

A CRITIC–CoCoSo-Based Decision Support Model for Coffee Bean Quality Evaluation in Coffee Beverage Production

(Model Pendukung Keputusan Berbasis CRITIC–CoCoSo untuk Evaluasi Kualitas Biji Kopi dalam Produksi Minuman Kopi)

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ABSTRACT

Consistency in coffee bean quality is essential for maintaining flavor stability and production efficiency in coffee-based beverages. However, quality evaluation in small-scale coffee industries is often subjective and lacks a structured decision support system. This study aims to develop a decision support model for evaluating coffee bean quality using a Multi-Criteria Decision Making (MCDM) approach by integrating the CRITIC (Criteria Importance Through Intercriteria Correlation) and CoCoSo (Combined Compromise Solution) methods. The CRITIC method is employed to determine objective criterion weights based on data variability and inter-criteria correlations, while the CoCoSo method is used to rank alternatives. A total of 15 coffee bean alternatives were evaluated using seven criteria: price, availability, aroma, taste, color, texture, and caffeine content. The weighting results indicate that color (0.215) and price (0.191) are the most influential criteria in the evaluation process. The ranking results show that alternative A9 achieved the highest preference score ($K = 4.1634$), followed by A7 ($K = 3.5747$) and A6 ($K = 3.4920$). These results demonstrate that coffee beans with strong performance across sensory and physical attributes tend to achieve higher rankings. The proposed CRITIC–CoCoSo model provides a systematic, objective, and practical decision support tool that can assist small to medium-scale coffee industries in selecting high-quality raw materials, improving product consistency, and enhancing production efficiency.

Keywords: Coffee Bean Quality; CRITIC-CoCoSo; Decision Support System; MCDM

ABSTRAK

Konsistensi kualitas biji kopi merupakan faktor penting dalam menjaga stabilitas cita rasa dan efisiensi produksi minuman berbasis kopi. Namun, proses evaluasi kualitas biji kopi pada industri skala kecil masih cenderung subjektif dan belum didukung oleh sistem pendukung keputusan yang terstruktur. Penelitian ini bertujuan untuk mengembangkan model sistem pendukung keputusan dalam evaluasi kualitas biji kopi menggunakan pendekatan Multi-Criteria Decision Making (MCDM) dengan mengintegrasikan metode CRITIC (Criteria Importance Through Intercriteria Correlation) dan CoCoSo (Combined Compromise Solution). Metode CRITIC digunakan untuk menentukan bobot kriteria secara objektif berdasarkan variasi data dan korelasi antar kriteria, sedangkan metode CoCoSo digunakan untuk melakukan pemeringkatan alternatif. Penelitian ini mengevaluasi 15 alternatif biji kopi berdasarkan tujuh kriteria, yaitu harga, ketersediaan, aroma, rasa, warna, tekstur, dan kadar kafein. Hasil pembobotan menunjukkan bahwa warna (0,215) dan harga (0,191) merupakan kriteria yang paling dominan dalam proses evaluasi. Hasil pemeringkatan menunjukkan bahwa alternatif A9 memperoleh nilai preferensi tertinggi sebesar $K = 4,1634$, diikuti oleh A7 sebesar $K = 3,5747$ dan A6 sebesar $K = 3,4920$. Hasil ini menunjukkan bahwa biji kopi dengan performa tinggi pada atribut sensorik dan fisik cenderung memiliki peringkat yang lebih baik. Model CRITIC–CoCoSo yang diusulkan mampu memberikan pendekatan evaluasi yang objektif, sistematis, dan aplikatif sebagai sistem pendukung keputusan untuk membantu industri kopi skala kecil hingga menengah dalam memilih bahan baku berkualitas,



meningkatkan konsistensi produk, serta efisiensi produksi.

Kata kunci: CRITIC-CoCoSo; kualitas biji kopi; MCDM; sistem pendukung keputusan

1. INTRODUCTION

The coffee industry has experienced rapid growth in line with the increasing global demand for coffee products with consistent flavor profiles and high quality. Competition among producers is no longer solely focused on production volume, but also on the ability to maintain raw material quality, sensory characteristic stability, and transparency throughout the supply chain [1]–[3]. Physicochemical factors such as moisture content, bean size, density, and micro-environmental conditions significantly influence sensory characteristics and the consistency of coffee flavor. Inconsistencies in these factors may lead to a decline in product quality and reduced consumer trust [4]. In addition, sustainability challenges in the coffee supply chain have become increasingly complex, highlighting the need for more integrated and objective quality evaluation systems [5].

