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Optimization of For mula and In Vitro Activity Testing of O/W Lotion Cosmetic Formulations Containing Ethanol Extract of Cat's Whiskers Leaves (*Orthosiphon aristatus*) as Sunscreen

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ABSTRACT
Exposure to ultraviolet (UV) radiation from sunlight can induce erythema, sunburn, and skin sensitivity, culminating in dermal damage. The application of sunscreen mitigates potential skin harm resulting from solar radiation. This investigation aims to ascertain the optimal formulation for lotion preparations incorporating Orthosiphon aristatus leaf extract and evaluate the sunscreen efficacy of said formulations through in vitro testing. Extraction procedures involved ethanol maceration, followed by phytochemical characterization of the resultant extract. Formulation of the extract into oil-in-water (O/W) lotion preparations was executed, with optimization conducted utilizing the Simplex Lattice Design (SLD) method, incorporating varied concentrations of stearic acid, cetyl alcohol, and olive oil to assess their impact on lotion viscosity, spreadability, and adhesion. Subsequent evaluation encompassed in vitro assessment of sunscreen activity for both the lotion and extract. Findings revealed the presence of flavonoids, saponins, and tannins in the extract. Optimal lotion formulation, determined via the SLD method, yielded concentrations of 2.00, 4.22, and 8.78 for stearic acid, cetyl alcohol, and olive oil, respectively. Formulation optimization was guided by minimizing viscosity while maximizing spreadability and adhesion. Confirmation studies underscored the predictive capacity of the SLD method in determining viscosity, spreadability, and adhesion of the cat's whiskers leaf extract lotion. SPF values for the extract and lotion were recorded as 33.63 ± 0.963 and 2.54 ± 0.001, respectively, at a concentration of 30,000 ppm.
Key words: Cat's whiskers, Lotion, SLD, SPF, Sunscreen.

INTRODUCTION
Exposure to ultraviolet (UV) rays from sunlight can cause erythema, sunburn, and sensitivity, leading to skin damage. This risk is higher in populations living in tropical regions such as Indonesia (Derebe et al., 2019). However, the use of sunscreen cosmetics can reduce the potential skin damage from sun exposure (Hamzavi, 2018).

Sunscreen formulations have the capability to scatter, absorb, or reflect UV rays. The efficiency of sunscreen in protecting the skin from the harmful

effects of sun exposure is expressed through the Sun Protection Factor (SPF) value. SPF is defined as the amount of UV energy required to produce the minimal erythema dose (MED) on skin protected by sunscreen, divided by the amount of UV energy required to produce the MED on unprotected skin. MED is defined as the shortest time required to cause erythema due to UV radiation (Wolf et al., 2003; Wood & Murphy, 2000).

Active ingredients commonly used in sunscreen formulations, such as Titanium Dioxide (TiO2), have been used since 1952 and function by physically reflecting UV rays (Physical Blocker) (Trivedi & Murase, 2017). However, this compound poses health risks, as noted by the International Agency for Research on Cancer (IARC), which classifies it as a carcinogen that can trigger cancer (Iarc, 2009). Additionally, UV filters like oxybenzone, octocrylene, octinoxate, and ethylhexyl salicylate create waste that is difficult to eliminate using standard wastewater treatment techniques, making them environmentally unfriendly and requiring special treatment for the waste produced (Schneider & Lim, 2019). Therefore, developing natural active ingredients for sunscreens is continually pursued due to their perceived safety and environmental friendliness.

Java Tea (Orthosiphon stamineus) contains chemical compounds including monoterpenes, diterpenes, triterpenes, saponins, polyphenols such as flavonoids, and phenolic acids (Arif et al., 2022). Polyphenols are the most dominant constituents in Java Tea (Hollman & Katan, 1999). The primary component of Java Tea is rosmarinic acid (RA), which belongs to the hydroxy cinnamic acid family and is a derivative of caffeic acid (Petersen & Simmonds, 2003). RA can be found in the stems and leaves of Java Tea, with the highest concentration in the leaves compared to the stems and branches (Koay & Amir, 2012). Other important bioactive components in Java Tea include flavonoids such as sinensetin (SEN), 3’-hydroxy-5,6,7,4’-tetramethoxyflavone (TMF), and eupatorin.

