IMPLEMENTATION OF RANK ORDER CENTROID AND SIMPLE ADDITIVE WEIGHTING METHODS FOR SENSORY EVALUATION OF BREWED PRODUCTS FROM BLUE PEA (*Clitoria ternatea* L.) FLOWER AND PEPPERMINT (*Mentha piperita* L.)

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ABSTRACT

This study investigates the sensory evaluation of brewed products derived from Blue Pea (*Clitoria ternatea L.*) flowers combined with Peppermint (*Mentha piperita* L.). Multiple Attribute Decision Making (MADM) methods, specifically Rank Order Centroid (ROC) and Simple Additive Weighting (SAW), were employed for this purpose. The brewed samples were prepared by boiling either the Blue Pea (*Clitoria ternatea L.*) flowers alone or a mixture of Blue Pea flowers and Peppermint (*Mentha piperita* L.), with varying amounts of added sugar. The organoleptic scores of four formulations were assessed by a panel of 30 untrained judges using a 9-point hedonic scale, focusing on taste, aroma, and color criteria. Data analysis began with ROC to determine the weights of each criterion, followed by SAW to identify the optimal formulation. The results indicated that the formulation consisting of 100 g of Blue Pea flowers and 200 g of sugar achieved the highest preference score of 0.9959.

Keywords: ROC, SAW, Organoleptic, Blue Pea, Peppermint

1. Introduction

Blue Pea (*Clitoria ternatea* L.), known as *Telang* in Indonesia, is an herb that has blue-colored flowers originating from tropical regions of Asia. This herb belongs to the Fabaceae family, typically grows at altitudes between 1-1800 m above sea level, and can be cultivated in various soil types with a pH range of 5.5 - 8.9. It grows optimally at temperatures around 19-28°C (Zahara, 2022). Previously, *Telang* has been utilized as a natural food coloring, especially for traditional foods in Southeast Asia. Moreover, Blue Pea is also used as a herb in traditional medicine in Asia and America, particularly for treating insomnia, epilepsy, dysentery, asthma, gastritis, fever, eczema, and many other diseases (Marpaung, 2020).

The anthocyanin compound in Blue Pea has antioxidative properties and naturally acts as the pigment for the herb (Priska et al., 2018; Rifqi, 2021), especially in the flower. In addition to its antioxidative properties, the antibacterial activities of *Telang* in food products have also been proven, which is attributed to its flavonoid, anthocyanin, tannin, flavanol, phenolic acid, and alkaloid contents (Nabila et al., 2022). Kamilla et al. (2009) proved that Blue Pea flower extract can inhibit three pathogenic bacteria most commonly found on surfaces, such as *Bacillus subtilis*, *Staphylococcus aureus*, and *Escherichia coli*.

Therefore, due to its health benefits, Blue Pea has been utilized commercially as a raw material for functional food and beverages. Previously, Khairina et al. (2021) and Ikhwan et al. (2022) introduced Blue Pea brewed products and their commercial potential to local communities in Manik Maraja Village and Simonis Village, respectively. Nurlina (2023) also developed Blue Pea brewed products as an alternative medicine to lower the blood pressure of elderly people with hypertension, and the results showed that it had a significant effect for that purpose. Furthermore, Kusuma (2019) developed a Blue Pea-based phlegm thinner product and found that it had mucolytic activity potential at certain concentrations.

The advantage of using Blue Pea as a raw material is its minimal effect on taste and aroma, thus reducing the likelihood of lowering sensory profile scores. To enhance the sensory profile of Blue Pea-based products, flavoring agents can be added (Marpaung, 2020). One common additive used to improve the sensory profile of brewed beverage products is peppermint. Peppermint is an aromatic herb known for its health benefits, particularly for the mouth and teeth. Additionally, peppermint is used to address respiratory problems, enhance the performance of the digestive system, and relieve nausea. In food product development, peppermint is usually employed to enhance the taste and aroma of products (Wilanda et al., 2021).

Peppermint has previously been utilized as a primary and additive ingredient in the development of brewed herbal products. Sucianti et al. (2021) used Peppermint (*Mentha piperita* L.) to develop an herbal tea bag product. Additionally, Anggraini et al. (2014) utilized Peppermint (*Mentha piperita* L.) as an additive for a *Pegagan* leaf-based brewed product, and the results showed significant increases in organoleptic scores. Furthermore, Apriliyani et al. (2021) developed a *Beluntas* leaf-based brewed product using Peppermint (*Mentha piperita* L.) as an additive to enhance the sensory profile scores. Therefore, Peppermint (*Mentha piperita* L.) is used to add flavor to Blue Pea-based products in this research.