Several studies have emphasized the importance of technology-based and analytical approaches in evaluating coffee quality. Consumer experience quality has been shown to correlate strongly with raw material quality and flavor consistency in coffee products [6]. Furthermore, the quality of Arabica coffee is influenced by various factors, including geographical origin, physicochemical properties, biochemical composition, and volatile compounds that contribute to aroma formation [4]. Other studies indicate that the coffee supply chain faces sustainability challenges that require the integration of quality, environmental, and social aspects [5]. Advances in artificial intelligence-based technologies have also been utilized to improve the accuracy and efficiency of coffee quality evaluation processes [7].

In the context of decision-making, Multi-Criteria Decision Making (MCDM) methods are widely used to address problems involving multiple, often conflicting criteria [8]. One commonly used method is CRITIC (Criteria Importance Through Intercriteria Correlation), which determines objective criterion weights based on data variability and inter-criteria correlations [9]–[12]. In addition, the Combined Compromise Solution (CoCoSo) method is employed to rank alternatives by balancing multiple criteria comprehensively [13], [14]. Several studies have demonstrated that the integration of CRITIC and CoCoSo methods can improve the accuracy and objectivity of decision-making processes across various domains [15], [16].

However, the application of the hybrid CRITIC–CoCoSo approach is still predominantly found in the fields of energy, infrastructure, and engineering systems, and has not been widely applied in the evaluation of agricultural product quality, particularly coffee beans [17]–[19]. Moreover, previous studies tend to focus on technical or environmental aspects separately, without integrating them into a comprehensive evaluation framework. This indicates the need for a decision support system capable of integrating multiple quality aspects in an objective and systematic manner [20]–[22].

Based on these issues, this study aims to develop a coffee bean quality evaluation model using the CRITIC–CoCoSo method. The proposed model is expected to provide objective weighting of criteria and generate comprehensive alternative rankings. Furthermore, this study is expected to support decision-making in small to medium-scale coffee industries and improve consistency and efficiency in raw material selection.

2. METHODS

2.1 Research Design

This study employs a quantitative approach with an observational experimental design. The focus of this research is on the numerical analysis of coffee bean quality parameters so that the results can be measured objectively and reproduced by other researchers. A quantitative approach is selected because it enables measurable evaluation based on real-world data.

This study applies a Multi-Criteria Decision Making (MCDM) framework by combining the CRITIC (Criteria Importance Through Intercriteria Correlation) and CoCoSo (Combined Compromise Solution) methods. This combination is used to develop a coffee bean quality evaluation model capable of generating objective criteria weights and comprehensive alternative rankings.

The CRITIC method has been proven to be an objective approach in determining criteria weights by considering inter-criteria correlation and the level of information contained in each criterion [23]–[25]. Meanwhile, CoCoSo is a relatively recent MCDM method that has been widely applied for ranking alternatives, as it integrates compromise solutions and produces stable and consistent results [26]–[31]. The implementation of the combined CRITIC–CoCoSo method in this study is carried out through interconnected research stages, as illustrated in the following flowchart.

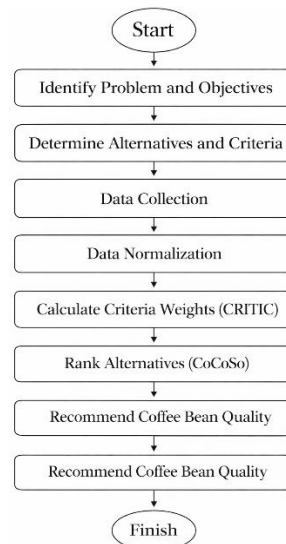


Figure 1. Research Stages

2.2 Problem Identification and Research Objectives

This stage aims to identify problems in evaluating coffee bean quality, such as inconsistency in raw material quality and the absence of an objective evaluation model. Based on these issues, the research objective is formulated, namely to develop a coffee bean quality evaluation model based on the CRITIC–CoCoSo method.

2.3 Determination of Alternatives and Criteria

The determination of alternatives and criteria in this study serves as the basis for systematically evaluating coffee bean quality. The alternatives consist of various types of coffee beans commonly used in the coffee beverage industry, representing diverse characteristics and geographical origins.

