Enhancing Consumer Decision-Making in Skincare: Implementation of the VIKOR Method for Product Recommendation Systems

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Abstract

The challenge of selecting the most suitable skincare products, particularly sunscreens, has become increasingly complex due to the overwhelming variety of choices available on the market. Consumers are often confronted with a plethora of products, making it difficult to discern which one best suits their needs. This study seeks to address this issue by employing the VIKOR multi-criteria decision-making (MCDM) method, which offers a structured approach to product selection based on various factors that are highly relevant to consumers. The VIKOR method, which focuses on minimizing regret and finding the closest compromise solution, is especially suited for handling decisions that involve conflicting criteria. In this study, five key criteria—skin type, brand origin, price, SPF rating, and UVA protection grade—were identified as being of particular importance to consumers. A dataset of 175 sunscreens formulated for oily skin and produced locally was systematically analyzed using the VIKOR algorithm. This method enabled the normalization and aggregation of diverse criteria, allowing for an objective, data-driven comparison of the products. The VIKOR-based approach efficiently ranked the sunscreens and identified AZARINE Hydramax-C Sunscreen Serum as the optimal product. This sunscreen achieved the lowest Q value of 0.07, signifying that it represented the best compromise solution across all criteria. The study's findings not only highlight the practical value of advanced decision-making tools in the context of consumer product selection but also contribute to broader discussions on consumer behavior and decision-making frameworks. By demonstrating the efficacy of the VIKOR method, this research paves the way for its future application in various industries, offering a replicable and adaptable model for improving decision processes in consumer goods selection across diverse markets.

Keywords: Customer-Decision Making, Recommender System, Skincare, VIKOR

I. INTRODUCTION

The skincare market in Indonesia is experiencing robust growth, driven by various factors including increased financial independence among women, a rising interest in natural and organic products, and a general enhancement in grooming habits among men. The market is projected to grow at a compound annual growth rate (CAGR) of 8.9% from 2021 to 2026, with the market size expected to increase from IDR 25 trillion ($1.7 billion) to IDR 38.4 trillion ($2.5 billion) in this period [1]. The ever-expanding array of skincare products available on the market has posed significant challenges for consumers in selecting products that best meet their specific skin needs.

This complexity in choice is further compounded by factors like price, product features, and consumer reviews, which often overwhelm decision-making processes. To address this, the implementation of sophisticated decision-support systems using Multi-Criteria Decision-Making (MCDM) methods has been gaining traction [2]. It is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making. It encompasses a wide range of decision-making situations that involve selecting the best option among alternatives based on multiple criteria, or ranking, prioritizing, and classifying options when facing trade-offs among different attributes.

One such method, the VIKOR (*VlseKriterijumska Optimizacija I Kompromisno Resenje*), has demonstrated significant potential in various sectors, including healthcare and customer service, by facilitating a closer alignment of choices with consumer preferences and requirements. For instance, research conducted by [3] employed a hybrid MCDM

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approach, integrating the VIKOR method, to optimize mobile health care strategies, showcasing the method's utility in enhancing decision accuracy and consumer satisfaction. Similarly, the application of the VIKOR method in selecting sustainable products and services as discussed by [4] emphasizes its adaptability and effectiveness in processing complex consumer data to derive actionable insights . These studies underline the method's robustness in dealing with trade-offs among conflicting criteria, which is essential for the skincare industry, where consumer preferences vary widely.

In the context of skincare, this study proposes the adaptation of the VIKOR method within a website-based recommendation system. By analyzing criteria such as price, SPF, protection grade, product ratings, and consumer feedback data from platforms like Sociolla, this approach aims to systematically rank skincare products. The goal is to simplify the consumer decision-making process, thereby allowing users to make informed choices based on a reliable analysis of multiple factors. The expected outcome is to provide consumers with a decision-making tool that offers a transparent, efficient, and user-friendly interface to navigate the complex skincare product landscape, thereby enhancing overall consumer satisfaction and trust in skincare recommendations.

