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The Effectivity of Bay Leaf Ethanol Extract (Syzygium polyanthum) as a Photoprotective Agent in Avobenzone and Octyl Methoxycinnamate Sunscreen Creams

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Abstract : UV rays can have harmful effects on the skin, including erythema, premature aging and skin cancer, making sunscreen essential for protection. A combination of avobenzone and octylmethoxycinnamate in cream form has been proven to provide good protection against UV radiation. However, exposure to UV light can degrade this combination. To address this issue, an ethanol extract of Bay Leaf (*Syzygium polyanthum*) was added as a photoprotective agent to prevent the decrease in sunscreen effectiveness. Different concentrations of Bay Leaf extract (1%, 3%, 6%, and 9%) were used to create sunscreen formulations, which were then evaluated for their physicochemical characteristics and effectiveness using in vitro methods. The evaluation was carried out under two conditions, before and after UV light exposure. One-way ANOVA was used to analyze the results. The results showed that the physicochemical characteristics (viscosity, pH and spreadability) met the requirements. The evaluation of the sunscreen in vitro effectiveness showed the best value as a photoprotective agent was at an extract concentration of 9%, which showed ANOVA test sig <0.05 and in vitro SPF, %TE, and %TP value of 29.63 ± 1,6 (ultra protection); 0.000003 ± 0.000011 (total block); and 0.000378 ± 0.000104 (total block), respectively. The in vitro SPF value before and after UV light exposure at extract concentration of 9%, showed the smallest decrease in % value, which was 29.61%. From this research, it can be concluded that the addition of ethanol extract of Bay Leaf in sunscreen cream can function as a photoprotector agent which shows an increase in effectiveness and can reduce the degradation of active ingredients caused by UV light.

Keywords - *Bay Leaf Ethanol Extract (Syzygium polyanthum), Avobenzone, Octyl Methoxycinnamate, Sunscreen, Photoprotective Agent.*

I. INTRODUCTION

Sunlight can have both positive and negative effects on the skin, depending on factors such as duration and frequency of exposure sunlight intensity, and individual skin sensitivity [1]. Ultraviolet (UV) radiation from sunlight is divided into UV A (320-400 nm), UV B (290-320 nm), and UV C (200-290 nm) [2]. UV A and UV B radiation can have negative effects on the skin, causing burns. The skin has a natural protection system against UV rays, but frequent exposure can overwhelm this system, requiring the use of sunscreen to provide additional protection [3].

Sunscreen is a cosmetic product that can prevent UV rays from penetrating the skin [4]. There are two types of sunscreen ingredients: physical blockers, which scatter UV radiation, and chemical absorbers, which

absorb UV radiation energy [5]. Physical blockers include inorganic compounds such as TiO_2 and ZnO while chemical absorbers include substances like Avobenzone and Octyl methoxycinnamate [6]. Avobenzone and octyl methoxycinnamate are commonly used together to provide protection against both UV A and UV B radiation [5]. However, exposure to UV light can degrade the effectiveness of these sunscreen ingredients. Avobenzone can be degraded by 36% after 15 minutes of exposure, while octyl methoxycinnamate can be degraded by more than 34% after 1 hour of exposure [7, 9]. To address this issue, antioxidant compounds can be added to sunscreen preparations. Phenolic compounds, found in plants like Bay Leaf (Syzygium polyanthum), have potential as photoprotective agents due to their antioxidant activity [10-11, 22].

This study aimed to determine the effectiveness of the ethanolic extract of Bay Leaf as a photoprotective agent in oil-in-water sunscreen preparations containing avobenzone and octyl methoxycinnamate. The effectiveness of the sunscreens was measured by in vitro SPF values, %TE values, and %TP values before and after UV exposure. [12, 23].

II. MATERIALS AND METHODS

This research was conducted at the Pharmaceutical Technology Laboratory and the Chemistry Laboratory of the Faculty of Pharmacy, University of Jember. The study consisted of several stages: 1. Extracting Bay Leaf and determining the total flavonoid value; 2. Preparing sunscreen cream; 3. Evaluating the physicochemical properties of the sunscreen cream (organoleptic, pH, viscosity, and spreadability); 4. Conducting in vitro testing of sunscreen cream preparations (SPF, %TE, and %TP values) with and without UV exposure; 5. Analyzing the data. The data was analyzed using One way ANOVA with a confidence level of 95%.