Table 1. Criteria Data

No	Criteria	Type	Code	Sub-Criteria	Score
1	Price	Cost	C1	Rp 18,000–Rp 24,000	5
				Rp 25,000–Rp 33,000	3
				Rp 34,000–Rp 40,000	1
2	Availability	Benefit	C2	Always available	5
				Easily obtained	4
				Moderately available	3
				Rarely available	2
				Seasonal / often unavailable	1
3	Aroma	Benefit	C3	Strong	5
				Moderate	3
				Weak	1
4	Taste	Benefit	C4	Strong	5
				Neutral	3
				Weak	1
5	Color	Benefit	C5	Uniform	5
				Fairly uniform	3
				Uneven	1
6	Texture	Benefit	C6	Large	5
				Medium	3
				Mixed	1
				Very high	5
7	Caffeine Content	Benefit	C7	High	4
				Medium	3
				Low	2
				Very low	1

This table presents the criteria and sub-criteria used in evaluating coffee bean quality. Seven main criteria are used: price (C1), availability (C2), aroma (C3), taste (C4), color (C5), texture (C6), and caffeine content (C7). Price is classified as a cost criterion, while the others are benefit criteria.

Table 2. Alternative Data

Coffee Beans	Code	Price	Availability	Aroma	Taste	Color	Texture	Caffeine
Siberteng	A1	22,000	Easily obtained	Strong	Strong	Uniform	Medium	Medium
Lau Gedang	A2	24,000	Moderate	Moderate	Strong	Fairly uniform	Medium	Medium
Naman Teran	A3	25,000	Rare	Strong	Neutral	Uniform	Medium	Medium
Baribu Dolok	A4	26,000	Seasonal	Weak	Neutral	Uniform	Medium	Medium
Kerinci	A5	32,000	Always available	Strong	Strong	Uniform	Mixed	High
Mandailing	A6	30,000	Always available	Strong	Strong	Uniform	Large	High
Gayo	A7	40,000	Easily obtained	Strong	Neutral	Uniform	Medium	High
Lintong	A8	35,000	Easily obtained	Moderate	Neutral	Uniform	Medium	Medium
Sidikalang	A9	40,000	Always available	Strong	Strong	Uniform	Large	Very High
Dolok Sanggul	A10	25,000	Moderate	Moderate	Neutral	Uniform	Medium	Medium
Solok Radjo	A11	35,000	Moderate	Strong	Weak	Uniform	Medium	Low
Agam	A12	33,000	Rare	Moderate	Neutral	Fairly uniform	Mixed	Medium
Lampung Robusta	A13	20,000	Always available	Strong	Strong	Fairly uniform	Large	Very High
Liwa Lampung	A14	21,000	Easily obtained	Moderate	Strong	Fairly uniform	Mixed	High
Tanggamus	A15	19,000	Moderate	Weak	Neutral	Fairly uniform	Medium	High

2.4 Data Collection

This stage involves collecting data used in the analysis, including observational data, secondary data, and coffee bean quality assessment data. Data collection techniques include observation, interviews with café workers, and questionnaires distributed to consumers.

2.5 Data Normalization

The collected data are normalized to ensure comparability across criteria. The normalization process is adjusted according to the type of criteria (benefit or cost).

2.6 Criteria Weight Calculation (CRITIC)

CRITIC determines objective weights by considering data variation and inter-criteria relationships.

2.6.1 Decision Matrix

The decision matrix represents the performance of each alternative against each criterion.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

2.6.2 Normalization

The normalization process transforms raw data into comparable values using:

$$d_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2)$$

This equation converts each criterion value into a normalized scale between 0 and 1.

2.6.3 Variability Calculation

The variability of each criterion is measured using standard deviation:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^n (d_{ij} - d_j)^2}{n}} \quad (3)$$

This value indicates how dispersed the data is; higher dispersion implies higher importance.

The correlation between criteria is calculated as:

$$R_{ij} = \frac{\sum_{i=1}^n (d_{ij} - \bar{d}_j)(d_{ij} - \bar{d}_h)}{\sqrt{\sum_{i=1}^n (d_{ij} - \bar{d}_j)^2} * \sqrt{\sum_{i=1}^n (d_{ij} - \bar{d}_h)^2}} \quad (4)$$

Then, the amount of information contained in each criterion is computed:

$$C_j = \sigma_j \sum_{j=1}^n (1 - R_{ij}) \quad (5)$$

2.6.4 Weight Determination.

The final weight of each criterion is obtained by normalizing C_j :

$$W_j = \frac{c_j}{\sum c_j} \quad (6)$$

A higher weight indicates a more important criterion.