A. Related Works

Research on the MCDM for optimizing products has been carried out by several previous researchers. A research conducted by [5] aims to recommend the selection of skincare products based on consumer preferences using ELECTRE method. The result shows that skincare garnier products are recommended to the best skincare based on consumers. This research result expected to provide the customer understanding about choosing skincare product. In line with research conducted by [6] that using SMART method could give a recommendation for medicine products based on consumer preferences. By using mobile application, the Simple Additive Weighting (SAW) method can be implemented to make calculation for selecting the most appropriate make over cushion and lipstick product for user [7], this phenomena shows that information technology as a primary medium could collaborate with decision support system to enhance consumer choose the best products based on their preferences [8].

The use of the VIKOR method in the decision-making process has also been done by many previous studies. The purposes of a research conducted by [9] is apply the VIKOR method in assessing the performance of educators. The assessment in the research that has been carried out using 4 (four) assessments are: Pedagogic, Personality, Social and Professional with criteria for each competency using the VIKOR method. Another research conducted by [10] using VIKOR to for ranking VIKOR method is the most ideal solution Short-distance and Alternative The solution with the longest distance from the solution Determines. Research conducted by [11] aims to create an analyst that can later be applied to computer systems, so that it can be said that by testing the system based on existing criteria, it will provide a definite answer in determining the creditworthiness of motorcycles to consumers. This study's findings reveal that by applying this DSS approach, it is possible to effectively rank consumers based on their eligibility for motorbike loans. Specifically, individuals ranked from 1 to 5 are deemed eligible for receiving loans at the Honda showroom. Conversely, those ranked 6 and beyond are considered ineligible. This systematic approach ensures that only suitable candidates receive financial assistance for purchasing motorcycles

Based on recent research, the VIKOR method has had a significant impact on decision support systems (DSS). Its primary contributions include:

1. **Handling Conflicting Criteria:** VIKOR efficiently handles decision problems involving conflicting criteria, allowing decision-makers to arrive at a compromise solution that balances the best and worst-case scenarios.
2. **Adaptability to Complex Problems:** The method's ability to integrate different types of criteria makes it adaptable to various domains such as healthcare, manufacturing, and energy management.
3. **Improving Decision Accuracy:** VIKOR enhances decision accuracy by integrating user preferences and considering the trade-offs between different criteria, leading to more nuanced decision-making.

The VIKOR method's impact on decision support systems lies in its ability to offer practical solutions in multi-criteria decision-making scenarios, thereby aiding decision-makers in choosing optimal solutions in complex, uncertain environments.

B. Theoritical Background

The VIKOR (*VIseKriterijumska Optimizacija I Kompromisno Resenje*) method is a multi-criteria decision making (MCDM) technique that was developed to solve complex decision problems with conflicting and non-commensurable (different units) criteria. The VIKOR method is particularly effective in situations where the decision-maker is unable to express a preference at the initial stage of decision-making [12], [13], [14], [15]. VIKOR was introduced by Opricovic in 1998. It was developed as a method to implement a kind of compromise decision making, which is based on the concept of ranking and selecting from among alternatives in the presence of conflicting criteria. This method is designed to approximate the ideal solution, helping decision-makers to reach a final decision that represents a maximum group utility for the majority and a minimum individual regret for the opponent.

The main advantages of the VIKOR method include its simplicity, its capacity to provide a clear and understandable compromise solution, and its effectiveness in reflecting the decision-maker’s preferences through the adjustable strategy weight. These characteristics make VIKOR a valuable tool in the arsenal of MCDM techniques. VIKOR's approach to MCDM promotes a balanced solution, taking into account both the best performance and the potential regrets, thus guiding decision-makers towards decisions that are acceptable to all stakeholders involved [16].

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II. RESEARCH METHOD

According to Figure 1, Data collection is carried out to obtain the information needed to achieve research objectives. In this study, the object of research was taken on the Sociolla website. Data collection in this research uses manually. During the manual data collection process, we systematically selected various sunscreen products from Sociolla's platform, recording pertinent details such as pricing, SPF ratings, ingredients, and user reviews directly into a structured format using spreadsheets. This method allowed us not only to gather quantitative metrics but also provided an opportunity for nuanced interpretation of consumer experiences reflected in their reviews—an aspect we deemed crucial given the subjective nature of skincare product efficacy. this study took 175 sunscreen product data. Currently there are several local skincare companies and brands that have sprung up and are sold freely on the market with low prices, promising testimonials, and instant whitening results. Especially on social media, especially on TikTok, there are many influencers who provide testimonials of skincare products by promising that the product is suitable for all skin types, but in fact in the review on Sociolla there are several people who are not suitable for the product.

