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Decision Support System

Decision Support System for Selecting Optimal Coconut Varieties for Coconut Milk Production: Integration of Analytic Hierarchy Process and Simple Additive Weighting Methods

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A B S T R A C T

Selection of optimal coconut varieties for coconut milk production is a crucial step in the food industry, considering that the quality and quantity of coconut milk are greatly influenced by the type of coconut used. This study aims to determine the best coconut varieties for coconut milk production by integrating two multicriteria decision-making methods, namely the Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW). The AHP method is used to determine the weight of each influential criterion, such as oil content, taste, price, and availability. Meanwhile, the SAW method is applied to rank various coconut varieties based on the weight of the criteria that have been obtained. The data used in this study were collected from various sources, including scientific literature, as well as field observation data. The results of the analysis indicate that certain coconut varieties have significant advantages in terms of quality and efficiency of coconut milk production. The coconut varieties selected through the combined AHP and SAW methods are expected to provide practical guidance for coconut milk producers in selecting optimal coconut varieties, so that they can improve the quality of the coconut milk produced. Thus, this study provides an important contribution in the field of agribusiness, especially in the selection of coconut varieties for coconut milk production, as well as implementing the use of AHP and SAW methods in complex and multi-criteria decision making.

INTRODUCTION

Coconuts play a central role in the food industry, and particularly in the production of coconut milk, where quality can vary greatly depending on the variety of coconut used. Factors such as water content, tenderness of the coconut flesh, and coconut milk yield are critical determinants in producing high-quality coconut milk.

In this context, coconut milk producers and coconut farmers need a system that can help them optimize the selection of coconut varieties. The method that can optimize the selection of coconut varieties is a decision support system and the definition of a decision support system is part of a computer-based information system used for decision making in an organization or company and in decision making of course there are several methods including the AHP method and the SAW method which can evaluate the criteria hierarchically and provide appropriate weights (Lestari, et al. 2021). The Analytical Hierarchy Process (AHP) method is a decision support system model developed by Thomas L. This decision support model will describe complex multi-factor or multi-criteria problems into a hierarchy. While Simple Additive Weighting (SAW) is a method used to find alternatives with certain criteria and the SAW method provides flexibility in providing direct assessments of coconut varieties in the decision support system.

The background of this study reflects the complexity of Decision making in coconut variety selection, which involves many interrelated factors. The integration of AHP and SAW is expected to provide a more holistic and accurate solution, including a hierarchy of criteria and direct evaluation of coconut varieties.

The success of this research can bring positive impacts not only to stakeholders in the coconut milk industry, but also to coconut farmers and the wider community. By developing an effective Decision Support System, this research contributes to improving the quality of coconut milk products, production efficiency, and the sustainability of the coconut industry as a whole.

METHOD

Current System Analysis

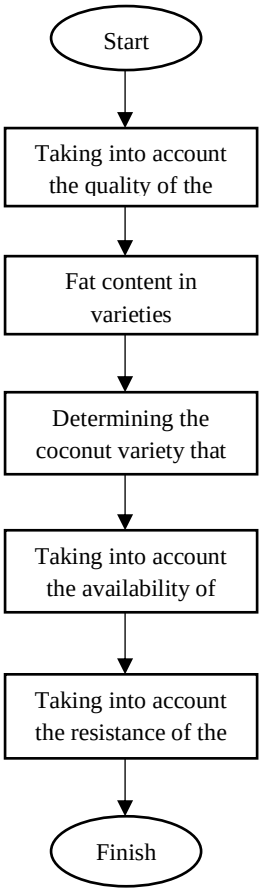

Figure 1. Analysis of the Running System

Therefore, in the current system, researchers will then create a web-based decision support system to determine the decision to select coconut varieties for coconut milk production, which will make it easier for entrepreneurs to choose suitable coconut varieties.