2.7 Alternative Ranking (CoCoSo)

2.7.1 Normalized Matrix

The normalized matrix is calculated differently for benefit and cost criteria:

Benefit:

$$r_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (7)$$

Cost:

$$r_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (8)$$

2.7.2 Calculation of S_i

The weighted sum of each alternative is calculated as:

$$S_i = \sum_{j=1}^n (W_j r_{ij}) \quad (9)$$

This represents the overall performance score.

2.7.3 Calculation of K_{ia}, K_{ib}, K_{ic}

Three aggregation strategies are used:

$$K_{ia} = \frac{P_i + S_i}{\sum_{i=1}^m (P_i + S_i)} \quad (10)$$

$$K_{ib} = \frac{S_i}{\min S_i} + \frac{P_i}{\min P_i} \quad (11)$$

$$K_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{(\lambda \max S_i + (1-\lambda) \max P_i)} \quad (12)$$

These represent different compromise solutions.

2.7.4 Final Score Calculation

The final score of each alternative is calculated as

$$K_i = (k_{ia} k_{ib} k_{ic})^{\frac{1}{3}} + \frac{1}{3} (k_{ia} + k_{ib} + k_{ic}) \quad (13)$$

The alternative with the highest K_i value is considered the best.

2.8 Recommendation of Coffee Bean Quality

Based on the CoCoSo ranking results, the best alternative is selected as a recommendation for coffee-based beverage industries.

2.9 Participants (Population and Sample)

This study was conducted in a café as the research site. Participants include café workers (baristas and managers) and consumers. Workers provide technical insights, while consumers evaluate sensory attributes such as aroma, taste, and overall quality. Participants were selected using purposive sampling. The study also includes 15 coffee bean alternatives representing diverse geographical origins and quality characteristics used in beverage preparation.

3. RESULTS AND DISCUSSION

The analysis begins with the calculation of objective weights for each criterion using the CRITIC method based on data variation and inter-criteria correlation. The resulting weights are then used as the basis for ranking coffee bean alternatives using the CoCoSo method. The results provide an overview of the relative importance of each criterion and produce a ranking of the best coffee bean alternatives, which can be used as a reference in decision-making for selecting raw materials in a consistent and efficient manner.

3.1 Criteria Weight Calculation Using the CRITIC Method

3.1.1 Decision Matrix

This section presents the decision matrix containing the evaluation scores of each alternative across all criteria. These data form the main basis for the multi-criteria decision-making process.

Table 3. Decision Matrix Data

Alternative	C1	C2	C3	C4	C5	C6	C7
A1	5	4	5	5	5	3	3
A2	5	3	3	5	3	3	3
A3	3	2	5	3	5	3	3
A4	3	1	1	3	5	3	3
A5	3	5	5	5	5	1	4
A6	3	5	5	5	5	5	4
A7	1	4	5	3	5	3	4
A8	1	4	3	3	5	3	3
A9	1	5	5	5	5	5	5
A10	3	3	3	3	5	3	3
A11	1	3	5	1	5	3	2
A12	3	2	3	3	3	1	3
A13	5	5	5	5	3	5	5
A14	5	4	3	5	3	1	4
A15	5	3	1	3	3	3	4

This table presents the decision matrix containing the evaluation scores of each alternative (A1–A15) against seven criteria (C1–C7). Criterion C1 is classified as a cost criterion, while C2–C7 are benefit criteria. This matrix shows the variation of scores among alternatives for each criterion. These values are used in the next normalization stage.

The maximum and minimum values are determined to define the range of each criterion. This information is required for the normalization process.

Table 4. Maximum and Minimum Values of Criteria

	C1	C2	C3	C4	C5	C6	C7
MAX	5	5	5	5	5	5	5
MIN	1	1	1	1	3	1	2

These ranges highlight the differences in scale across criteria. They serve as the basis for the normalization step.

3.1.2 Normalization

Normalization is performed to standardize the scale of all criteria. This ensures that all values can be compared fairly.