To obtain the most optimum formulation for a Blue Pea and Peppermint-based brewed product using its organoleptic scores, Multiple Attribute Decision Making (MADM) methods were implemented. The methods used in this study were Rank Order Centroid (ROC) and Simple Additive Weighting (SAW). ROC is a method used for weighting the criteria, which will be further processed by decision support tools. The implementation of ROC is done by arranging the criteria based on their priority compared to other criteria (Badaruddin, 2019). Previously, ROC has been used as a weighting method for decision-making in several studies. Israwan et al. (2021) used ROC as a weighting method for a MOORA (Multi-Objective Optimization on the Basis of Ratio) based decision support tool to select prospective employees. Badaruddin (2019) used ROC as a weighting method for a SAW-based decision support tool to evaluate employee performance. Furthermore, Dewi et al. (2021) developed a web-based decision support system using ROC and ARAS (Additive Ratio Assessment) to select the best salesperson.

In this study, SAW was used as the main decision support tool to obtain the best formulation for a Blue Pea

(*Clitoria ternatea* L.) Flower and Peppermint (*Mentha piperita* L.) brewed product. The main principle of SAW is to find the weighted sum of performance ratings for each alternative across all attributes involved. Previously, SAW has been used in research due to its simplicity. Setiadi et al. (2018) used SAW to select the best student based on his/her performance. Resti (2017) implemented SAW as a decision support tool for selecting the location of a new branch of a store. In the research field of food product development, Utama and Baroto (2018) used SAW to determine the optimum production method for *tempe* based on its organoleptic quality. Furthermore, Muliawati et al. (2024) combined the Analytical Hierarchy Process (AHP) and Simple Additive Weighting (SAW) methods to assess the organoleptic quality of salted egg products, utilizing various combinations of egg sources (chicken and duck) and salting mixtures.

2. Research Methodology

The equipments used in this experiment were a stove, a scale, a wooden stirring spoon, plastic cups, plastic bottles, and a kettle. The materials used were Blue Pea (*Clitoria ternatea* L.) flowers, Peppermint (*Mentha piperita* L.), sugar, and water. The procedure began by boiling the Blue Pea flowers with water. Four different formulations were prepared: (A) Blue Pea 100 g + sugar 100 g; (B) Blue Pea + Peppermint (100 g) + sugar (100 g); (C) Blue Pea 100 g + sugar 200 g; (D) Blue Pea + Peppermint (100 g) + sugar (200 g). The mixtures were then stirred until homogeneous and cooled down.

The brewed products were evaluated by 30 untrained panelists through an organoleptic test, focusing on the criteria of taste, aroma, and color. This test employed a 9-point hedonic scale, ranging from extremely dislike (1) and very dislike (2) to dislike (3), slightly dislike (4), neutral (5), slightly like (6), like (7), very like (8), and extremely like (9). The data collected from the panelists were analyzed using descriptive statistics, and the findings were presented as mean ± standard error.

The selection of the best formulation of the brewed products was conducted by involving Rank Order Centroid (ROC) and Simple Additive Weighting (SAW) as decision-making tools. The decision-making procedure begins by determining the weight of sensory evaluation criteria using ROC. The formula of ROC is written as follows: (Panjaitan and Desnelita, 2021)

$$\mathrm{Wk} = \frac{1}{k}\sum_{\mathrm{i}=1}^{k}\left(\frac{1}{i}\right) \qquad (1)$$

where Wk is the final weight of each criterion, *k* is the number of criteria, and *i* is the priority level of each criterion, which is prior determined by assigning the priority order. In this study, the priority order of each criterion was obtained by an interview with an expert in the field of agro-industrial engineering. Furthermore, the weight of each criterion along with the sensory evaluation scores of the alternatives are processed by SAW by the following procedures: (Febriyanto and Rusi, 2020)

A. Determining the criteria (C_j) and alternatives (A_i) used in decision-making, where *i* is the number of rows (*i* = 1, 2, ..., *n*) and *j* is the number of columns (*j* = 1, 2, ..., *m*).