Traditionally, Java Tea has been used to treat angiogenesis-related diseases, urinary lithiasis, edema, inflammation, eruptive fever, influenza, hepatitis, jaundice, rheumatism, diabetes, and hypertension (Akowuah et al., 2004). Research on the use of Java Tea leaf extract has shown various benefits, including antioxidant, immunomodulatory, antidiabetic (Arifah et al., 2022), antimicrobial (Tung et al., 2022), antihyperuricemia (Zhu et al., 2023), and anticancer (Samidurai et al., 2020) activities. However, studies on the potential of Java Tea leaf extract as a sunscreen are lacking, despite its high phenolic compound content.

Polyphenol compounds play a role in capturing UV rays, similar to phenol groups found in many synthetic sunscreen agents. According to Yanuarti et al. (2017), bioactive phenol compounds can act as active ingredients in capturing solar dust and can increase the SPF value of sunscreen creams. The

structural similarity between natural phenol compounds and synthetic sunscreen agents suggests that they might also be effective as sunscreens (Galanakis, 2011).

This research aims to formulate Java Tea leaf extract into an oil-in-water (O/W) lotion that functions as a sunscreen, thereby enhancing the utilization of Java Tea leaves in the cosmetic field.

MATERIAL AND METHODS

Material

Avocado (*Persea americana* Mill) leaves, ethanol 96%, carbopol, glycerin, aquadest, triethanolamine, corrigen odoris (lemon), NaOH, $FeCl_3$, adhesive strength testing instrument, spreadability testing instrument, and other laboratory glasswares.

Methods

Extraction

The maceration method was selected as the extraction method. A total of 50 grams of dried simplicia powder was soaked in 500 liters of 80% ethanol for 7 days with occasional stirring. The macerate was then filtered and concentrated using a rotary evaporator at a temperature of 50°C and a speed of 50 rpm to obtain a thick extract.

Phytochemical Screenin

a. Alkaloid Detection (Surahmiada, 2019)
   Dragendorff's Test: To 3 mL of the test extract, 4 drops of Dragendorff's reagent are added. The formation of an orange-red precipitate indicates a positive presence of alkaloids.

   Wagner's Test: To 3 mL of the test extract, 4 drops of Wagner's reagent are added. The formation of a reddish-brown precipitate indicates a positive presence of alkaloids.

   Mayer's Test: To 3 mL of the test extract, 4 drops of Mayer's reagent are added. The formation of a whitish-yellow precipitate indicates the presence of alkaloids.

b. Saponin Test
   To 3 mL of the extract sample in a test tube, 5 mL of distilled water is added and heated. The formation of foam indicates a positive presence of saponins.

c. Tannin Test

To 3 mL of the extract sample in a test tube, 5 drops of 0.1M FeCl3 solution are added. A positive test is indicated by the appearance of a dark blue or greenish-black color, showing the presence of tannins.

d. Flavonoid Test
   Lead Acetate Test: The extract is dissolved in a few drops of 0.1M lead acetate solution. The formation of a yellow precipitate indicates the presence of flavonoids.

Formulation of Lotion Preparation

Tabel 1. Variasi Komposisi untuk Menentukan Formula Optimal

Bahan	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
Asam Stearat	4.5	2.0	8.0	2.2	7.1	4.5	5.0	4.7
Cetyl Alcohol	4.6	7.0	5.0	2.2	2.0	4.6	8.0	2.0
Olive Oil	5.9	6.0	2.0	10.6	5.9	5.9	2.0	8.3
Glycerin	3	3	3	3	3	3	3	3
Water	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1
Ekstrak Kumis	1	1	1	1	1	1	1	1
TEA	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Methylparaben	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Phenoxyethanol	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

The oil phase and the water phase were each combined and heated to a temperature of 65°-75°C. The water phase was then added to the oil phase while stirring with a homogenizer set at 8000 rpm, ensuring continuous mixing. Subsequently, the extract, which had been dissolved in a portion of the water phase, was added and stirred until a homogeneous mixture was achieved.