Table 5. Normalized Data (CRITIC Method)

Alt	C1	C2	C3	C4	C5	C6	C7
A1	0.00	0.75	1.00	1.00	1.00	0.50	0.33
A2	0.00	0.50	0.50	1.00	0.00	0.50	0.33
A3	0.50	0.25	1.00	0.50	1.00	0.50	0.33
A4	0.50	0.00	0.00	0.50	1.00	0.50	0.33
A5	0.50	1.00	1.00	1.00	1.00	0.00	0.67
A6	0.50	1.00	1.00	1.00	1.00	1.00	0.67

Alt	C1	C2	C3	C4	C5	C6	C7
A7	1.00	0.75	1.00	0.50	1.00	0.50	0.67
A8	1.00	0.75	0.50	0.50	1.00	0.50	0.33
A9	1.00	1.00	1.00	1.00	1.00	1.00	1.00
A10	0.50	0.50	0.50	0.50	1.00	0.50	0.33
A11	1.00	0.50	1.00	0.00	1.00	0.50	0.00
A12	0.50	0.25	0.50	0.50	0.00	0.00	0.33
A13	0.00	1.00	1.00	1.00	0.00	1.00	1.00
A14	0.00	0.75	0.50	1.00	0.00	0.00	0.67
A15	0.00	0.50	0.00	0.50	0.00	0.50	0.67

Normalization is performed to eliminate differences in scale and measurement units among criteria. Normalization removes differences in scale among variables. The resulting data are ready for CRITIC weight calculation.

3.1.3 Variability Calculation

Variability is calculated to measure the dispersion of each criterion. This indicates the level of variation among alternatives.

Table 6. Standard Deviation (σ)

C1	C2	C3	C4	C5	C6	C7
0.399	0.311	0.368	0.316	0.488	0.327	0.278

Standard deviation reflects the degree of variation in each criterion. Higher values indicate greater dispersion among alternatives. The correlation matrix is used to identify relationships between criteria. This is important in the CRITIC method to assess redundancy.

Table 7. Correlation Matrix

	PRICE	AVAILABILITY	AROMA	FLAVOR	COLOR	TEXTURE	CAFFEINE CONTENT
C1	1,00	0,04	0,29	-0,51	0,67	0,14	-0,16
C2	0,04	1,00	0,61	0,62	0,08	0,35	0,67
C3	0,29	0,61	1,00	0,25	0,40	0,30	0,21
C4	-0,51	0,62	0,25	1,00	-0,23	0,17	0,65
C5	0,67	0,08	0,40	-0,23	1,00	0,22	-0,23
C6	0,14	0,35	0,30	0,17	0,22	1,00	0,39
C7	-0,16	0,67	0,21	0,65	-0,23	0,39	1,00

Correlations show both positive and negative relationships between criteria. These results are used in the total variability calculation. Total variability is computed using standard deviation and correlation values. This value represents the contribution of each criterion.

Table 8. Variability Values

	PRICE	AVAILABILITY	AROMA	FLAVOR	COLOR	TEXTURE	CAFFEINE CONTENT	$\sum(1 - r_{ij})$
C1	0,00	0,96	0,71	1,51	0,33	0,86	1,16	5,53
C2	0,96	0,00	0,39	0,38	0,92	0,65	0,33	3,64
C3	0,71	0,39	0,00	0,75	0,60	0,70	0,79	3,95
C4	1,51	0,38	0,75	0,00	1,23	0,83	0,35	5,06
C5	0,33	0,92	0,60	1,23	0,00	0,78	1,23	5,09
C6	0,86	0,65	0,70	0,83	0,78	0,00	0,61	4,43
C7	1,16	0,33	0,79	0,35	1,23	0,61	0,00	4,47

The variability is calculated using the standard deviation and correlation values. Higher variability indicates a greater contribution of a criterion in decision-making. Higher variability values indicate greater importance of a criterion. These values are used as the basis for final weight determination.

3.1.4 Criteria Weights

Criteria weights are calculated based on variability and standard deviation results. These values represent the relative importance of each criterion.

Table 9. Criteria Weights

Criterion	σ	$\Sigma(1-r_{ij})$	C_j	W_j
Price	0.3994	5.5282	2.2080	0.191
Availability	0.3115	3.6406	1.1340	0.098
Aroma	0.3684	3.9537	1.4565	0.126
Taste	0.3162	5.0561	1.5989	0.138
Color	0.4880	5.0943	2.4858	0.215
Texture	0.3273	4.4283	1.4495	0.125
Caffeine	0.2779	4.4701	1.2424	0.107

The final weights show the relative contribution of each criterion. These values will be used in the final decision-making process.