B. Filling in the performance ratings for each alternative on all criteria. The performance ratings were obtained from the mean calculation of organoleptic scores.

C. Determining the weight values (W) for all criteria. The weight value for each criterion is obtained from the calculation of the Rank Order Centroid (ROC).

D. Creating a decision matrix (X) using the values of performance ratings for each alternative on all criteria. Thus, the configuration of the decision matrix will be as follows:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1j} \\ \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} \end{bmatrix}$$

E. Normalizing the decision matrix by calculating the normalized performance ratings (r_{ij}) depending on the attribute type: (1) benefit, or (2) cost. The equation for each type will be as follows:

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{\max x_{ij}} & \text{if j is a benefit attribute} \\ \dfrac{\min x_{ij}}{x_{ij}} & \text{if j is a cost attribute} \end{cases}$$

In this study, the criteria of taste, aroma, and color were categorized as benefits. This is due to the higher score of each criterion showed the higher panelists' preference for the product (green tea extract).

F. Performing the weight sum calculation to determine the preference score (V_i) for all alternatives using the following equation:

$$V_i = \sum_{j=1}^{n} W_j \, r_{ij}$$

The alternative which has the highest V_i score will be chosen as the final result of decision making, which also indicates its position as the best formulation of brewed products based on its sensory scores.

3. Result

The average scores for each organoleptic criterion obtained from the organoleptic test of the brewed products are summarized in Table 1, highlighting the sensory evaluation results for four brewed product samples. Sample (C) achieved the highest score for taste, indicating an appealing flavor experience among panelists. In terms of aroma, Sample (B) received the highest score, suggesting a favorable aromatic profile. Sample (A) achieved the highest score for color, reflecting strong visual appeal. Overall, these results demonstrate that while variations exist in taste and aroma among the samples, certain formulations excel in specific organoleptic criterion.

Table 1. Organoleptic test results of brewed products

Sample	Organoleptic Criterion		
	Taste	Aroma	Color
A) Blue Pea 100 g + sugar 100 g	7.03 ± 0.21	5.90 ± 0.33	7.73 ± 0.20
B) Blue Pea + Peppermint (100 g) + sugar (100 g)	7.03 ± 0.29	6.63 ± 0.26	7.53 ± 0.20
C) Blue Pea 100 g + sugar 200 g	7.07 ± 0.21	6.70 ± 0.28	7.53 ± 0.22
D) Blue Pea + Peppermint (100 g) + sugar (200 g)	6.83 ± 0.26	6.73 ± 0.22	7.60 ± 0.18

Furthermore, decision-making methods were employed to determine the most preferred formulation for the brewed product. In this study, Rank Order Centroid (ROC) was utilized as the weighting method for the criteria, while Simple Additive Weighting (SAW) served as the decision-making tool for the alternatives. The initial step in the decision-making process involved establishing the weights of the criteria — taste, aroma, and color — using ROC to reflect their priority ranking. This priority ranking was derived from interviews with experts in the field of agro-industrial engineering. The final conclusion regarding the priority rank of the criteria is as follows: **Taste > Aroma > Color**. The calculations of the weight for each criterion are presented in Table 2.

Table 2. The criteria weight calculation using ROC

Criterion	Weight Calculation Using ROC
Taste	$\frac{1+\frac{1}{2}+\frac{1}{3}}{3} = 0.611$
Aroma	$\frac{0+\frac{1}{2}+\frac{1}{3}}{3} = 0.278$
Color	$\frac{0+0+\frac{1}{3}}{3} = 0.111$

The next step involved creating a normalized decision matrix from the sensory evaluation results presented in Table 1. The maximum values (x_{ij}) for the criteria of taste, aroma, and color are 7.07, 6.73, and 7.73, respectively. Consequently, calculations were performed using Equation (3), and the resulting normalized decision matrix is presented in Table 3.