Product Quality Evaluation

a. Viscosity
   A sample of 100 g of the formulation was placed in a 100 ml beaker, and its viscosity was measured using a Brookfield Viscometer at room temperature (28°C) with spindle no. 4 at a speed of 60 rpm.
b. Spreadability
   A 0.5 g sample of the formulation was placed on a glass plate. Another glass plate was placed on top of the sample, and a 500 g weight was placed on the stack for 5 minutes. The diameter of the spread was measured. This procedure was repeated three times to calculate the average diameter.
c. Adhesion
   A 0.5 g sample of the formulation was placed on a pre-determined area of a glass slide. Another glass slide was placed on top of the sample, and a 50 g weight was applied for 1 minute. The glass slides were then

mounted on a testing apparatus, and an 80 g weight was applied. The time taken for the two glass slides to separate was recorded. This test was repeated at least three times to calculate the average separation time.

d. pH
   A pH meter was calibrated using pH 4, 7, and 10 buffer solutions. A 100 g sample of the formulation was placed in a 100 ml beaker, and the pH was measured by immersing the electrode into the sample until a constant pH value was obtained.

Optimization of Lotion Formulation

Formula optimization was conducted using Design Expert software with the Simplex Lattice Design (SLD) method. The parameters used to determine the optimal formula were viscosity, spreadability, and adhesion. The factors affecting these parameters were identified as the concentrations of stearic acid, cetyl alcohol, and olive oil. The response used as the basis for determining the optimal formula was the one yielding a significant model and a non-significant lack of fit.

Determination of SPF Value of the Extract

Java tea ethanol extract was weighed at 100 mg, 200 mg, and 300 mg, and diluted with 80% ethanol to 10 ml (resulting in concentrations of 10,000 ppm, 20,000 ppm, and 30,000 ppm). A UV-vis spectrophotometer was calibrated using 80% ethanol. The absorption curve of the test sample was recorded in a cuvette at wavelengths between 290-320 nm, using 80% ethanol as a blank. The average absorption (Ar) at 5 nm intervals was determined. The absorbance results for each extract concentration were recorded, and the SPF values were calculated.

Determination of SPF Value of the Lotion

Lotion samples were weighed at 100 mg, 200 mg, and 300 mg, and diluted with 80% ethanol to 10 ml (resulting in concentrations of 10,000 ppm, 20,000 ppm, and 30,000 ppm). The samples were sonicated in a water bath for 5 minutes and then filtered using filter paper. The filtrate was measured for absorbance using a UV-vis spectrophotometer at wavelengths between 290-320 nm. The average absorption (Ar) at 5 nm intervals was determined. The absorbance results for each lotion concentration were recorded, and the SPF values were calculated.

RESULT AND DISCUSSION

Phytochecimal Screening

Table 2. Phytochemical Screening of Java Tea Leaf Ethanol Extract

Test	Result
Alkaloid	-
Flavonoid	+
Saponin	+
Tannin	+

In this study, preliminary phytochemical screening indicated the presence of flavonoids, saponins, and tannins in the Java Tea (Orthosiphon stamineus) leaf ethanol extract. These findings align with previous research by Surahmaida and Umarudin (2019), which also identified these compounds in the plant. *Orthosiphon stamineus*, commonly known as "Kumis Kucing," is renowned for its diuretic properties and contains anti-inflammatory agents. This species, a member of the Lamiaceae family and native to Southeast Asia, has been the subject of extensive phytochemical investigations (Ameer et al., 2012). The phytochemical constituents in this plant are considered to contribute significantly to its pharmacological activities. Table 2 presents the results of the phytochemical screening of *Orthosiphon stamineus*.