3.2 Ranking Using the CoCoSo Method

3.2.1 Calculation of Si

This stage calculates the aggregated performance score (Si) for each alternative. The values are obtained by combining weighted normalized criteria.

Table 10. Aggregation Score (Si)

ALTERNATIF	COST	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT	Si
	C1	C2	C3	C4	C5	C6	C7	
A1	0,04	0,08	0,13	0,14	0,21	0,08	0,06	0,73
A2	0,04	0,06	0,08	0,14	0,13	0,08	0,06	0,58
A3	0,06	0,04	0,13	0,08	0,21	0,08	0,06	0,67
A4	0,06	0,02	0,03	0,08	0,21	0,08	0,06	0,55
A5	0,06	0,10	0,13	0,14	0,21	0,03	0,09	0,75
A6	0,06	0,10	0,13	0,14	0,21	0,13	0,09	0,85
A7	0,19	0,08	0,13	0,08	0,21	0,08	0,09	0,85
A8	0,19	0,08	0,08	0,08	0,21	0,08	0,06	0,78
A9	0,19	0,10	0,13	0,14	0,21	0,13	0,11	1,00
A10	0,06	0,06	0,08	0,08	0,21	0,08	0,06	0,64
A11	0,19	0,06	0,13	0,03	0,21	0,08	0,04	0,74
A12	0,06	0,04	0,08	0,08	0,13	0,03	0,06	0,48
A13	0,04	0,10	0,13	0,14	0,13	0,13	0,11	0,76
A14	0,04	0,08	0,08	0,14	0,13	0,03	0,09	0,57
A15	0,04	0,06	0,03	0,08	0,13	0,08	0,09	0,49
BOBOT	0,19	0,10	0,13	0,14	0,21	0,13	0,11	

The Si values represent the overall aggregated performance of each alternative. Higher Si indicates better overall performance across criteria. This step calculates the comparative power score (Pi) for each alternative. Pi reflects the relative strength of each alternative compared to the best values.

Table 11. Comparative Power Weight (Pi)

ALTERNATIF	COST	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT	Pi
	C1	C2	C3	C4	C5	C6	C7	
A1	0,74	0,98	1,00	1,00	1,00	0,94	0,95	0,64
A2	0,74	0,95	0,94	1,00	0,90	0,94	0,95	0,52
A3	0,81	0,91	1,00	0,93	1,00	0,94	0,95	0,61

ALTERNATIF	COST	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT	Pi
	C1	C2	C3	C4	C5	C6	C7	
A4	0,81	0,85	0,82	0,93	1,00	0,94	0,95	0,47
A5	0,81	1,00	1,00	1,00	1,00	0,82	0,98	0,65
A6	0,81	1,00	1,00	1,00	1,00	1,00	0,98	0,79
A7	1,00	0,98	1,00	0,93	1,00	0,94	0,98	0,83
A8	1,00	0,98	0,94	0,93	1,00	0,94	0,95	0,76
A9	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
A10	0,81	0,95	0,94	0,93	1,00	0,94	0,95	0,60
A11	1,00	0,95	1,00	0,80	1,00	0,94	0,91	0,65
A12	0,81	0,91	0,94	0,93	0,90	0,82	0,95	0,45
A13	0,74	1,00	1,00	1,00	0,90	1,00	1,00	0,66
A14	0,74	0,98	0,94	1,00	0,90	0,82	0,98	0,48
A15	0,74	0,95	0,82	0,93	0,90	0,94	0,98	0,44
BOBOT	0,19	0,10	0,13	0,14	0,21	0,13	0,11	

Pi shows how close each alternative is to the ideal performance. Higher values indicate stronger comparative dominance.

3.2.2 Calculation of Kia, Kib, Kic

This stage computes the combined creative weights using three aggregation approaches. These values integrate both additive and multiplicative perspectives.