Interface Design

Based on the input and output designs that have been made, an interface is made for each menu, the interface of the decision support system for selecting optimal coconut varieties for coconut milk production, using the PHP and MySQL programming languages, the interface designs made are as follows:

1. Login Menu Interface Design
2. Admin Menu Interface Design
3. User Data Interface Design
4. Add Coconut Variety Form Interface Design
5. Edit Coconut Variety Interface Design
6. Edit Coconut Criteria Interface Design
7. Priority Criteria Calculation Interface Design
8. Final Calculation Result Interface Design

Integration of AHP and SAW Methods

Selecting the best coconut for making coconut milk by combining the AHP and SAW methods The weight value formula, combining the Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods to find the best coconut varieties can be done through several systematic steps. Here are the detailed steps:

1. Collecting Criteria and Alternative Data
2. Knocking Sound
3. Water content
4. Skin Condition
5. Price
6. Ripeness Level
7. Coconut Quality

RESULTS AND DISCUSSION

System Implementation

The implementation of this system is the stage of implementing the design that has been made. The decision support system used in selecting optimal coconut varieties for coconut milk production. By integrating the Analytical Hierarchy Process and Simple Additive Weighting methods. The discussion includes the steps for implementing both methods, analysis of the data obtained, and evaluation as the basis for creating the system. The system created is web-based using the PHP programming language and MySQL database. The interface is designed using a responsive design, namely a website display that will follow the size of the monitor screen used. The screen display will be more optimal if using a monitor screen that uses a resolution of 1366 x 768 pixels. Based on the design above, the implementation of the information system interface is as follows:

Login Menu Interface

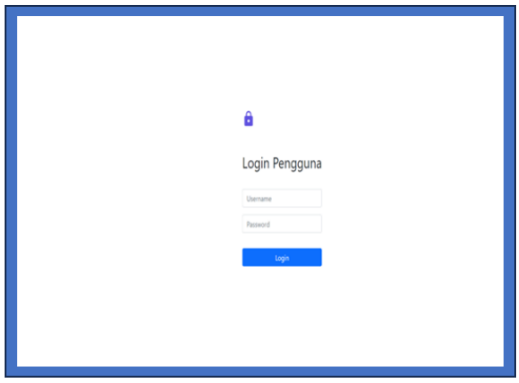

Figure 2. Login Menu Interface

On the first system interface display that can be seen when the program is run is the login display. The display presented can be seen in Figure 2, the first thing the user does is perform the login process. To find out the access rights on the system if the user logs in as an admin, the user will be directed to the admin homepage and vice versa, if the user logs in as a user, they will be directed to the user homepage.

Admin Home Interface

Figure 3. Admin Home Interface

Implementation of the admin home interface which contains several menus, including the coconut variety menu, coconut criteria menu, user data menu, and count menu. The admin home page display can be seen in Figure 3.

User Home Interface

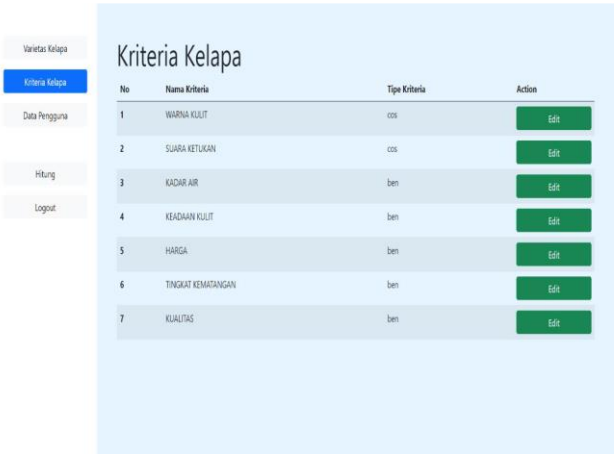

Figure 4. User Home Interface

On the user interface display displays several menus, which can only be accessed by the user. Menus that can only be accessed by the user include: coconut criteria menu and count menu. Users can only input the type of criteria according to the assessment in the system. There are two types of criteria including: cost which means (smallest is best) and benefit which means (largest is best). The user home interface can be seen in Figure 4.