Orthosiphon stamineus is rich in polyphenolic compounds, which are key contributors to its antioxidant properties. The polyphenolic compounds identified in this plant include flavonoids, phenolic acids, and tannins. Additionally, it contains active compounds such as rosmarinic acid, sinensetin, eupatorin, and salvianolic acid, all of which are noted for their potential health benefits (Abdelwahab et al., 2011).

Flavonoids, one of the largest groups of natural phenolic compounds, are present in all green plants (Roshanak et al., 2016). These active substances exhibit a range of biological activities, including free radical scavenging, inhibition of hydrolytic and oxidative enzymes, and anti-inflammatory effects. The protective properties of flavonoids against skin issues caused by UV radiation are particularly noteworthy. Flavonoids can function as active sunscreen agents, protecting the skin from UV damage (Choquenet et al., 2009).

The phytochemical analysis conducted in this study also revealed the presence of saponins and tannins in Orthosiphon stamineus. These compounds contribute to the plant's antibacterial activity, enhancing its therapeutic potential.

Optimization of Lotion Formulation

In this study, the optimization of the formulation was analyzed using Design of Experiments (DoE) software version 11, employing the Simplex Lattice Design method. This approach allowed for the identification of the optimal formulation with the best physical properties. The variations among the eight optimal formulations generated in this study were primarily based on the concentrations of Stearic Acid, Cetyl Alcohol, and Olive Oil.

The key parameters for determining the optimal formula were viscosity, spreadability, and adhesion. These parameters provided the basis for establishing the recommended formulation, ensuring it fell within the smallest and largest target ranges. The data from the viscosity, spreadability, and adhesion tests were processed using the software to ascertain the optimum formula from the eight formulations. The results of this optimization process are presented in Table 3.

Table 3. Average Values of Viscosity, Spreadability, and Adhesion for Lotion Formulations

Formula	**Respon**		
	Viscosity (m.Pas)	**Spreadability (cm)**	**Adhesiveness (s)**
1	9710,33 ± 342,53	8,2916 ± 0,807	4,283 ± 1,787
2	15319 ± 4024, 04	8,725 ± 0,610	20,776 ± 1,586
3	18348,33 ± 2468,46	7,333 ± 0,292	14,946 ± 0,566
4	4541,00 ± 751,38	10,458 ± 1,136	1,96 ± 0,704
5	10748,67 ± 2454,60	7,85 ± 0,505	4,253 ± 1,247
6	19007,33 ± 1260,53	10,333 ± 0,639	4,513 ± 1,577
7	19766,00 ± 1,73	7,658 ± 0,310	11,283 ± 1,353
8	5205,33 ± 1101,36	9,3 ± 1,096	7,1 ± 2,127

Data analysis using Design of Experiments (DoE) version 11 with the Simplex Lattice Design (SLD) method resulted in an optimal formula with a desirability value of 0.842. The determination was based on the approach of maximizing the desirability value, which ranges from 0 to 1. A value closer to 1 indicates a higher likelihood of achieving the desired response.

Viscosity

The viscosity response in this study was analyzed using DoE version 11 with the Simplex Lattice Design method, followed by ANOVA for linear model analysis. This model was chosen due to its smallest p-value, indicating it is the most appropriate for assessing viscosity. The p-value obtained in this study was < 0.05, specifically 0.0191, suggesting that the model provides a significant response regarding the interaction between stearic acid, cetyl alcohol, and olive oil on the lotion's viscosity. Additionally, the lack of fit analysis yielded a p-value of 0.9836, indicating the model's non-significance concerning pure error. This result shows no significant difference between the observed data and the model's predicted data.

