S04	3,000	7,000	4,000	4,380
S03 – S04	7,000	3,000	3,000	3,979

Perform a matrix multiplication between the priority weights between alternatives and the priority weights of the criteria. Calculations in Excel can use the MMULT formula.

Table 10. Results of Selection of Tofu Dregs Supplier

	Priority	Eka Factory	Factory 568	SS Ratu Jaya Factory	CSR Factory
Quality	0,304	0,327	0,145	0,448	0,080
Quantity	0,099	0,408	0,181	0,339	0,073
Price	0,184	0,207	0,106	0,577	0,110
Service	0,157	0,375	0,179	0,373	0,073
Payment Tolerance	0,256	0,351	0,296	0,282	0,071
Total	32,70%	18,47%		40,73%	8,10%

3.1.4 Use Case Diagram

The use case diagram, depicted in Figure 3, illustrates the various interactions and functionalities within the developed decision support system for selecting tofu dregs suppliers. It provides a visual representation of how different actors, such as users and the system itself, interact with the application to achieve specific goals related to supplier selection.

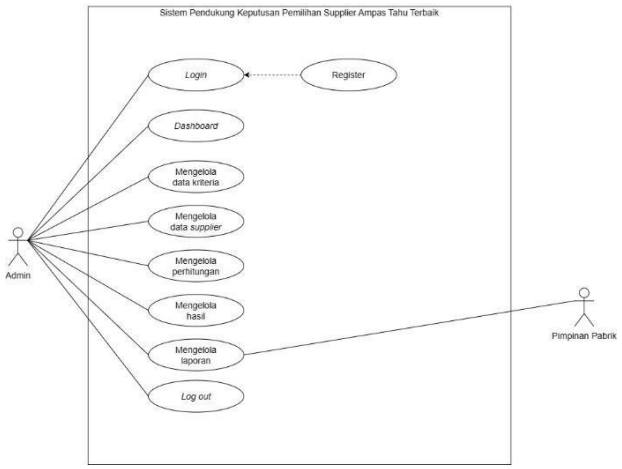

Figure 3. Use Case Diagram

3.1.5 Tampilan Layar

Figure 4 showcases the primary user interface of the developed application, which is the main menu screen. This graphical representation offers an insight into the user experience, displaying the key options and functionalities available to users when utilizing the decision support system. The menu design aims to make the application user-friendly and intuitive, facilitating efficient supplier selection based on predefined criteria.

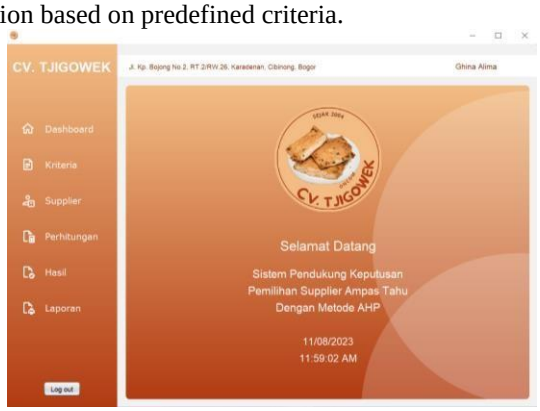

Figure 4. Main Menu Display.

3.2. Discussion

The Analytical Hierarchy Process (AHP) methodology plays an important role in objectively assessing the importance of various criteria in the supplier selection process. Critically evaluate criteria such as quality, quantity, price, service, and payment tolerance, emphasizing their role in the decision-making process. This chapter carefully explores the process of weighing these criteria, based on participants' responses, thereby providing valuable insight into a company's overall priorities during supplier selection. In addition, the results of supplier assessment and subsequent priority determination. AHP calculations culminate in the identification of the most prominent suppliers, which are carefully aligned with predetermined criteria. This segment carefully dissects the reasons underlying the selection of a particular supplier, effectively highlighting their laudable attributes and any shortcomings in meeting a company's diverse needs. The major impact of the developed decision support system on the company's decision-making process is the focus of this discussion. This outlines the system's ability to simplify and speed up the complex supplier selection process, resulting in decisions that are not only more informed but also executed more efficiently. Additionally, it highlights the inherent advantages of using a structured methodology such as AHP in supplier selection, underscoring the objectivity and rigor applied to the decision-making process. Several research formulas show how decision support systems attempt to overcome the challenges described in the problem identification phase. A systematic systems approach, which accommodates multiple criteria and offers objective assessments, promises to mitigate problems such as supplier complaints and substandard service quality. Additionally, this approach also considers the potential to improve supplier relationships and mitigate conflict, which is often an undesirable outcome in the procurement field. User experience and usability of decision support systems has involved user feedback collected from individuals actively involved with the system during the supplier

