

## Determination of Sunscreen Gel's SPF (Sun Protecting Factor) Value Containing Cemba Leaf Extract (*Acacia rugata* (Lam.) Fawc. Rendle)

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**Abstract**—Excessive sun exposure can have negative effects on the skin. One way to reduce this impact is to use sunscreen. Cemba leaves have been used as a local culinary spice by the people of Kabupaten Enrekang. It has been demonstrated that the phenolic and flavonoid chemical found in cemba leaf extract have antioxidant activity, which may make them useful as sunscreen. This study aims to formulate cemba leaf extract into a stable sunscreen gel preparation and to determine the resulting sun-protecting factor (SPF) value. Using the laboratory experimental method, cemba leaves were extracted using the maceration method and the extract was made as an active ingredient in a gel preparation with concentrations of each formula including 0.5% (F1), 1% (F2), and 1.5% (F3). The gel preparation that had been made was then tested for stability using the cycling test method at temperatures of 4°C and 40°C. The research results of the cemba leaf extract gel preparations showed good stability and met the quality requirements in term of organoleptic, homogeneity, pH viscosity, spreadability, and adhesiveness with no significant difference before and after the cycling test ( $p < 0.05$ ). Determination of SPF value using UV-Vis spectrophotometry obtained the values of each formula respectively are 31.99 (F1), 43.23 (F2), and 43.24 (F3). The three formulas show activity as sunscreen seen from the SPF value  $> 15$  which is included in the ultra-category.

**Keywords:** Cemba Leaf Extract; Sunscreen Gel; SPF

### 1. INTRODUCTION

The Indonesia's climate is tropical, with a monsoonal wet season dan dry season. It's topography is highly varied, ranging from marine and coastal systems, to peat swamps and mountain forests (World Health Organization, 2015). Countries with tropical climates experience higher sun exposure during the dry season, coupled with higher humidity levels (Damayanti et al., 2024). Ultraviolet (UV) levels on the earth's surface vary with time, geographic location, and season. The highest UV radiation is found in tropical areas because the sun is positioned directly on the equator and has a longer exposure time so that more radiation is absorbed. Indonesia, which is located on the equator, receives more ultraviolet radiation (Fauziyyah et al., 2023).

The UV Index (UVI) predicts the level of ultraviolet radiation from 1 to 11+. A scale of 1 means a low UV category and minimal risk of overexposure, while a scale of 11+ means an extremely high risk. The UV index plays a vital role in raising public awareness of the dangers associated with exposure to UV radiation and educating people about the necessity of taking protective measures. Personal sun exposure habits are the most important individual risk factors for UV damage (World Health Organization, 2022). Erythem, pigmentation, skin aging, and skin cancer can be caused by exposure to ultraviolet rays from the sun. By limiting sun exposure, these problems can be avoided. The main method for preventing the harmful effects of ultraviolet radiation on the skin, such as premature aging, skin cancer, and skin cancer symptoms, is to use sunscreen. Other common sun protection measures include limiting the amount of time spent in the sun during the day, wearing hats and long-sleeved clothing that protects the skin, and seeking shade from objects or building (Ou-Yang & Shyr, 2017).

Sunscreen, which is a product made of a variety of ingredients that protect the skin by absorbing, blocking, or scattering ultraviolet radiation, is effective as a primary photoprotection. The Food and Drug Administration has approved the use of sunscreen to prevent sunburn, aging, sun-induced pigmentation, and cancer (Rukhsar et al., 2023) The ability of sunscreen to protect the skin by ending erythema is stated in the Sun Protecting Factor (SPF). SPF is the amount of ultraviolet energy needed to produce a Minimal Erythema Dose (MED) on the skin protected by the active product or sunscreen. Sunscreen has been shown to prevent skin cancer from sunlight as well as other harmful effects of ultraviolet light (Destiawan et al., 2021). Currently, there are various chemicals that dominate the raw materials for making sunscreen and other beauty products. Although it has sunscreen activity and is very helpful in reducing the negative effects of ultraviolet rays on the skin, many active ingredients from synthetic compounds can cause allergic reactions and skin irritation. Therefore, several studies have innovated to create sunscreen preparations using natural ingredients as active ingredients that tend to be safer (Juanita & Juliadi, 2020).

Cemba leaves are a type of rare and endemic plant in South Sulawesi, precisely in Kabupaten Enrekang. Cemba leaves have been used as a local culinary spice. Local people believe that adding cemba leaves to food not only adds flavor but also gets healthy food. Cemba leaf extract has been reported to have to potential to be used in sunscreen preparations. Cemba leaves have been studied to contain chemical compounds including flavonoids, phenols, saponins, alkaloids, and tannins. In previous studies, the total phenolic and flavonoid levels in each gram of cemba leaf extract tested using a TLC Densitometer were 0.879 gGAE/g and 0.73 gGAE/g, respectively (Dahlia et al., 2022). Phenolic compounds are known to have antioxidant activity because they have hydroxyl groups that can donate hydrogen atoms,

so they can act as antioxidants and neutralize free radicals into more stable compounds. Flavonoid compounds are one group of phenolic compounds and are reported to have strong antioxidant activity. Flavonoids have the ability to eliminate very dangerous oxidizing compounds (Ahmad & Dahlia, 2014). Other studies also show that cemba leaf extract has strong antioxidant activity, indicated by an IC<sub>50</sub> value of 94.039 µg/ml (Ahmad et al., 2023). One of the main mechanisms of flavonoids as photoprotective is through the absorption of UV light by conjugated double bonds in flavonoids to stabilize free radicals, especially due to the presence of hydroxyl groups attached to the aromatic ring (José et al., 2016). The compounds of cemba leaves makes it interesting to be formulated into sunscreen preparations.