The viscosity measurement results for the Java tea leaf extract lotion, analyzed using Design Expert version 11, can be expressed by the following equation:

$$Y = 15386.2A + 24102.4B + 3880.34C$$

Where:
Y = Viscosity response
A = Proportion of stearic acid
B = Proportion of cetyl alcohol
C = Proportion of olive oil

The viscosity response equation indicates that cetyl alcohol has the highest coefficient value compared to stearic acid, thus having the greatest impact on increasing the viscosity of the topical formulation. Cetyl alcohol, being a solid, is commonly used as a thickening or hardening agent in lotions. Stearic acid also contributes to increasing the viscosity as a thickening agent. Conversely, the addition of olive oil tends to decrease the viscosity, as indicated by its lower coefficient value compared to cetyl alcohol and stearic acid.

In addition to the inherent properties of each optimized component affecting the formulation's viscosity, the concentration of each ingredient in the formula also plays a role. The normal plot of residual viscosity response (Figure 2) shows that the viscosity measurements are evenly distributed, approaching the normal line, indicating a well-fit model.

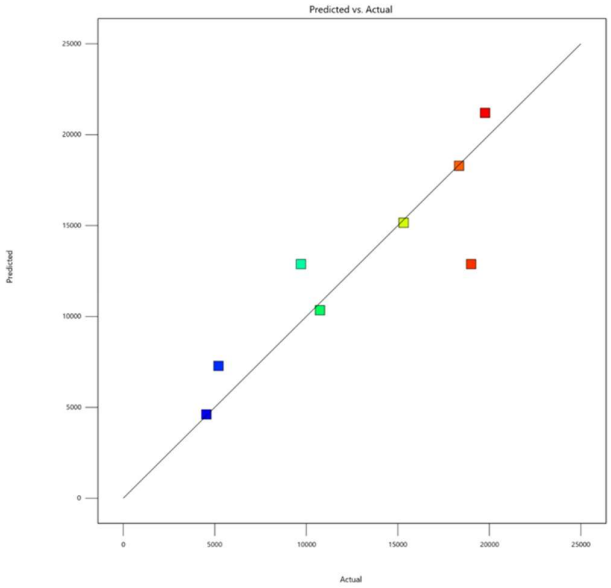

Figure 2. Normal Plot of Residual Viscosity Response

The normal plot of residual viscosity response demonstrates the uniform distribution of viscosity measurements, closely aligning with the normal line, affirming the adequacy of the model.

Spreadability

The response evaluation for spreadability was analyzed using the Simplex Lattice Design (SLD) method to determine the optimal composition of stearic acid and cetyl alcohol. The statistical analysis results showed that the linear model was not significant, and the lack of fit was also not significant. Therefore, the spreadability response cannot be used as a basis for determining the optimal formula. The spreadability response equation obtained through the SLD method is as follows:

$$Y = 6.74A + 8.22B + 10.51C$$

Where:
Y = Spreadability response
A = Proportion of stearic acid
B = Proportion of cetyl alcohol
C = Proportion of olive oil

The spreadability response equation indicates that spreadability is influenced by olive oil and cetyl alcohol, with olive oil having a more significant impact due to its higher coefficient value compared to cetyl alcohol. The optimal formula for spreadability is closely related to viscosity. The relationship between spreadability and viscosity is inversely proportional; as the

spreadability value increases, the viscosity decreases. Measuring the spreadability of the optimal formula aims to determine the lotion's ability to spread when applied.