selection process. The results of the analysis regarding the impact and results of implementing an AHP-based decision support system in selecting tofu dregs suppliers have underlined the transformative role of this system in encouraging more effective and efficient decision making within the scope of the company's procurement process. Additionally, the company is also considering its potential to address long-term issues plaguing supplier relationships, thereby offering a path to smoother and more productive supplier engagement.

4. Related Work

Several related studies have delved into decision support systems for supplier selection using various methodologies. In a study conducted by Alda Meilita, Syariani, and Luthfi Indriyani (2022) Decision Support System (DSS) for Selecting the Best Supplier using the Analytical Hierarchy Process (AHP) Method, the authors aimed to identify the best supplier employing the AHP method with criteria such as quality, quantity, and delivery [9]. Another research effort by Usep Saprudin (2020) resulted in a decision support system for identifying superior red chili seeds by combining AHP and SAW methods to assist farmers in decision-making [10]. Additionally, a study by Bambang Adi Saputro, Nunu Kustian, and Abdul Mufti (2021) implemented the AHP method, aiding store owners in selecting products that align with consumer preferences, thereby saving time in information retrieval and report generation due to the data stored in a database. Furthermore, the use of Java as a programming language and platform has been highlighted. Java serves not only as a programming language but also as a platform and technology to address the evolving internet landscape. Java applications can be developed independently, akin to programs in C or Pascal, or embedded as applets within HTML documents [11]. Lastly, Unified Modeling Language (UML) is introduced as a standardized language for defining, visualizing, building, and documenting software system artifacts, encompassing both business and non-system software modeling. UML is recognized for its effectiveness in representing complex software systems [12].

This research stands out in several significant ways. Firstly, it concentrates on the tofu production industry, catering to its distinct needs and challenges in selecting suppliers for tofu dregs, a vital ingredient in oncom production. Second, it adopts a comprehensive approach by considering a wide range of criteria, including quality, quantity, price, service, and payment tolerance, offering a holistic evaluation of potential suppliers. Thirdly, the integration of the Analytical Hierarchy Process (AHP) methodology ensures a systematic and mathematically rigorous approach to supplier evaluation, enhancing decision-making reliability. Additionally, the study places a strong emphasis on user experience and usability, recognizing the critical impact of user-friendly design on the effectiveness of decision support tools. Furthermore, it explores the potential for the developed system to influence long-term supplier relationships, addressing issues like complaints and service quality. The research also aligns with industry practices by emphasizing the relevance of Java as a programming language and platform. Lastly, the introduction of Unified Modeling Language (UML) enhances the clarity and comprehensibility of system documentation, following best practices in software engineering. These distinctive elements collectively contribute to the uniqueness and effectiveness of the decision support system developed for supplier selection in the tofu production industry.

5. Conclusion

The research findings can be summarized as follows:

1) The utilization of this application demonstrates the capacity to offer a more objective and efficient solution to supplier selection. By employing the Analytical Hierarchy Process (AHP) methodology, this decision support system facilitates a meticulous analysis of crucial criteria within the supplier selection process.
2) The criteria employed for the selection of tofu dregs suppliers, encompassing aspects such as quality, quantity, price, service, and payment tolerance, have been meticulously defined and assessed. This meticulous approach permits a comprehensive evaluation of potential suppliers based on relevant key factors.
3) The supplier ranking process relies on total weight computations, derived from respondents' evaluations of the significance of each criterion. Consequently, supplier selection decisions are underpinned by a robust foundation of data and analysis, fostering enhanced confidence in the decision-making process.

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