Table 3. Normalized decision matrix

Sample	Normalized Value of Organoleptic Criterion		
	Taste	Aroma	Color
A) Blue Pea 100 g + sugar 100 g	0.99	0.88	1.00
B) Blue Pea + Peppermint (100 g) + sugar (100 g)	0.99	0.99	0.97
C) Blue Pea 100 g + sugar 200 g	1.00	1.00	0.97
D) Blue Pea + Peppermint (100 g) + sugar (200 g)	0.97	1.00	0.98

The normalized decision matrix is further processed for the calculation of the preference score for each alternative using equation (4). The preference scores represent the relative ranking of each sample based on the assigned organoleptic criteria: taste, aroma, and color. By integrating the weighted normalized values, the resulting scores provide insight into which sample is the most preferred. The results of the calculation were presented in Table 4. The findings show that Sample C (Blue Pea 100 g + Sugar 200 g) attained the highest preference score, with a preference score of 0.9959, making it the most preferred among the four samples evaluated. Sample B (Blue Pea + Peppermint 100 g + Sugar 100 g) and Sample D (Blue Pea + Peppermint 100 g + Sugar 200 g) ranked slightly lower, with the preference scores of 0.9895 and 0.9774, respectively. On the other hand, Sample A (Blue Pea 100 g + Sugar 100 g), received the lowest preference score, making it the least appealing option.

Table 4. Preference Score (Vi) Calculation for Alternatives

Sample	Normalized Value and Weight of Organoleptic Criterion			Preference Score (V_i)
	Taste	Aroma	Color	
	0.611	0.278	0.111	
A) Blue Pea 100 g + sugar 100 g	0.99	0.88	1.00	0.9623
B) Blue Pea + Peppermint (100 g) + sugar (100 g)	0.99	0.99	0.97	0.9895
C) Blue Pea 100 g + sugar 200 g	**1.00**	**1.00**	**0.97**	**0.9959**
D) Blue Pea + Peppermint (100 g) + sugar (200 g)	0.97	1.00	0.98	0.9774

4. Discussion

Based on the preference scores obtained from the Rank Order Centroid (ROC) and Simple Additive Weighting (SAW) calculations, Sample C (Blue Pea 100 g + Sugar 200 g) is identified as the optimal formulation for the brewed product. This formulation effectively balances the natural sweetness of sugar with the distinctive flavor profile of blue pea flowers (*Clitoria ternatea*), which are renowned for their potential health benefits, including antioxidant and anti-inflammatory properties (Khairina et al., 2021; Kamilla et al., 2009). Moreover, the vibrant blue color of the blue pea flower is attributed to its high anthocyanin content, which has been shown to provide various health advantages, such as improving cognitive function and enhancing skin health (Rifqi, 2021; Priska et al., 2018). The combination of blue pea and sugar not only creates an aesthetically pleasing beverage but also contributes to its marketability as a health-oriented drink. Research indicates that beverages incorporating blue pea extract have commercial potential due to their functional properties and consumer appeal (Lakshan et al., 2019; Marpaung, 2020).

On the other hand, while Peppermint (for example, *Mentha piperita* L.) is known for its refreshing aroma and flavor, there are several reasons why Peppermint may not achieve the highest preference score compared to the combination of blue pea and sugar. One reason is taste preference. Blue pea imparts an attractive blue color and a unique flavor that may be more appealing to consumers than the overpowering flavor of Peppermint, which can be perceived as too strong or sharp. The intense flavor of Peppermint can dominate the overall taste experience of the brewed product, which may not be favored by all consumers. This aligns with the study by Anggraini et al. (2014), which found that adding Peppermint beyond a certain concentration could decrease panelists' taste preference for brewing products made from *Pegagan* (*Centella asiatica*, L. Urban) leaf.

5. Conclusion

This study successfully demonstrated the application of Rank Order Centroid (ROC) and Simple Additive Weighting (SAW) methods in identifying the optimal formulation of brewed products derived from Blue Pea (*Clitoria ternatea L.*) flowers and Peppermint (*Mentha piperita* L.) based on organoleptic scores. Sample C, consisting of 100 g of Blue Pea flowers and 200 g of sugar, was identified as the preferred choice, achieving a final preference score of 0.9959.

For future research on brewed products from Blue Pea flowers, several recommendations regarding quality parameters to be evaluated using decision-making approaches are suggested. First, conducting a nutritional analysis of the final products, including assessments of antioxidant content, antibacterial activities, and anti-inflammatory properties will provide valuable insights into the health benefits of these beverages. Additionally, investigating the color stability of the brews under various storage conditions — such as different temperatures and light exposures — will help ascertain how these factors impact the visual quality of the products. Future research should also explore the impact of varying brewing temperatures on the organoleptic and physicochemical properties of the products.

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