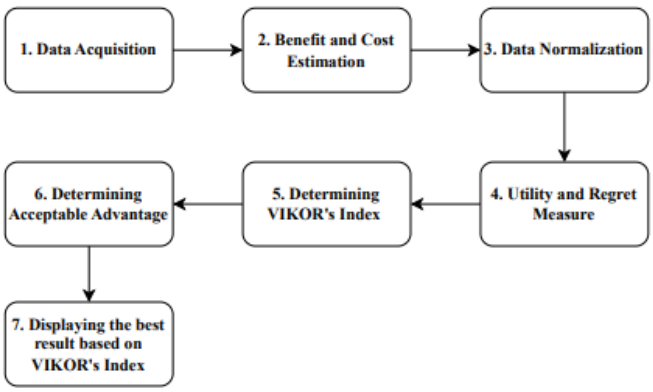

Figure 1. Research Flow

The VIKOR method is a multi-criteria decision-making technique that stands for VlseKriterijumska Optimizacija I Kompromisno Resenje, which translates to Multicriteria Optimization and Compromise Solution. It is particularly useful for situations where a decision needs to be made in the presence of conflicting criteria. Here's a step-by-step breakdown of the VIKOR method [17]: (1) Data Acquisition, define all relevant criteria that will be used to evaluate the alternatives. Criteria should be quantifiable as much as possible. (2) Benefit and Cost Estimation, benefits in VIKOR are the positive criteria that an alternative offers while osts are considered as one of the criteria for evaluating the alternatives. (3) Normalization, the goal of normalization is to ensure that no single criterion disproportionately influences the outcome due to its scale. (4) Utility and Regret Measure, these measures are computed using the normalized criteria values and their respective weights. (5) VIKOR's Index, aims to identify a compromise solution by considering both the maximum group utility and the minimum individual regret. (6) Acceptable Advantage, helping to clarify complex choices in a variety of practical and strategic contexts. (7) Displaying the best result, by using web-based application, system will recommend the best result of skincare product.

The VIKOR method's impact on decision support systems lies in its ability to offer practical solutions in multi-criteria decision-making scenarios, thereby aiding decision-makers in choosing optimal solutions in complex, uncertain environments.

A. Data Acquisition

A decision support system (DSS) is a system intended to support managerial decision makers in semi-structured decision situations. It is intended to be an adjunct to stakeholders to extend their capabilities but not to replace their judgement [18], [19], [20]. In designing a skin care product selection system, there are several criteria used. The criteria used in this study are price, product rating, sun protection factor (SPF), protection level, product weight, user recommendation and user repurchase. Table 1 shows the criteria data and their weight values.

Table 1. Criteria Data and the Weight Values

Code	Criteria	Description	Attribute
C1	Price	consider sunscreen products to be selected or recommended.	Cost
C2	Product Rating	help potential buyers or users in finding product information	Benefit
C3	SPF	SPF measures the level of protection a sunscreen should provide against UVB rays.	Benefit
C4	Protection Grade	Protection Grade of UVA (PA) is a grading system to measure protection against UVA.	Benefit
C5	Weight	The greater the weight of the product, the more sunscreen users choose the product,	Benefit
C6	Users Recommend	an assessment that the product can be recommended or not, with the results of the value range 0 - 200.	Benefit
C7	Users Repurchase	an assessment that the product is worth repurchasing or not, with the results of the value range 0 - 200.	Benefit

In determining alternative data using data filters from 175 sunscreen products as follows:

1. Skin type: Oily
2. Brand origin: Local
3. Price: 0 – 100.000
4. SPF: 0 – 50
5. Protection grade: PA++++

Furthermore, the amount of alternative data obtained from the filter above is 14 sunscreen product data and the following Table 2 below is an alternative data table.