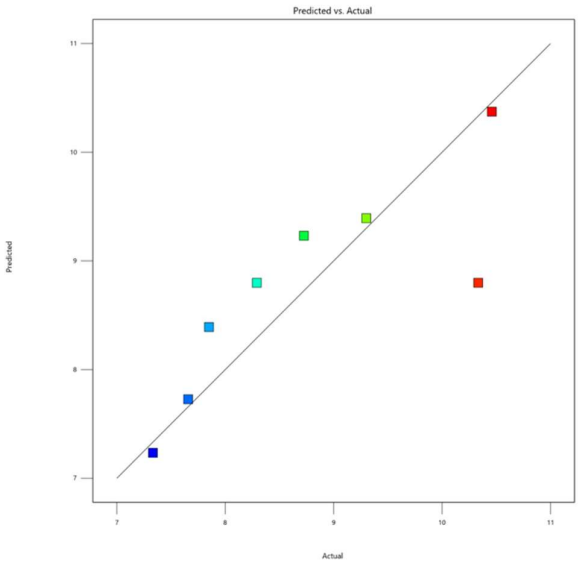

Figure 3. Normal plot of residuals spreadability response

Analysis of the normal curve plot of residuals spreadability response in Figure 3 shows that the results of the dispersion power measurements are evenly distributed close to the normal line.

Adhesiveness

The adhesive force response was selected within the smallest and largest range of values from the 95% Prediction Interval (PI) taking into account that the adhesive force response value fell within the PI range (Table 4). In its use as a sunscreen lotion, adhesive power is related to the lotion's substance or water resistance properties. If the adhesion is too low, the substance of the lotion will decrease, so it cannot provide optimal protection for the skin. However, if the adhesive force is too high it will reduce comfort when used and the contact surface area. Apart from that, too high adhesive power will also inhibit physiological skin functions, such as inhibiting skin breathing.

Table 4. Response Test Results for Cat's Whisker Leaf Extract Lotion

Respon	**Result**	**95% PI**	
		Low	**High**
Spreadability	8,1	8,20361	11,6802
Adhesion	8,37	-4,23974	19,7473
Viscosity	6658,67	1709,65	16027,2

The response for adhesiveness was analyzed using the same method as the viscosity and spreadability response tests. Based on the statistical analysis results, the suggested model is linear and significant. The Simplex Lattice Design (SLD) response equation for adhesiveness indicates that the adhesiveness of the lotion is influenced by olive oil, as the component value for olive oil is higher than that for the other components. The SLD response equation for adhesiveness is as follows:

$$Y=-23.11A+(-34.10)B+(-1.93)C$$

Where:
Y = Adhesiveness response
A = Proportion of stearic acid
B = Proportion of cetyl alcohol
C = Proportion of olive oil

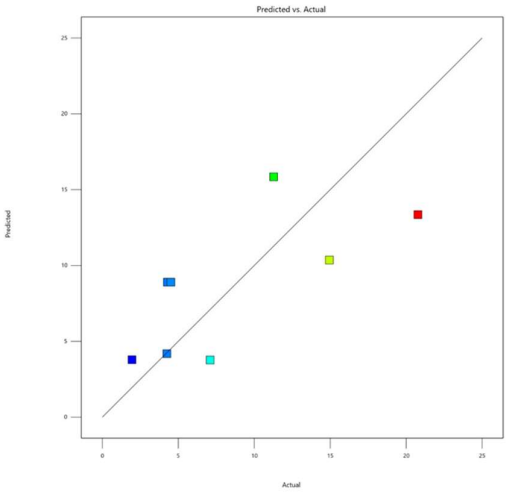

Figure 4. Normal plot of residuals adhesion response

The purpose of measuring adhesiveness is to determine the ability of a lotion to remain on the skin surface. The average adhesiveness of the optimum

sunscreen lotion in this study is 8.37 seconds (Table 3). Adhesiveness is closely related to viscosity, with a direct relationship: the thicker the formulation, the higher the adhesiveness. The analysis of the normal plot of residuals for the adhesion response (Figure 4) shows that some measurement results are close to the normal line, while others deviate from it.

Determination of SPF Value for Extract

The ethanol extract of Orthosiphon stamineus leaves was prepared in three dilution concentrations: 10,000 ppm, 20,000 ppm, and 30,000 ppm, which were then measured using a UV-Vis Spectrophotometer at wavelengths between 290-320 nm. The average absorbance results from the UV-Vis Spectrophotometer were used to calculate the SPF value using the following formula:

$$SPF = CF \times JUMLAH (Abs \times EE \times I)$$

Explanation:
EE : Erythemal Effect Spectrum
I : Solar Intensity Spectrum
Abs : Absorbance of the sunscreen product
CF : Correction Factor

The values of EE x I are constants and are detailed in Table 5 (Erlina Yulianti et al., 2015).