Table 12. Creative Weight Calculation

ALTERNATIF	CALCULATION OF CREATIVE WEIGHT					
	Si	Pi	λ	Ka	Kb	Kc
A1	0,73	0,64		1,20	2,99	0,687
A2	0,58	0,52		1,05	2,40	0,551
A3	0,67	0,61		1,15	2,79	0,640
A4	0,55	0,47		1,01	2,21	0,507
A5	0,75	0,65		1,21	3,05	0,699
A6	0,85	0,79		1,33	3,59	0,822
A7	0,85	0,83		1,35	3,69	0,844
A8	0,78	0,76	0,5	1,27	3,37	0,770
A9	1,00	1,00		1,50	4,37	1,000
A10	0,64	0,60		1,12	2,69	0,617
A11	0,74	0,65		1,20	3,02	0,692
A12	0,48	0,45		0,96	2,03	0,464
A13	0,76	0,66		1,23	3,10	0,710
A14	0,57	0,48		1,03	2,29	0,526
A15	0,49	0,44		0,96	2,03	0,466

Kia is calculated using a ratio aggregation approach, Kib uses a minimum ratio approach, and Kic applies a λ -based compromise approach. The Kia, Kib, and Kic values represent different aggregation perspectives. These values are later used to compute the final ranking score.

3.2.3 Final Ranking

The final ranking is obtained by combining all previous calculations. This step determines the best alternative based on overall performance.

Table 13. Final Preference Score

Alternative	K	Rank
A9	4.1634	1
A7	3.5747	2
A6	3.4920	3
A8	3.2941	4
A13	3.0693	5
A5	3.0264	6
A11	2.9965	7
A1	2.9788	8
A3	2.7951	9
A10	2.7072	10
A2	2.4521	11
A14	2.3574	12
A4	2.2818	13
A15	2.1239	14
A12	2.1198	15

The final ranking identifies A9 as the best-performing alternative. This is followed by A7 and A6 with relatively close scores. The line chart visualizes the final preference scores of all alternatives. It provides a clear comparison of ranking distribution.

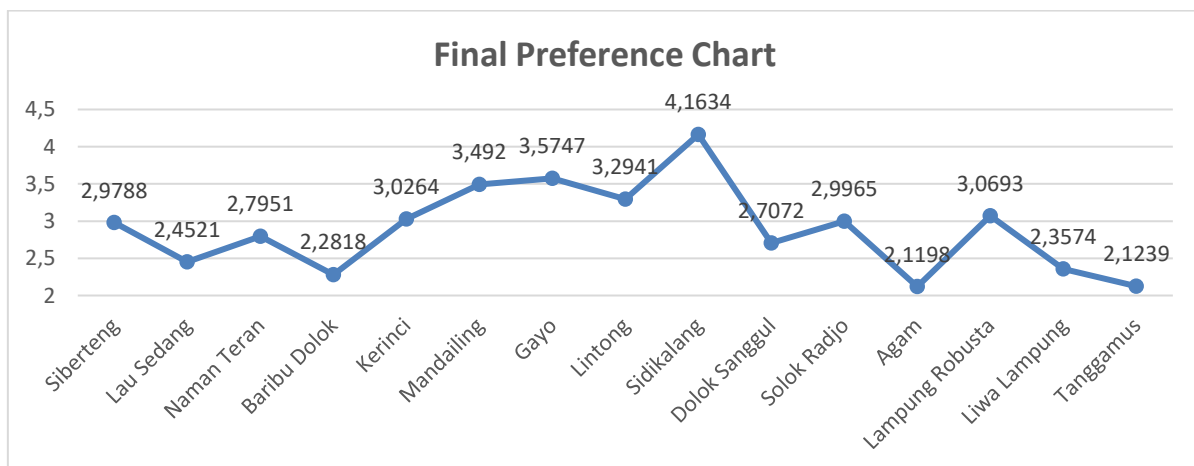


Figure 2. Final Preference Score Line Chart

The Figure 2 illustrates the comparison of preference scores among alternatives. The results show that A9 has the highest score (4.1634), followed by A7 and A6. This indicates that A9 is the best alternative.

3.3 Discussion

The results of this study demonstrate that the integration of the CRITIC and CoCoSo methods provides a robust and objective framework for evaluating coffee bean quality. The CRITIC method successfully determines criteria weights based on data variability and inter-criteria correlation, ensuring that the weighting process is free from subjective bias. This is consistent with previous studies stating that CRITIC is effective in extracting objective information from decision matrices by considering both contrast intensity and conflict among criteria [11], [12], [23], [24]. Furthermore, the enhancement of CRITIC in recent works confirms its robustness in producing reliable weights for multi-criteria decision-making (MCDM) problems [9].