User Data Interface

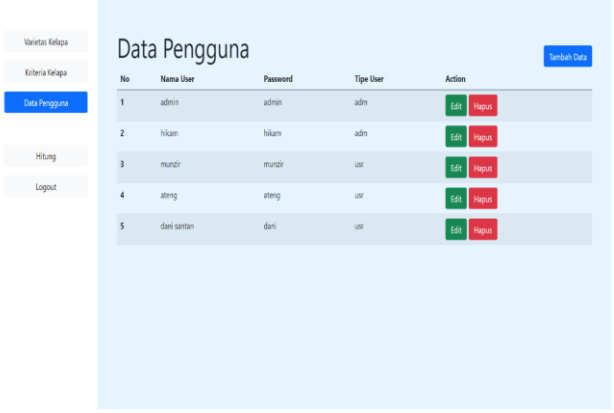

Figure 5. User Data Interface

On the user data interface displays all user data. The user data menu can only be accessed by the admin. The user data menu contains some information including: user name, password, user type, action, delete data and add data. The data can generally be managed by the admin. The admin can delete data and add user data. The user data menu interface can be seen in Figure 5.

Add Coconut Variety Form Interface

Figure 6. Add Coconut Variety Form Interface

On the add coconut variety interface menu, it displays some information including: variety id, coconut variety name, quantity, water pH level, fat content, quality, availability in the production area. The add coconut variety menu can only be accessed and managed by the admin, the admin is responsible for adding and deleting coconut variety data. The add coconut variety form can be seen in Figure 6.

Coconut Variety Edit Interface

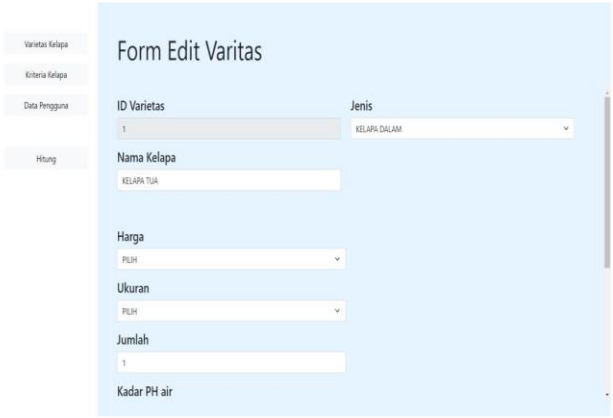

Figure 7. Coconut Variety Edit Interface

On the coconut variety edit menu, it functions to edit coconut variety data according to the data that the admin wants to change. The coconut variety edit menu can only be accessed and managed by the admin. The variety edit menu can be seen in Figure 7.

Edit Criteria Interface

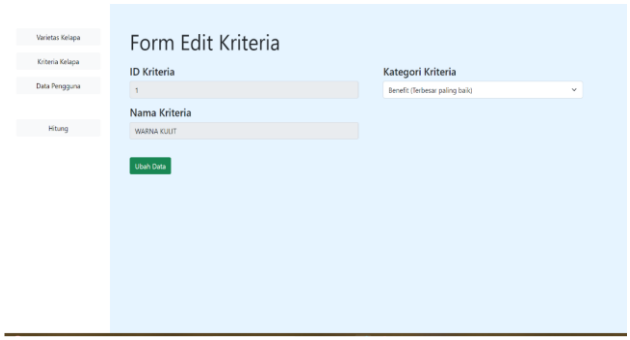

Figure 8. Edit Criteria Interface

On the criteria edit interface there are several information including: criteria id, criteria name and criteria category. This form functions to change the criteria category that can be accessed by both users and admins. The criteria edit form can be seen in Figure 8.