The study involved the development of 5 formulations of sunscreen cream, labeled as F0 (without ethanolic extract of Bay Leaf), F1, F2, F3, and F4 (containing ethanolic extract of bay leaf with various concentrations). The details of the formulations can be found in Table I.

TABLE I. Formulation of Sunscreen Cream Preparations

Materials	Concentration (%)				
	F0	F1	F2	F3	F4
Avobenzone	3	3	3	3	3
Octyl methoxycinnamate	4	4	4	4	4
Bay leaf extract	**0**	**1**	**3**	**6**	**9**
Stearic acid	14	14	14	14	14
Cetil alcohol	2	2	2	2	2
Sorbitol	6	6	6	6	6
TEA	2	2	2	2	2
Tween 80	10	10	10	10	10
Aquadest	59	58	56	53	50

III. RESULTS AND DISCUSSION

1. Determination of total flavonoid content of Bay Leaf ethanol extract

The ethanolic extract of bay leaf has potential as a photoprotective agent due to its flavonoid content. Flavonoids contain conjugated aromatic groups that can absorb UV A and UV B rays, which are known to cause skin damage [13]. The total flavonoid content of the bay leaf extract was measured using a UV-Vis spectrophotometer at a wavelength of 425 nm with quercetin as a comparison. The absorbance measurements were used to calculate the % total flavonoid content in the extract, resulting in a total flavonoid level of 47.99 mg equivalent to quercetin/g extract [14]. In a study by Apitalau in 2021 using the same solvent, the total flavonoid content of bay leaf extract was found to be 5.028 mg equivalent to quercetin/g extract. Differences in total flavonoid levels may be influenced by the type and age of the bay leaf used [18, 19].

2. Sunscreen Cream Preparation

The sunscreen cream is available in 5 different formulas, labeled as formulas 0, 1, 2, 3, and 4. Each formula contains the same active ingredients and additives, specifically avobenzone and octyl methoxycinnamate, with equal amounts of 3% and 4%, respectively [7]. However, the amount of Bay Leaf extract used in each formula varies, with percent ages of 0%, 1%, 3%, 6% and 9 %.The results of the sunscreen cream formulation can be found in Figure 1.

F0 F1 F2 F3 F4

Fig. 1. Results of sunscreen cream preparations

Organoleptic tests were visually conducted to assess the shape, color and smell of the sunscreen cream. The ideal cream should have a soft texture, a light green color that does not stain, and a specific odor of bay leaves that does not cause irritation.

The results of the sunscreen cream preparations showed consistent texture but varied in smell and color. F0 had a white color with a characteristic odor of avobenzone and octyl methoxycinnamate while F1, F2, F3, and F4 had light pale green, light green, slightly brownish green and brownish green colors with a characteristic odor of Bay Leaf, respectively. The difference in color in the formulas containing the ethanolic extract of Bay Leaf (F1, F2, F3, and F4) was attributed to the varying concentration of the extract in each preparation, with a higher amount resulting in a darker color.

3. Sunscreen Cream Viscosity

The study aimed to test the viscosity of sunscreen cream in order to determine the even distribution of active ingredients in the preparation. Creams with higher viscosity are more difficult to homogenize and viscosity testing also determines the ability of creams to spread evenly on the skin. The ideal viscosity range is between 50 dPa.s to 150 dPa.s. The Viscoster VT-04 with spindle number 2 was used for vicosity testing, and the results are shown in Figure 2.

The results in Figure 2 indicate that all five formulas have viscosity within the desired range. The One-Way ANOVA test showed a significance value of 0.000 ($p < 0.05$), indicating that at least two groups were significantly different with the addition of Bay Leaf ethanol extract. Further analysis using post hoc (LSD) revealed significant differences between the formula without ethanolic extract of Bay Leaf (F0) and the four formulas containing the extract. This suggests that the addition of Bay Leaf extract affects the viscosity of the cream preparations.