Table 5: Normalized Product Function Used in SPF Calculation

No.	Panjang Gelombang (λ nm)	EE X I
1.	290	0.0150
2.	295	0.0817
3.	300	0.2874
4.	305	0.3278
5.	310	0.1864
6.	315	0.0839
7.	320	0.0180
	Total	1

The testing results indicate that higher concentrations of the Orthosiphon stamineus leaf extract lead to higher SPF values. Detailed results of the SPF test for the extract are presented in Table 6, where the 30,000 ppm

concentration of the leaf extract exhibits an SPF value reaching 33.632 ± 0.963. The high SPF value of the leaf extract at its highest concentration suggests that the protective capability of the extract falls within the medium protection category.

Table 6. SPF Test Results for Cat's Whisker Leaf Extract and Lotion

	Cat's Whisker Leaf Extract			**Lotion**		
SPF	10.000 ppm	20.000 ppm	30.000 ppm	10.000 ppm	20.000 ppm	30.000 ppm
	11.791 ± 0.608	22.549 ± 1.124	33.632 ± 0.963	2.178 ± 0.075	2.135 ± 0.060	2.536 ± 0.005

Determination of SPF Value for Lotion

The determination of the SPF value for the lotion was conducted using the same method as for the extract, based on the absorbance results of each dilution concentration (10,000 ppm, 20,000 ppm, and 30,000 ppm) measured with a UV-Vis Spectrophotometer in the wavelength range of 290-320 nm. The SPF calculation results for the lotion with the active ingredient from Orthosiphon stamineus leaf extract revealed that higher concentrations result in higher SPF values.

The SPF values for the three tested concentrations showed an increase, with the 3% concentration (30,000 ppm) yielding an SPF value of 2.536 ± 0.005. The high SPF value at the 30,000 ppm concentration indicates that the lotion with a 3% extract concentration has the highest protective ability compared to the lower concentrations.

However, the SPF values for the lotion were lower compared to the SPF values of the extract before formulation. This decrease can be attributed to the testing method using the UV-Vis Spectrophotometer with a dilution system. The presence of other substances besides the lotion, such as solvents, can influence the absorbance results. This leads to greater UV light absorption, which can affect the SPF values (Yulianti et al., 2015).

CONCLUSION

This study successfully formulated an optimum sunscreen lotion using Orthosiphon stamineus (Java Tea) leaf extract, evaluated through various physical properties and SPF determination. The initial phytochemical screening confirmed the presence of flavonoids, saponins, and tannins in the extract, aligning with previous research. These compounds, especially flavonoids, contribute significantly to the antioxidant and UV-protection properties of the plant.

Optimization of the lotion formula was achieved using the Design of Experiments (DoE) approach with the Simplex Lattice Design (SLD) method. The optimal formula, identified with a desirability value of 0.842, balanced the concentrations of stearic acid, cetyl alcohol, and olive oil to achieve desired physical characteristics. The statistical analysis indicated that cetyl alcohol had the most significant impact on viscosity, olive oil on spreadability, and a combination of components on adhesion.

SPF determination for both the extract and the formulated lotion showed that higher concentrations of the extract resulted in higher SPF values. The SPF of the lotion at a 3% extract concentration (30,000 ppm) was 2.536 ± 0.005, indicating moderate protection. However, the SPF values were lower in the formulated lotion compared to the pure extract due to potential interactions with other formulation components during UV-Vis spectrophotometric testing.

Overall, Orthosiphon stamineus leaf extract shows promise as a natural active ingredient in sunscreen formulations, offering antioxidant and UV-protective benefits. Further research should focus on refining the formulation and exploring long-term stability and skin compatibility to enhance its commercial viability as a sunscreen product.

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