From a practical perspective, the resulting criteria weights indicate that attributes such as color, price, and taste have higher importance compared to others. This finding aligns with the concept that food quality evaluation is strongly influenced by both intrinsic product characteristics and consumer perception [2]. In the context of coffee, physical appearance and sensory attributes play a crucial role in determining perceived quality and consumer acceptance. The application of the CoCoSo method in this study further strengthens the decision-making model by providing a stable and consistent ranking of alternatives. CoCoSo combines multiple compromise strategies, allowing it to balance different

evaluation perspectives effectively [13]. Previous research has shown that CoCoSo produces reliable ranking results across various domains, including engineering, energy planning, and infrastructure decision-making [16]–[19]. In this study, the method successfully identified alternative A9 as the best coffee bean, followed by A7 and A6, indicating that these alternatives have superior overall performance across all evaluated criteria.

When compared with existing literature on coffee quality, this study offers a more operational and decision-oriented approach. Research by Markos Makiso Urugo et al. emphasizes that coffee quality is influenced by geographical conditions, physicochemical properties, and volatile compounds [4]. While such studies provide deep scientific insights, they often require complex laboratory analysis. In contrast, the proposed CRITIC–CoCoSo model translates these quality dimensions into measurable criteria that can be evaluated more practically at the industry level.

Similarly, studies on coffee supply chain and sustainability highlight the importance of maintaining consistent raw material quality to ensure overall product quality [5], [21], [22]. The findings of this study support this perspective by demonstrating that a structured evaluation model can help decision-makers select high-quality coffee beans consistently. This is particularly important in the food industry, where traceability, quality assurance, and standardization are critical factors [1], [3].

In addition, consumer-oriented research indicates that coffee quality significantly affects customer satisfaction and overall experience [6]. By providing a systematic ranking of coffee beans, the proposed model contributes to improving product consistency, which in turn can enhance customer satisfaction and perceived value. This aligns with the broader understanding that quality management in food products directly influences consumer trust and demand [2].

Compared to advanced analytical approaches such as machine learning or sensor-based evaluation (e.g., electronic nose systems), which are used to analyze coffee aroma and composition [7], this study offers a simpler yet effective alternative. The CRITIC–CoCoSo approach does not require specialized equipment or complex data acquisition processes, making it more accessible for small and medium-scale coffee businesses. Despite its simplicity, the model is still capable of producing reliable and interpretable results, which is a key advantage in practical applications.

Moreover, the integration of objective weighting and compromise ranking methods addresses a common limitation in traditional decision-making systems, which often rely on subjective judgments. By leveraging data-driven techniques, this study contributes to the growing body of research on intelligent decision support systems in the food and beverage industry [8], [20].

Overall, this study extends previous research by bridging the gap between theoretical quality assessment and practical decision-making. While earlier studies focus on specific aspects such as chemical composition, sustainability, or consumer perception, this research integrates multiple dimensions into a unified evaluation framework. As a result, the proposed model not only enhances decision accuracy but also supports consistency, efficiency, and scalability in coffee quality evaluation.

However, it is important to note that this study is limited to a predefined set of criteria and alternatives. Future research could incorporate additional factors such as roasting level, origin traceability, and environmental impact to further improve the comprehensiveness of the model. Additionally, integrating the CRITIC–CoCoSo method with advanced analytical tools or real-time data systems could provide more dynamic and adaptive decision-making capabilities.

4. CONCLUSION

This study proposes a decision support model for evaluating coffee bean quality by integrating the CRITIC and CoCoSo methods within a Multi-Criteria Decision Making (MCDM) framework. The CRITIC method effectively determines objective criterion weights based on data variability and inter-criteria correlation, reducing subjectivity in the evaluation process. The results indicate that color (0.215) and price (0.191) are the most influential criteria in assessing coffee bean quality.

The CoCoSo ranking results reveal that alternative A9 achieves the highest preference score ($K = 4.1634$), followed by A7 ($K = 3.5747$) and A6 ($K = 3.4920$). These findings confirm that coffee beans with strong performance across sensory attributes and physical characteristics tend to rank higher in the evaluation model.

Overall, the proposed CRITIC–CoCoSo model provides a systematic, objective, and practical decision support tool for coffee bean quality evaluation. The model is particularly applicable for small to medium-scale coffee industries, as it enables consistent raw material selection and improves decision-making efficiency without requiring complex analytical tools.

This study contributes to the application of MCDM methods in the coffee sector by offering a structured and data-driven evaluation framework. Future research may extend this model by incorporating additional criteria, such as roasting level and origin traceability, or by integrating more detailed sensory and analytical data to enhance evaluation accuracy.

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