The addition of Bay Leaf extract causes a decrease in viscosity due to the use of TEA emulsifier with stearic acid. The reaction of TEA with stearic acid forms an anionic soap with a pH of about 8, which acts as an emulsifying agent [15]. The alkaline nature of TEA and the acidic nature Bay Leaf extract (pH 4.0) contribute to the change in viscosity of the preparation.

The Post hoc LSD test showed no significant difference between formulas 1, 2, 3, and 4, indicating that varying concentrations of the ethanolic extract of Bay Leaf (ranging from 1% to 9%) did not cause a change in viscosity.

4. Sunscreen Cream Dispersion

The dispersion test is conducted to assess the spreadability of cream preparations using an extensometer. It is important for cream preparations to have the ability to spread evenly on the skin surface in order to be effective. Poor dispersion can affect the uniformity of sunscreen application and, consequently, its effectiveness in protecting the skin from UV radiation. Additionally, if a cream preparation dooes not spread

well, it can take longer to apply, which may impact consumer acceptance. Therefore, it is desirable for preparations to spread easily and evenly with minimal effort.

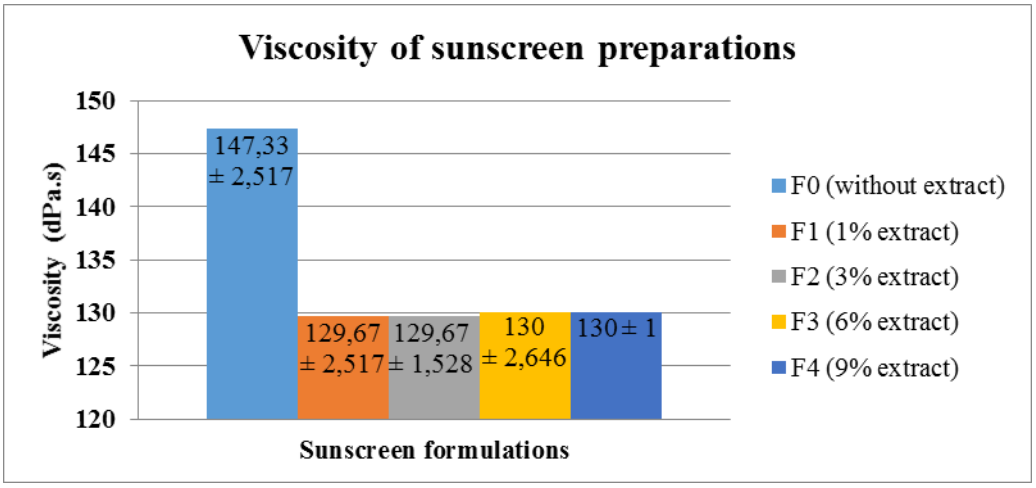
The results of the average dispersion test for each formula are presented in Figure 2. The data indicates that all five formulas meet the expected requirements of 5-8 cm, demonstrating good spreadability [16]. The dispersion value of the sunscreen cream preparation was statistically analyzed using One Way ANOVA. The test results showed a significance value of 0.000 ($p < 0.05$), leading to a post hoc test (LSD) to identify significantly different groups.

The data from F0 and F1 did not show a significant difference, while the other formulas exhibited significant differences. This suggests that the addition of 1% extract did not significantly impact the spreadability of the cream. However, higher concentrations of extract resulted in different dispersion results. Specifically, an increase in the concentration of Bay Leaf led to lower dispersion values indicating greater difficulty in spreading on the skin. This aligns with the theoretical understanding that higher viscosity values correspond to lower dispersion values, as evidenced by the decrease in dispersion value observed in this test.

5. pH Evaluation

The pH of the cream preparation was evaluated to determine if it fell within the expected pH range. It is important for cosmetic preparations to have a pH similar to that of the skin, which typically ranges from 4.5- to 8, in order to prevent dryness or irritation [16]. The pH testing results for each formulation can be found in Figure 2.

A statistical analysis using One Way ANOVA was conducted to determine the pH value of the sunscreen cream preparation. The results of the test showes that the addition of Bay Leaf extract concentration had an impact on lowering the pH value of the avobenzone and octyl methoxycinnamate cream preparations. This is attributed to the acidic nature of the bay leaf extract, which has a pH value of 4.0. As a result, the addition of the extract in the preparation led to a decrease in pH. The level of spreadability value leading to a decrease in the pH value. Event with the addition of extracts up to a concentration of 9%, the pH value remained within the required range, making the sunscreen cream safe for use.