AHP Data Processing Interface

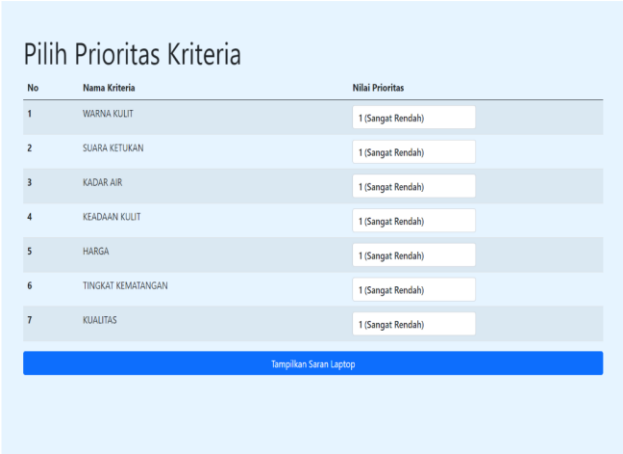

Figure 9. AHP Data Processing Interface

On the AHP data processing interface consists of: criteria input interface, criteria table, normalization, criteria weight, consistency. The following is an explanation of each interface:

1) Criteria priority selection interface

The criteria priority selection interface consists of: number, criteria name and priority value. For the assessment index from 1 to 9, each assessment index has a different meaning. The following is the assessment weight according to the index number in the system:

a) 1 means very low
b) 3 means low
c) 5 means normal
d) 7 means important
e) 9 means very important
f) 2,4,6,8 means the two things are equally important

The following is the criteria priority selection interface in Figure 9.

2) Criteria input interface

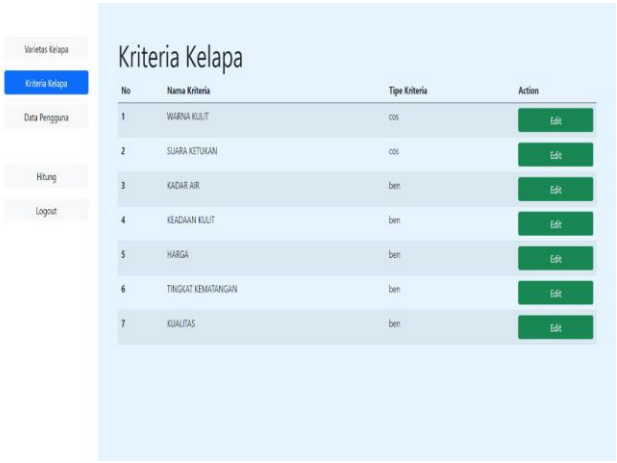

Figure 10. Criteria Input Form Interface

In the criteria input interface image there are several pieces of information including: criteria name, criteria type and criteria edit form. Specifically in the criteria type there are two very important assessments in the data processing process in the AHP method. Among: cost assessment which means (smallest is best) and benefit which means (largest is best). The coconut criteria menu can be seen in figure 10.

The final results of the AHP data processing process are: criteria table, ratio consistency value, index consistency value, value before normalization, value after normalization.

```
0.04;0.04;0.04;0.04;0.04;0.04;0.04;
0.13;0.13;0.13;0.13;0.13;0.13;0.13;
0.08;0.08;0.08;0.08;0.08;0.08;0.08;
0.13;0.13;0.13;0.13;0.13;0.13;0.13;
0.13;0.13;0.13;0.13;0.13;0.13;0.13;
0.21;0.21;0.21;0.21;0.21;0.21;0.21;
0.29;0.29;0.29;0.29;0.29;0.29;0.29;

A2
0.04;0.13;0.08;0.13;0.13;0.21;0.29;

A3
0.2913;0.8807;0.5894;0.8807;0.8807;1.4672;2.0527;

A4
7.28;6.77;7.37;6.77;6.77;6.99;7.08;

CI
0.00071428571428574

CR
0.00054112554112556

sebelum normalisasi
2;3;1;2;3;2;3;
3;3;3;3;4;3;4;
3;3;2;3;2;3;4;
4;4;3;4;2;4;2;
3;3;3;2;3;3;1;

setelah normalisasi
1;1;0.33;0.5;0.75;0.5;0.75;
0.67;1;1;0.75;1;0.75;1;
0.67;1;0.67;0.75;0.5;0.75;1;
0.5;0.75;1;1;0.5;1;0.5;
0.67;1;1;0.5;0.75;0.75;0.25;
```