Table 2. Skin Care Alternatives

Code	Alternative Desciption
S1	Wardah UV Shield Aqua Fresh Essence SPF 50
S2	Wardah UV Shield Active Protection Serum SPF 50

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Code	Alternative Desciption
S3	Dear Me Beauty Skin Barrier Sunscreen Gel
S4	True to Skin Sunfriends Soothing Sunscreen Gel SPF 50 PA ++++
S5	Implora Implora Perfect Shield Sunscreen SPF-40 PA ++++
S6	WARDAH UV Shield Light Matte Sun Stick
S7	AZARINE Hydrasoothe Sunscreen Mist
S8	AZARINE Tone Up Mineral Sunscreen Serum
S9	BARENBLISS barenbliss My UV Armor SPF 50 PA++++
S10	MORIGANIC UV Watery Sun Cream
S11	BLP BEAUTY Multipurpose Tinted Sunscreen SPF50/PA++++ 5gr
S12	AZARINE Hydramax-C Sunscreen Serum
S13	For Skins Sake Velvet Sunscreen SPF 50 PA ++++
S14	You Beauty You Tone Up UV Elixir SPF 50+ PA++++

III. RESULT AND DISCUSSIONS

A. Benefit and Cost Estimations

Inline with Fig 1, In the VIKOR method, **cost and benefit estimation** is crucial as it directly affects the ranking and selection of alternatives. The accuracy of these estimations impacts the reliability and validity of the decision-making process [21]. Proper handling of costs and benefits ensures that the decision reflects both economic efficiency and the satisfaction of broader organizational or societal goals. Below Formula 1 and 2 are the formula for calculating benefits and costs in the VIKOR method.

$$B = \frac{max - n}{max - min} \quad (1)$$

$$C = \frac{n - min}{max - min} \quad (2)$$

Based on the results of cost and benefit calculations, Table 3 shows the Cost (C) and Benefit (B) values for each alternative and feature.

Table 3. Benefit and Cost Estimation Result

Code	C	B	B	B	B	B	B
	C1	C2	C3	C4	C5	C6	C7
S1	0.359937	0.000000	0.000000	0.750000	0.545455	0.882353	0.900000
S2	0.672926	0.000000	0.000000	0.750000	0.454545	0.882353	0.850000
S3	0.985915	0.000000	0.000000	0.000000	0.454545	0.294118	0.300000
S4	0.672926	0.000000	0.000000	0.000000	0.545455	0.235294	0.300000
S5	0.000000	1.000000	0.000000	0.000000	0.181818	0.117647	0.250000
S6	1.000000	0.000000	0.000000	1.000000	0.690909	1.000000	0.750000
S7	0.453834	0.000000	0.000000	0.750000	0.000000	0.764706	0.600000
S8	0.610329	0.000000	0.000000	0.250000	0.600000	0.529412	0.500000
S9	0.829421	0.000000	0.000000	0.500000	0.545455	0.529412	0.550000
S10	0.985915	0.000000	0.000000	0.250000	0.363636	0.000000	0.000000
S11	0.359937	0.000000	0.000000	1.000000	1.000000	0.764706	1.000000
S12	0.453834	0.000000	0.000000	0.250000	0.363636	0.352941	0.400000
S13	0.688576	0.000000	0.000000	0.250000	0.909091	0.058824	0.200000
S14	0.688576	0.000000	0.000000	0.750000	0.363636	0.705882	0.800000

Table 4. Determining the Criteria Weight

C1	C2	C3	C4	C5	C6	C7	Weight
4	3	3	2	2	1	1	**16**
0.25	0.1875	0.1875	0.125	0.125	0.0625	0.0625	**1**

Table 5. Normalization Phase

Code	C	B	B	B	B	B	B
	C1	C2	C3	C4	C5	C6	C7
S1	0.08998	0.00000	0.00000	0.09375	0.06818	0.05515	0.05625
S2	0.16823	0.00000	0.00000	0.09375	0.05682	0.05515	0.05313
S3	0.24648	0.00000	0.00000	0.00000	0.05682	0.01838	0.01875
S4	0.16823	0.00000	0.00000	0.00000	0.06818	0.01471	0.01875
S5	0.00000	0.18750	0.00000	0.00000	0.02273	0.00735	0.01563
S6	0.25000	0.00000	0.00000	0.12500	0.08636	0.06250	0.04688
S7	0.11346	0.00000	0.00000	0.09375	0.00000	0.04779	0.03750
S8	0.15258	0.00000	0.00000	0.03125	0.07500	0.03309	0.03125
S9	0.20736	0.00000	0.00000	0.06250	0.06818	0.03309	0.03438
S10	0.24648	0.00000	0.00000	0.03125	0.04545	0.00000	0.00000
S11	0.08998	0.00000	0.00000	0.12500	0.12500	0.04779	0.06250
S12	0.11346	0.00000	0.00000	0.03125	0.04545	0.02206	0.02500
S13	0.17214	0.00000	0.00000	0.03125	0.11364	0.00368	0.01250
S14	0.17214	0.00000	0.00000	0.09375	0.04545	0.04412	0.05000