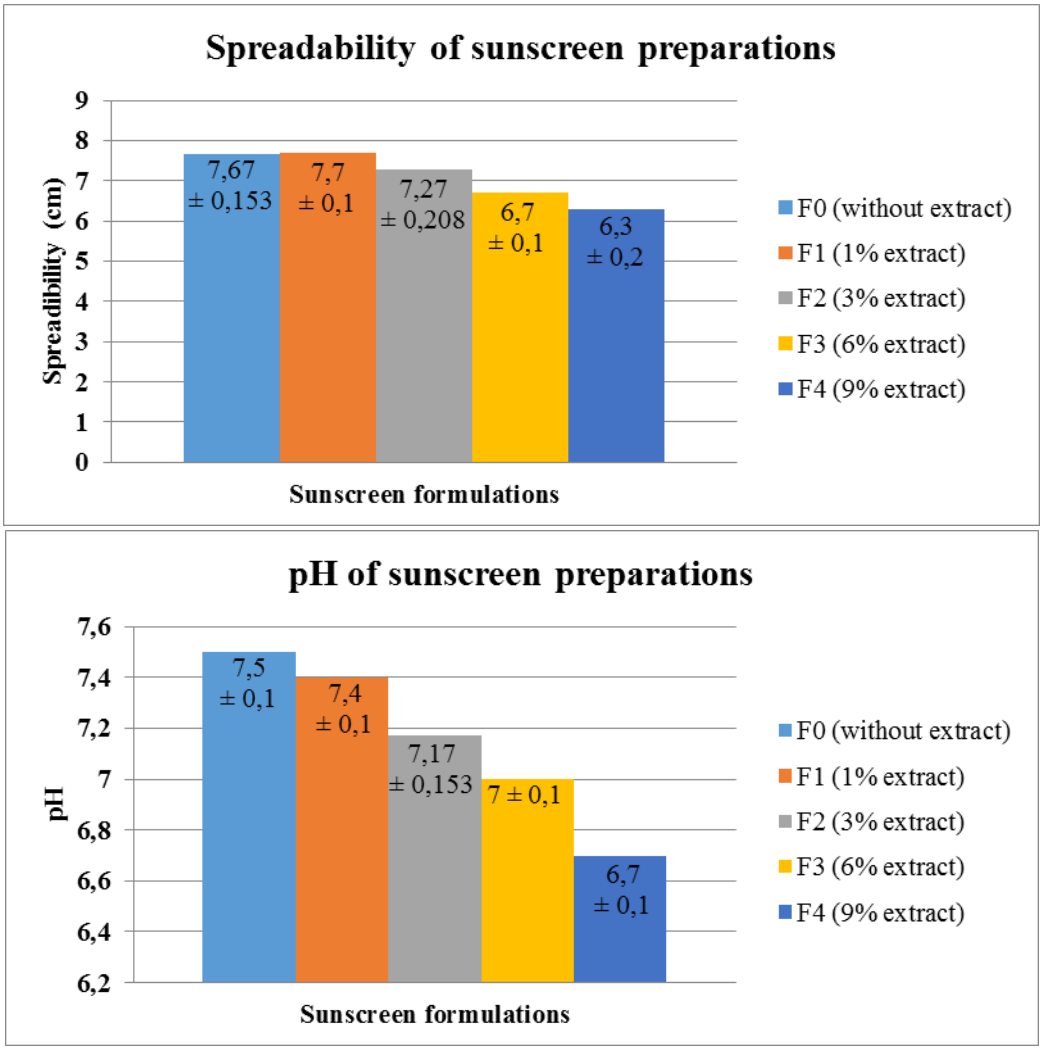


Fig. 2. Test results of viscosity, spreadibility, and pH

6. SPF Value

There are two methods for measuring the SPF value of a sunscreen preparation: in vitro and in vivo. In vitro methods are divided into two types. The first type involves measuring the absorption or transmission of UV radiation through the sunscreen product layer on a quartz plate or biomembrane [20]. The second type involves determining the absorption characteristics of sunscreen using spectrophotometric analysis of the diluted solution of sunscreen which is then tested using a mathematical equation. The equation is as follows:

$[AUC]_{\lambda p-a}^{\lambda p} = \frac{Ap-a+Ap}{2}$ (λp - λp-a).....(1)

Log SPF = $\frac{AUC}{\lambda n-\lambda 1}$ x 2.....(2)

Information:
AUC = area under the absorption curve
Ap = absorption at the wavelength after
Ap-a = absorption at the previous wavelength
Λn-λ1 = erythemogenic activity interval

7. The SPF (in vitro) value before UV exposure

The test was conducted at a wavelength of 290 nm, and an absorption value of 0.05 or higher was observed within a 1 nm interval. The results of the test are detailed in table II. The SPF value in vitro before exposure was statistically analyzed using One Way ANOVA in SPSS. The data obtained a significance value of 0.000 ($p < 0.05$), indicating significant differences between at least two groups. Post hoc analysis (LSD) was then performed.

Statistical results revealed a non-significant difference between F0 and F3, and between F1 and F2, while the other formulas showed a significant difference. The data indicated a decrease in SPF with the addition of 1% (F1) and 3% (F2) bay leaf extract compared to F0, which did not contain the extract. This suggests that the addition of bay leaf extract up to a concentration of 3% can decrease the effectiveness of SPF in vitro due to the interaction between the active ingredients and the extract.

The avobenzone and octyl methoxycinnamate with ethanol extract of bay leaves. According to Utami's research the concentration of 0.001% of bay leaf ethanol extract resulted in an SPF value of 5.34, while after being formulated into a sunscreen, the SPF value decreased to 4.97 [11]. Additional ingredients in the preparation can affect the activity of the extract because it can inhibit the release of the active compound content from the extract to diffuse into the media, so that the extract contained in the preparation cannot be completely released. Therefore, in this test the addition of 1% and 3% bay leaf ethanol extract was unable to completely release the active compound content in avobenzone and octyl methoxycinnamate sunscreen preparations.

The addition of extract at a concentration of 6% (F3) showed statistical results that were not significantly different from F0. This indicates that the addition of bay leaf extract at a concentration of 6% did not cause a change in in vitro effectiveness. The addition of 9% extract (F4) showed a significant difference in the SPF value in vitro with F0, which was an increase in the effectiveness of the SPF in vitro. This indicates that the compound content in the ethanolic extract of bay leaves is able to be completely released into sunscreen preparations, causing an increase in the effectiveness of SPF in vitro at an additional concentration of 9%.

8. The SPF (in vitro) value after UV exposure

The experiment involved exposing the test to UV light for 120 minutes and then observing at a wavelength of 290 nm to a wavelength that showed an absorption value greater than or equal to 0.05 with an observation range (interval) of 1 nm. The results are presented in table II. The SPF value in vitro after exposure was obtained and statistically analyzed by One Way ANOVA, which yielded a significance value of 0.000 ($p < 0.05$), indicating significant differences between at least two group. Post hoc analysis (LSD) was then conducted.

The statistical analysis data showed a significant difference after the addition of bay leaf extract at concentrations of 6% (F3) and 9% (F4), indicating that the addition of bay leaf extract increases the effectiveness of the SPF in vitro preparations at concentrations of 6% and above. However, the addition of extracts of 3% and 1% did not result in a significant difference in the SPF value in vitro. The results of in vitro SPF testing for sunscreen cream preparations before and after exposure to UV rays were obtained, and a paired T test was performed. The test showed a significant difference between the in vitro SPF values before and after exposure to all sunscreen formulas, indicating a decrease in effectiveness after exposure to UV light for 120 minutes. After conducting SPF test data in vitro before and after exposure to UV light, it was observed that there was a change in the category of almost all formulations, specifically F0, F1, F2, and F3, from Ultra to Maximal. In terestingly, F4 did not change categories despite a decrease in the SPF value in vitro. This indicates that F4 with the addition of 9% bay leaf ethanol extract can maintain the SPF value compared to other formulations.