Figure 11. Output Interface AHP Calculation Process

3) SAW Method Ranking Results Interface

On the interface of the ranking results of the saw method, the results are obtained from the results of :

1) Determination of criteria weights
2) Compiling the Decision matrix

3) Normalization of the Decision matrix
4) Calculating the normalization of the weighted matrix
5) Calculating the final score for each alternative
6) Calculating the consistency index and ratio
7) Ranking

The following is the interface of the normalization results and the suggestion results can be seen in Figure 12.

```
A3
0.98;0.98;0.98;0.98;0.98;0.98;0.98;

A4
7;7;7;7;7;7;7;

CI
0

CR
0

sebelum normalisasi
2;3;1;2;3;2;3;
3;3;3;3;4;3;4;
3;3;2;3;2;3;4;
4;4;3;4;2;4;2;
3;3;3;2;3;3;1;

setelah normalisasi
1;1;0.33;0.5;0.75;0.5;0.75;
0.67;1;1;0.75;1;0.75;1;
0.67;1;0.67;0.75;0.5;0.75;1;
0.5;0.75;1;1;0.5;1;0.5;
0.67;1;1;0.5;0.75;0.75;0.25;

Hasil Saran
0.677;1;
0.863;2;
0.747;3;
0.735;4;
0.688;5;

Hasil Saran (Terurut)
0.863;2; KELAPA MUDA;
0.747;3; KELAPA TUA GENJAH;
0.735;4; KELAPA PANDAN TUA;
0.688;5; KELAPA DALAM TUA;
0.677;1; KELAPA TUA;
```

Figure 12. Output Interface SAW Calculation Process

In this case, we have four alternative coconut varieties (A1, A2, A3, and A4) evaluated based on seven criteria (C1, C2, C3, C4, C5, C6, and C7). The purpose of this discussion is to determine the best coconut variety by combining the Analytical Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods.

a. Step 1: Determine the weight of the criteria with the AHP method, in the AHP method, we compare each criterion with other criteria. As an example of a case study. Here are the steps:
   1) Constructing Pairwise Comparison Matrix:
      In the AHP method, we compare each criterion with other criteria on a scale (1-9). For example, we construct a pairwise comparison matrix as follows:
   2) Matrix normalization
      After compiling the pairwise comparison matrix, then calculate the sum of each column and divide each element by the sum of the columns. The row summation method is used to find the criteria weight.
      a) Number of columns C1 = 1 + 2 + 0.33 + 3 + 0.33 + 0.2 + 0.14 = 7.0
      b) Number of columns C2 = 0.5 + 1 + 0.2 + 2 + 0.33 + 0.14 + 0.11 = 4.28
      c) Number of columns C3 = 3 + 5 + 1 + 7 + 0.33 + 0.2 + 0.14 = 16.67
      d) Number of columns C4 = 0.33 + 0.5 + 0.14 + 1 + 0.2 + 0.11 + 0.11 = 2.39
      e) Total column C5 = 3 + 3 + 3 + 5 + 1 + 0.33 + 0.2 = 15.53
      f) Total column C6 = 5 + 7 + 5 + 9 + 3 + 1 + 0.33 = 30.33
      g) Total column C7 = 7 + 9 + 7 + 9 + 5 + 3 + 1 = 41.0