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B. Normalization

According to [21], In many cases, weights are determined based on the opinions and judgments of experts familiar with the domain. This can be done through direct rating, where experts assign weights according to their understanding of the importance of each criterion. Table 4 shows the weight of each criterion.

Normalization in the VIKOR method is a crucial step that transforms the various criteria values, including costs and benefits, into a common scale that allows them to be compared directly as shown in Table 5. This is particularly important in multicriteria decision-making where the criteria could have different units and scales. The goal of normalization is to ensure that no single criterion disproportionately influences the outcome due to its scale.

C. Utitlity and Regret Measures

Two key measures are used to assess the alternatives based on multiple criteria: the utility measure (S) and the regret measure (R). These measures are computed using the normalized criteria values and their respective weights, which have been determined as discussed previously. The utility measure S in VIKOR is essentially an aggregated index that combines all the criteria into a single score for each alternative (Formula 3).

$$S_i = \Sigma_{j=1}^{n} W_j \left[\frac{(f^+{}_j - f_{ij})}{(f^+{}_j - f^-{}_j)}\right] \quad (3)$$

S_i is the utility score for alternative i,w_j is the weight of the j-th criterion, f_{ij} is the normalized value of the j-th criterion for the i-th alternative, and n is the total number of criteria. The regret measure R focuses on the maximum regret of not choosing the best option available for any criterion. It is essentially designed to capture the worst-case scenario relative to the ideal solution for each criterion. The regression measure (R) value is the maximum value of each alternative that has been normalized.

Table 6. Utility and Regret Measure

	Si	Ri
	0.36	0.09
	0.43	0.17
	0.34	0.25
	0.27	0.17
	0.23	0.19
	0.57	0.25
	0.29	0.11
	0.32	0.15
	0.41	0.21
	0.32	0.25
	0.45	0.13
	0.24	0.11
	0.33	0.17
	0.41	0.17
Max.	0.57	0.25
Min.	0.23	0.09

Table 6 is the result of Utility Measure (Si) and Regression Measure (Ri). The Utility Measure value is obtained by summing the results of multiplying the weights with the matrix results, while the Regret Measure value is by finding the maximum value of multiplying the weights with the normalization results.

D. Vikor's Index

The VIKOR index, denoted as Q, is a crucial element in the VIKOR method, which is used for multi-criteria decision making. It aims to identify a compromise solution by considering both the maximum group utility and the minimum individual regret. The index Q is calculated for each alternative, helping decision-makers to rank the alternatives based on their overall performance across multiple criteria (Formula 4).

$$Q_i = v\left[\frac{(S_i - S^+)}{(S^+ - S^-)}\right] + (1 - v)\left[\frac{(R_i - R^+)}{(R^+ - R^-)}\right] \quad (4)$$

The Q helps in identifying a compromise solution that balances between the best utility and the least regret, making it suitable for scenarios where consensus or a balanced decision is sought. By calculating Q for each alternative, decision-makers can rank the alternatives from the best to the worst (Table 7). The alternative with the lowest Q value is considered the best option as it offers a balance between achieving the highest utility and minimizing regret.

Table 7. Vikor's Index

Alternatives	*with veto*	*by consensus*	*voting by majority rule*
	Q (v = 0.25)	Q (v = 0.5)	Q (v = 0.75)
S1	0.10	0.19	0.29
S2	0.50	0.53	0.55
S3	0.81	0.65	0.48
S4	0.38	0.29	0.20
S5	0.45	0.30	0.15
S6	1.00	1.00	1.00
S7	0.14	0.15	0.16
S8	0.35	0.32	0.29
S9	0.67	0.62	0.56
S10	0.80	0.62	0.44
S11	0.31	0.42	0.53
S12	0.10	0.07	0.04
S13	0.45	0.40	0.35
S14	0.50	0.51	0.51