The decrease in in vitro SPF value and changes in product category were attributed to the photodegradation of the active ingredients. To address thus issue, the strategy employed was the addition of ethanolic extract of bay leaf in the sunscreen cream formulation. This is evident from the decrease in the percent degradation in the five tested formulas as shown in Table II. For instance, Formula 0 exhibited a % degradation value of 45.78%, indicating that sunscreen preparations without bay leaf extract could degrade by as much as 45.78% after 120 minutes of UV exposure. However, the % degraded decreased with the addition of ethanolic extract of bay leaf in the sunscreen cream preparation formula. The most effective formula in reducing % degradation was F4 with an extract concentration of 9%. It was observed that the more ethanol extract of bay leaf added, the more significant the effect in overcoming the photodegradation of the active ingredients of a sunscreen combination of avobenzone and octyl methoxycinnamate.

Upon analyzing the SPF test results, it became evident that the best sunscreen preparation exhibited the highest SPF value both before and after exposure to UV rays with the lowest % degradation value. This was found in formula 4 with a concentration of ethanol extract of bay leaf of 9%.

9. TE Percent Value

The absorbance value obtained can be used to calculate the absorption value for 1 g/l. This absorption value is then converted into a T value using the formula:

A=-log T .....(3)

The formula for calculating the erythema transmission value is the multiplication of the transmission value with the erythema effectiveness factor (Fe) at a wavelength of 292.5-337.5 nm, as described by Cumpelik in 1972:

$$\%\text{Transmisi eritema} = \frac{\sum(T \times Fe)}{\sum Fe} \quad .....(4)$$

Information:

T = transmission % value

Fe = erythema flux constant

$\sum$Fe = total solar erythema flux

$\sum$(T.Fe) = the amount of erythema flux transmitted by the sunscreen material at a wavelength of 292.5-337.5 nm [21]

10. The %TE value before UV exposure

The results of the %TE test before UV exposure can be found in table III. The %TE value of sunscreen cream preparations before exposure was analyzed using One-Way ANOVA. The normality test for %TE data showed a significance value of <0.05 in the F4 group, indicating that the data is not normally distributed. However, the homogeneity test had a significance value of > 0.05, indicating homogeneous data variance. Since this did not meet the requirements of the One-Way ANOVA test, the Kruskal-Wallis test was used for further analysis of %TE data before UV exposure.

In the Kruskal-Wallis test, a significance value of 0.013 ($p < 0.05$) was obtained, indicating significant differences in the %TE value of sunscreen cream with various concentrations of ethanol extract of bay leaf. A post hoc analysis using the Mann-Whitney test showed a non-significant difference between F0 and F3, and between F1 and F2, while the other formulas showed a significant difference. The data indicated an increase in the %TE value with the addition of 1% (F1) and 3% (F2) extract compared to F0 which does not contain bay leaf extract. This suggests that the addition of bay leaf extract up to a concentration of 3% in the preparation can decrease the effectiveness of the erythema transmission % value. Similar to the SPF value, this decrease in effectiveness may be due to imperfect interactions between the active ingredients avobenzone and octyl methoxycinnamate with ethanol extract of bay leaves.

The addition of 6% extract (F3) did not show a significant difference from F0, indicating that it did not cause a change in the percentage of erythema transmission. However, the addition of 9% extract (F4) showed a significant difference in the percentage of erythema transmission compared F0, indicating a decrease in the %TE value. This suggests that the compound content in the ethanolic extract of bay leaves is able to completely release into the sunscreen preparation, causing an increase in the effectiveness of the % value of erythema transmission at an additional concentration of 9%.

11. The %TE value after UV exposure

The results of the %TE test after exposure to UV light are presented in table III. The %TE value of sunscreen cream preparations after exposure was statistically analyzed for normality using the F4 group, which obtained a significance of <0.05, indicating that the data is not normally distributed. However, the homogeneity test showed a significance value > 0.05, indicating homogeneous data variance. As this did not meet the requirements of the One-Way ANOVA test, the Kruskal-Wallis test was used for further analysis of %TE data after exposure to UV light.