   3) Calculating criteria weights
      To determine the weight of the criteria we need to calculate the average of each row of the normalized matrix. Here is the sum of each row of the normalized matrix.
      a) Weight C1 = (0.1429 + 0.1168 + 0.1799 + 0.1381 + 0.1931 + 0.1648 + 0.1707) / 7 = 0.1438
      b) Weight C2 = (0.2857 + 0.2336 + 0.2998 + 0.2092 + 0.1931 + 0.2307 + 0.2195) / 7 = 0.2417
      c) Weight C3 = (0.0471 + 0.0467 + 0.0599 + 0.0586 + 0.1931 + 0.1648 + 0.1707) / 7 = 0.1067
      d) Weight C4 = (0.4286 + 0.4673 + 0.4197 + 0.4184 + 0.322 + 0.2965 + 0.2195) / 7 = 0.3674
      e) Weight C5= (0.0471 + 0.0771 + 0.0198 + 0.0837 + 0.0644 + 0.0989 + 0.1219) / 7 = 0.0733
      f) Weight C6 = (0.0286 + 0.0327 + 0.0119 + 0.046 + 0.0213 + 0.0329 + 0.0732) / 7 = 0.0352
      g) Weight C7 = (0.02 + 0.0257 + 0.0084 + 0.046 + 0.0129 + 0.0109 + 0.0244) / 7 = 0.0212

b. Step 2: Compiling a decision matrix for the SAW method with existing alternatives. Next, we compile a decision matrix for the SAW method based on alternative data from subjective assessment results.

c. Step 3: Normalization of the decision matrix
In the SAW method, to normalize the decision matrix using the formula:

$$\left(r_{ij} = \frac{x_{ij}}{x_{jmax}} \right) \quad (1)$$

d. Step 4: Calculating preference values with SAW
Using the weights from the AHP that have been calculated, by multiplying each normalization element, by the criteria weight, and summing them for each alternative:

$$\left(V_i = \sum_{j=1}^{n} (W_j \, x \, r_{ij}) \right) \quad (2)$$

e. Step 5: Determining the Best Alternative
Determining the best alternative based on the calculated preference value, the alternative with the highest value is the best. In this case:

Table 1. Best Alternative

Alternative	Preference Value
A1	0.9893
A2	0.9414
A3	0.5119
A4	0.4157

So, the best alternative is A1 with the highest preference value of 0.9893. The combination of AHP and SAW methods allows us to determine the weight of the criteria objectively and calculate the preference value by considering various criteria holistically.

If CI is very close to 0 or very small, the comparison matrix is considered consistent. If CI is greater than the threshold value set at 0.1, then the comparison matrix is considered inconsistent. In the case above, it can be concluded that the matrix value is consistent.

$$\left(CI = \frac{\lambda_{max} - n}{n - 1}\right)$$

$$CI = \frac{7.2 \quad -7}{7-1} = 0.03$$

Consistency Ratio (CR) is a measure used in pairwise comparison analysis to evaluate how consistent the comparison matrix that has been created is. The RI value depends on the size of the comparison matrix (the number of criteria/alternatives). RI values are generally available in reference tables for various matrix sizes. For example, for a 7x7 matrix, the RI is :

$$\left(CR = \frac{CI}{RI}\right)$$

$$\text{CR} = \frac{0.03}{1.32} = 0.022$$

CR value 0.02, this indicates a good level of consistency.

CONCLUSIONS

Based on the results of the discussion of the decision support system for selecting coconut varieties for coconut milk production by integrating the AHP and SAW methods, it can be concluded as follows : The AHP method is used for the criteria weighting process According to the request (input). The SAW method is used to process data to obtain the best coconut variety recommendations for coconut milk production, based on the test results, Correctness is included in the very good criteria, Reliability is included in the very good criteria, Integrity is included in the very good criteria, Usability is included in the very good criteria. Which means that overall the SPK for selecting coconut varieties for coconut milk production meets user needs, displays information that is in accordance with user input correctly, is safe from authorized parties, the SPK display is attractive and easy to use.

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