The best result from ranking with (v = 0.25), (v = 0.5), and (v = 0.75) is CARASUN Solar Smart UV Protector Sunscreen which is the same as the best ranking from ranking Q. However, it is necessary to check the Acceptable Advantage to determine the ranking again. Determine the Acceptable Advantage with the following Formula 5:

$$Q(\text{S2}) - Q(\text{S1}) \geq DQ \quad (5)$$

DQ represents the threshold value of group utility deviation for making a decision (Formula 6). It is used to identify if an alternative solution is significantly better than the others, helping to establish the conditions under which an alternative can be considered the most appropriate compromise solution.

$DQ = 1/(m-1)$ (6)

M refers to number of alternatives. The purpose of DQ is to ensure that the selected compromise solution achieves a sufficient advantage in terms of utility and regret over other alternatives. It is a decision parameter that establishes a threshold for distinguishing between close competing alternatives. According to Formula 5, Table 8 shows the Acceptable Advantage of ranking. It can be concluded that, the value of v = 0.5 which is 0.081889296 is greater than the DQ value which is 0.076923077

Table 8. Acceptable Advantage

V	$Q(A2) - Q(A1)$
v=0,25, $Q(A2) - Q(A1)$	0.001209203
v=0,5, $Q(A2) - Q(A1)$	**0.081889296**
v=0,75, $Q(A2) - Q(A1)$	0.109541273

The smallest value is the best and most effective value based on the VIKOR method (the smaller the index value (Qi), the better the alternative solution) [17]. Based on the results of proving the two conditions (Table 9), it can be seen that both conditions are met. AZARINE Hydramax-C Sunscreen Serum (S12) can be proposed as a compromise solution and is the best ranking of sunscreen recommendations using the VIKOR method.

Table 9. Best Result of VIKOR

Alternatives	Q (v = 0.5)	Rank
S12	0.07	1
S7	0.15	2
S1	0.19	3
S4	0.29	4
S5	0.30	5
S8	0.32	6
S13	0.40	7
S11	0.42	8
S14	0.51	9
S2	0.53	10
S9	0.62	11
S10	0.62	12
S3	0.65	13
S6	1.00	14

E. Application Development

In this research, the Unified Modelling Language (UML) is used as a tool in carrying out the design and design stages of the application. UML was created to provide the tools needed by software developers in analysing, designing and implementing software-based systems [22]. At this stage, the business processes of the system will be defined. Business processes can be understood as a collection of activities that can define business events and work performed by a system to convert inputs into value-added outputs for users [23], [24]. The use case diagram is shown in Figure 2.

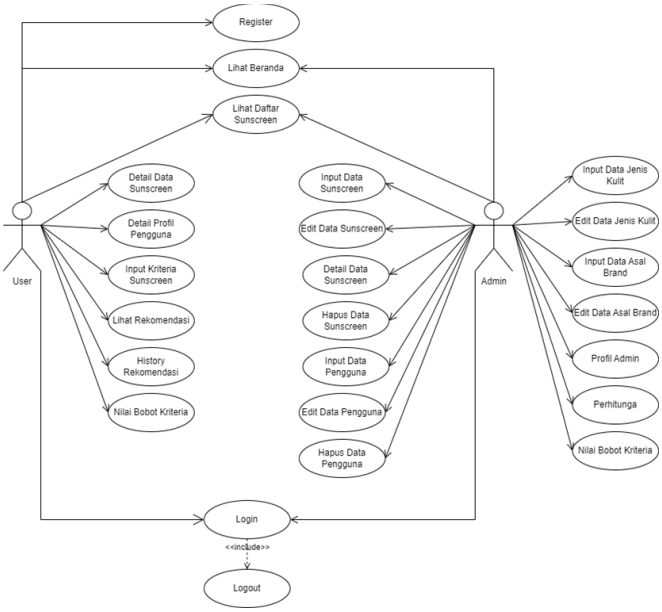

Figure 2. Use Case Diagram

The dashboard page is the first page displayed to users after they successfully log in. On this page contains an explanation of the VIKOR Method Decision Support System.