In the Kruskal-Wallis test, a significance value of 0.011 ($p < 0.05$) was obtained. A post hoc analysis using the Mann-Whitney test showed that there was no significant difference at concentrations of 0% (F0) and 3% (F2), while the other formulas showed a significant difference. The data obtained after exposure to UV light showed an increase in %TE with the addition of 1% bay leaf ectract (F1) and a decrease in %TE with the addition of 3% to 9% extract compared to F0, which did not contain bay leaf extract. This indicates that the

addition of bay leaf extract at a concentration of 3% to 9% in the preparation can increase the effectiveness of the % erythema transmission value.

The %TE value of sunscreen cream preparations before and after exposure was analyzed using a paired T test. The normality value obtained was a significance value > 0.05 using the Shapiro-Wilk test, indicating that the data is normally distributed and allowing for the paired t test to be performed. The results of this test showed a significance value of 0.000 ($p < 0.05$), indicating a significant difference between the %TE values before and after UV exposure. The statistical data showed a significant increase in the %TE value after exposure to UV light, indicating a decrease in sunscreen effectiveness. Despite the decrease in the %TE value after UV exposure, all five formulas remained in the total block category based on %TE, as indicated by literature from Maulida defining the total block category as <1% [17].

Based on the analysis results of the %TE test, the best sunscreen preparation was determined by the lowest %TE value both before and after UV exposure. The best formula was found to be formula 4 with a concentration of 9% ethanol extract of bay leaf.

12. TP Percent Value

The pigment transmission value is determined by multiplying the transmission value with the pigmentation effectiveness factor (Fp) at a wavelength of 332.5-372.5 nm, using the formula [21]

$$\%\text{Transmisi Pigmentasi} = \frac{\sum(T \times Fe)}{\sum Fe} \quad \text{.....(5)}$$

Information:
T = transmission % value
Fp = pigmentation flux constant
$\sum$Fp = total amount of sunlight pigmentation flux
$\sum$(T.Fp) = the amount of pigmentation flux transmitted by the sunscreen material at a wavelength of 332.5-372.5 nm

13. The %TP value before UV exposure

The results of the %TP test before UV exposure are presented in table III. The %TP value of sunscreen cream preparations before exposure was analyzed using One-Way ANOVA. The normality test for %TP data yielded a significance value of <0.05 indicating that the data was not normally distributed. However, the homogeneity test had a significance value of > 0.05, indicating that the data variance was homogeneous. As this did not meet the requirements of the One-Way ANOVA test, the Kruskal-Wallis test was used for further analysis of %TP data before exposure to UV light.

In the Kruskal-Wallis test, a significance value of 0.016 ($p < 0.05$) was obtained. A post hoc analysis using the Mann-Whitney test showed a non-significant difference between F0 and F2, and between F1 and F2, while the other formulas showed a significant difference. The data indicated an increase in the %TP value with the addition of 1% bay leaf extract (F1) compared to F0, which does not contain bay leaf extract. This suggests that the addition of bay leaf extract up to a concentration of 1% in the preparation can decrease the effectiveness of the % transmission pigmentation value. Similar to the SPF value, this decrease in effectiveness may be due to imperfect interactions between the active ingredients avobenzone and octyl methoxycinnamate with ethanol extract of bay leaves. The addition of 3% bay leaf extract (F2) showed no significant difference from F0 indicating that it did not cause a change in the percentage of pigmentation transmission.

However, the addition of 6% (F3) and 9% (F4) extracts showed a significant difference in the percentage value of erythema transmission compared to F0, resulting in a decrease in the %TP value. This suggests that the compound content in the ethanolic extract of bay leaves is able to be completely released into the sunscreen preparation, causing an increase in the effectiveness of the % value of pigmentation transmission at the addition of 6% and 9% concentrations, respectively.

14. The %TP value after UV exposure

The results of the %TP test after exposure to UV light are presented in Table III. The %TP value of sunscreen cream preparations after exposure was statistically analyzed using the normality test of %TE data. The analysis yielded a significance of <0.05 in group F(4), indicating that the data is not normally distributed. However, the homogeneity test showed a significance value of >0.05, indicating that the variance of the data is homogeneous. Since the data did not meet the requirements of the One-Way ANOVA test, the Kruskal-Wallis test was used for further analysis of %TE data after exposure to UV light.