Figure 3. Dashboard Page

Figure 3 illustrates the main dashboard of the system, which provides users with an overview of the VIKOR-based Decision Support System (DSS) for skincare product recommendations. The dashboard includes key system functionalities, such as access to alternative product data, selection criteria, and results. It serves as the entry point for users to interact with the system and begin the decision-making process.

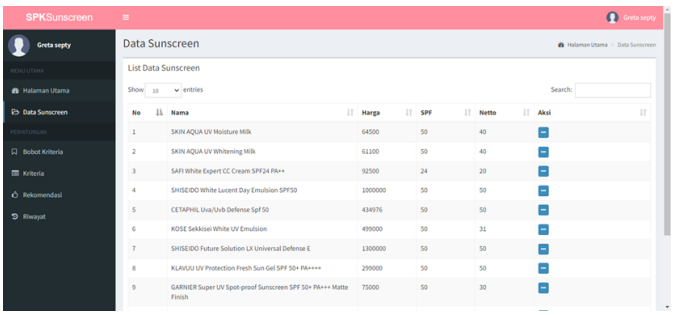

Figure 4. Alternative Data Page

Figure 4 shows the alternative data page displays a list of skincare products that are included in the decision-making process. This figure represents the dataset of 14 sunscreen products that were selected based on specific criteria (such as skin type, brand origin, and SPF level). The page ensures transparency by allowing users to see all the alternatives before ranking them with the VIKOR method.

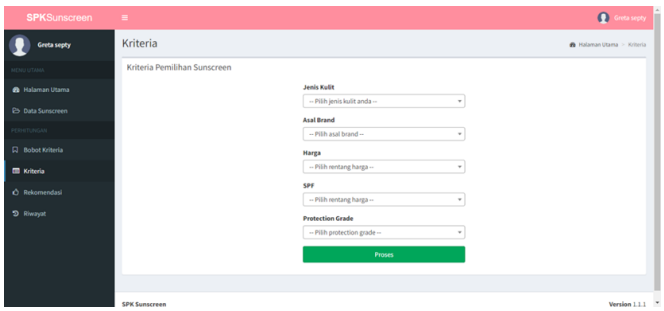

Figure 5. Weight Criteria Page

Figure 5 presents the interface where users or experts assign weights to each decision criterion. The system prioritizes key attributes like price, SPF rating, protection grade, product weight, user recommendations, and repurchase likelihood. The assigned weights influence the ranking process, ensuring that recommendations align with consumer preferences.

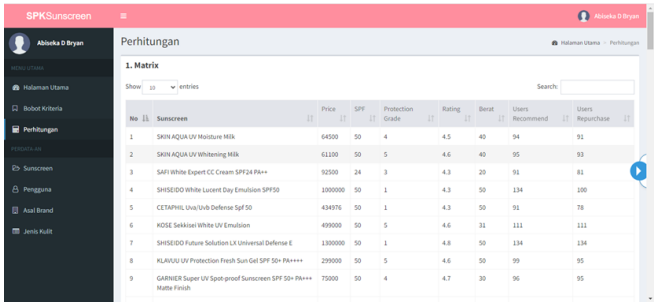

Figure 6. Matrix Calculation

The matrix calculation (Figure 6) shows the computational process of the VIKOR method, where the benefit and cost values for each alternative are calculated. This step standardizes different criteria into a normalized decision matrix, which helps to fairly compare the sunscreen products based on multiple factors.

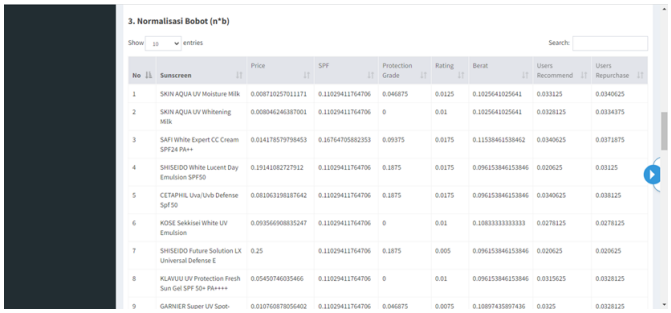

Figure 7. Normalization Phase

Figure 7 visualizes the normalization process, a crucial step in multi-criteria decision-making (MCDM). It converts all criteria values into a comparable scale, ensuring that no single criterion disproportionately affects the ranking. The normalization process is necessary to handle data variations and maintain fairness in product evaluation.

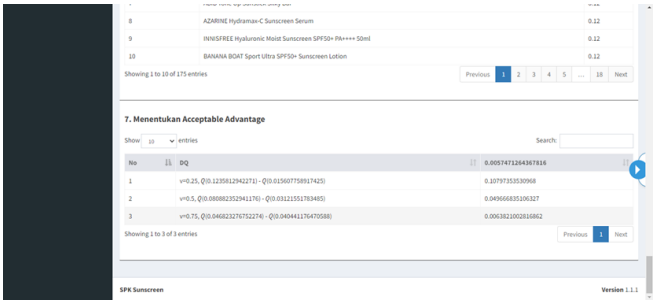

Figure 8. Acceptable Advantage

The acceptable advantage (Figure 8) depicts the final ranking results of the VIKOR method, determining the best sunscreen product recommendation. The system calculates the Q index for each alternative, identifying the best compromise solution. The sunscreen product with the lowest Q value (AZARINE Hydramax-C Sunscreen Serum) is highlighted as the most optimal choice.

F. Functionality Testing

Black box testing is used in application testing because it focuses on the functionality of the system without examining the internal code or programme structure. This method ensures that the application runs according to predefined specifications and fulfils user needs. By testing inputs and outputs without regard to the internal workings of the application, it is effective for detecting bugs in key functions, data validation, and integration between features [25], [26], [27], [28]. Black box testing also facilitates testing from an end-user perspective, as its approach reflects the way the application will be used in real life. In addition, this method is easier to implement by testers who do not have a technical background, so it can be done collaboratively with various parties. The method is carried out to test whether each process in each user access right is successfully carried out in accordance with its function or there are still errors.

Table 10. Functional Testing Result

Scenario	Testing	Expected Result	Test Result
Registration	Registering new user	To create a new user for new applicant	**Pass**
Login	Doing user login to applicant	To create a success login process using new user	**Pass**
Input dataset and criteria	Input dataset and criteria for product recommendation calculation	To set amount of data including their criteria in system	**Pass**

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formulation of product recommendations using VIKOR	Formulate the best product based on the existing dataset and its criteria	To retrieve the best product based on VIKOR's method	**Pass**

The functional testing results in Table 10 confirm that all major features of the system work correctly. Each scenario tested has met the expected outcomes, proving that the system is ready for practical implementation. The successful application of the VIKOR method ensures accurate, efficient, and transparent decision-making for skincare product selection. Further refinements can focus on enhancing user experience, expanding product datasets, and improving recommendation precision based on user feedback.

IV. CONCLUSIONS

This study provides a robust framework for improving the way consumers select skincare products. By incorporating the VIKOR method into the product recommendation system, the study effectively addresses the complexities and varied preferences inherent in skincare choices. This approach not only prioritizes consumer-specific criteria such as skin type, concerns, and preferences but also balances these against product efficacy and cost, ensuring a comprehensive evaluation of options. The implementation of the VIKOR method has demonstrated potential in offering consumers a more personalized and scientifically grounded decision-making tool, thereby enhancing user satisfaction and trust in skincare recommendations. This study paves the way for further exploration into tailored recommendation systems in personal care and beyond, suggesting a promising avenue for the application of multi-criteria decision-making tools in consumer-oriented industries.

Furthermore, we recognize that contemporary consumers are increasingly concerned about sustainability factors and ingredient safety when selecting skincare products. As part of future research directions, we aim to explore these critical aspects more thoroughly:

- **Sustainability Factors**: Investigating eco-friendly ingredients used in sunscreens will be essential. This includes assessing the environmental impact of sourcing materials and evaluating brands' commitments to sustainable practices such as biodegradable packaging or carbon-neutral production processes.
- **Ingredient Safety**: There is a growing demand among consumers for transparency regarding product formulations. Future studies could focus on analyzing consumer preferences for paraben-free options or other potentially harmful chemicals in sunscreens. Understanding how these factors influence purchasing decisions will provide deeper insights into market trends and consumer behavior.

By integrating these elements into subsequent research efforts, we hope not only to enhance our understanding of current market dynamics but also contribute positively towards promoting safer and more sustainable skincare choices among consumers.

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