In the Kruskal-Wallis test, a significance value of 0.017 ($p < 0.05$) was obtained. A post hoc analysis using the Mann-Whitney test showed that there was no significant difference in concentrations up to 3% (F2), while the other formulas showed a significant difference. The data obtained after exposure to UV light indicated an increase in the value of %TP with the addition of extract by 1% (F1) and 3% (F2), and a decrease in the value of %TP with the addition of extract by 6% and 9% when compared to F0. which does not contain bay leaf extract. This suggests that the addition of bay leaf extract with a concentration of 6% to 9% in the preparation, can increase the effectiveness of the % value of pigmentation transmission.

The %TP value of sunscreen cream preparations before and after exposure was statistically analyzed using a paired T-test. The normality test yielded a significance value >0.05 using the Shapiro-Wilk test, indicating that the data is normally distributed. The paired t-test showed a significance value of 0.000 ($p <0.05$), indicating that there is a significant difference between the %TE values before and after UV exposure. The statistical data showed a significant increase in the value of %TP after exposure to UV light, indicating that the sunscreen was less effective. A good sunscreen is one that gives the lowest %TP value, indicating its ability to prevent pigmentation. Despite the decrease in the effectiveness of the %TP value after UV exposure, all five formulas remained in the total block category based on %TP. According to literature, the %TP value indicating the total block category is <1-2% [17].

Based on the analysis results of the %TP test, the best sunscreen preparation is determined by the lowest %TP value both before and after UV exposure. The best formula was found to be formula 4 with a concentration of ethanol extract of bay leaf of 9%.

TABLE II. SPF Test Results

Formulation	SPF *(Sun Protection Factor)*				
	Before UV exposure		After UV exposure		Degradation (%)
F0	18.9584 ± 0.2775	Ultra	10.2787 ± 0.4796	Maximal	45.78%
F1	15.3737 ± 1.8244	Ultra	9.1341 ± 0.7938	Maximal	41.97%
F2	16.8917 ± 0.8781	Ultra	10.4788 ± 0.5206	Maximal	37.96%
F3	20.7521 ± 1.3412	Ultra	13.7038 ± 1.6982	Maximal	31.71%
F4	29.6262 ± 1.6351	Ultra	20.8527 ± 1.3926	Ultra	29.61%

TABLE III. Test Results for %TE and %TP

Formulation	%TE (Erythema Transmission) ± SD		%TP (Pigmentation Transmission) ± SD		Category
	Before UV exposure	After UV exposure	Before UV exposure	After UV exposure	
F(0)	0.00025 ± 0.000043	0.00418 ± 0.001016	0.002632 ± 0.000268	0.024767 ± 0.003764	Total block
F(1)	0.00058 ± 0.000205	0.00786 ± 0.002448	0.004463 ± 0.001375	0.040364 ± 0.011535	Total block
F(2)	0.000356 ± 0.00059	0.00405 ± 0.000928	0.001127 ± 0.000733	0.023618 ± 0.004864	Total block
F(3)	0.00016 ± 0.000102	0.0015 ± 0.000877	0.001522 ± 0.000458	0.010073 ± 0.004199	Total block
F(4)	0.00003 ± 0.000011	0.00025 ± 0.000076	0.000378 ± 0.000104	0.001972 ± 0.000511	Total block

IV. CONCLUSION

The study concluded that the sunscreen cream preparations had consistent texture, but varied in smell and color. F0 had a white color and a distinct odor of avobenzone and octyl methoxycinnamate, while F1, F2, F3, and F4 had pale green, light green, slightly brownish green, and brownish green colors with the characteristic odor of bay leaves, respectively. The color difference were due to varying extract concentrations, with higher concentrations resulting in darker colors. Viscosity, spreadibility, and pH of the preparations did not show significant differences, but higher viscosity corresponded to lower spreadibility and pH values. The study found that a 9% ethanol extract of bay leaf showed the best in vitro sunscreen effectiveness, increasing SPF value and decreasing %TE and %TP with a significance of <0.05. Additionally, the study showed that exposure to UV light decreased the effectiveness of sunscreen cream preparations, but this drecrease could be minimized by increasing the concentration of bay leaf ethanol extract in the formulation.

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