## 2. RESEARCH METHODOLOGY

This research was conducted using a laboratory experimental method to test the content of cemba leaf extract as UV protector in sunscreen gel preparations.

### 2.1 Materials

The tools used were analytical scales (PIONEER), rotary evaporator (EYELA N-1300S-WB), climatic chamber (CLIMACELL), pH meter (YIERYI TPH 01707), UV-Vis spectrophotometer (LAMBDA 365), and digital viscometer Brookfield (WANT NDJ/DV). The materials used in this study were cemba leaf extract (*Acacia rugata* (Lam.) Fawc. Rendle), distilled water, glycerin, hydroxy propyl methyl cellulose, methanol, methyl paraben, and oleum rosae.

### 2.2 Methods

#### 2.2.1 Processing and Sampling

The sample used were cemba plant leaves taken in Patongloan Village, Baroko District, Enrekang Regency, South Sulawesi. Cemba leaves were cleaned from dirt and wet sorted by washing them with clean water to remove dirt still attached to the leaves. After that, the leaves were drained and shredded. Then drying was carried out without direct sunlight by airing at room temperature until dry and dry sorting was carried out.

#### 2.2.2. Extract Preparation

The cemba leaf sample that had been made into a simplicia was macerated using 96% methanol solvent. First, the simplicia was weighed as much as 500 grams and then put into a maceration container. Next, 1 L of 96% methanol was added until completely submerged, covered, and left for 24 hours protected from light while stirring occasionally. After that, the filtrate and residue were separated by filtering into a new container to obtain a liquid extract. Furthermore, the residue was added back with the solvent liquid and the maceration process was carried out again twice. The filtrate was then evaporated with a rotary evaporator at 60°C until a thick extract was obtained (Sasidharan et al., 2011).

#### 2.2.3 Making Gel Preparation

The ingredients for the preparation of the gel were calculated based on the draft formula in **Table 1**. The percentage of ingredients in a formula is determined based on the desired function of each ingredient. First, prepare the tools and materials to be used. 20 mL of distilled water was heated to a temperature of 75°C, then HPMC was added and stirred for 15 minutes until it expands. After expanding, propylene glycol was mixed little by little. Meanwhile, methyl paraben was dissolved in glycerin then added to the base mixture and fragrance was added. The extract that has been dissolved with distilled water was added to the gel base little by little while stirring until homogeneous. Finally, the volume was filled with distilled water up to 50 mL until a homogeneous gel was formed.

**Table 1.** Design of Cemba Leaves Extract (*Acacia rugata* (Lam.) Fawc. Rendle) Gel Formula

Ingredients	Concentration					Function
	F0/K(-)	F1	F2	F3	K(+)	
Cemba leaf extract	-	0.5%	1%	1.5%		Active substance
HPMC	2%	2%	2%	2%		Gelling agent
Propylene glycol	15%	15%	15%	15%	Whitelab	Humectant
Glycerin	10%	10%	10%	10%	Sunscreen Gel	Solubility enhancer
Methyl paraben	0.1%	0.1%	0.1%	0.1%		Preservative
Oleum rosae	q.s.	q.s	q.s	q.s		Fragrance
Aquadest	ad 50 mL	ad 50 mL	ad 50 mL	ad 50 mL		Solvent

F0/K (-) is a gel base formula and negative control that did not contain cemba leaf extract. F1, F2, and F3 are sunscreen gel formulas that contain cemba leaf extract, each in concentrations of 0.5%, 1%, and 1.5%.

## 2.2.4 Physical Stability Test of Gel Preparation

Stability testing was carried out using the cycling test method (freeze-thaw test) for 3 cycles. One cycle consists of storage at a temperature of 4°C for 24 hours then stored at 40°C for the next 24 hours. The test was carried out for 3 cycles and at the end of the third cycle, the physical properties of the preparation were observed and then compared with the condition before storage (Juliana et al., 2024). The physical properties observed before and after the cycling test include:

### a. Organoleptic Test

Using visual observation, organoleptic observation is performed by assessing the consistency, color, clarity, and odor of the product.

### b. Homogeneity Test

To verify the homogeneity, 0.1 grams of each formula's preparation was applied to a glass object, smooth it out with another glass object, and then look for any particles or substance that haven't been blended evenly.

### c. pH Test

A pH meter was used to do the pH test. To calibrate the pH meter, buffer solution with pH values of 4, 7, and 10 were first used. Next, 100 mL of distilled water were added to 0.1 gram of the gel preparation. After dipping the electrode into the mixture, the pH was displayed on the pH indicator panel.

### d. The Spreadability Test

To measure the spreadability of gel preparation, 0.5 grams of the preparation was put on a piece of transparent glass. The preparation was covered with another glass and a 50 mg weight was added, then the diameter of the preparation spread formed on the glass was measured.

### e. Adhesion Test

Weighing 0.5 grams of the gel preparation, spreading it on a glass object, and then covering it with another glass object was how the adhesive strength test was done. The load was lifted and the time recorded when the 2 attached glass slides are separated.

### f. Viscosity Test

A viscometer was used to measure the preparation's viscosity by pouring 100 gram of it into a glass beaker with a capacity of 100 mL. Then Spindle No. 2 was installed on the device and rotated with a revolver to lower the spindle until it was completely submerged in the gel. The viscometer speeds was set at 30 rpm and the visible scale was observed. The viscosity value was recorded after a stable number was obtained. Measurements were made 3 times.

## 2.2.5 Determining SPF Value

### a. Sample Preparation

The preparation of cempa leaf extract gel was weighed as much as 0.02 grams then put into a 10 mL measuring flask and dissolved with ethanol pro analysis to obtain a sample solution. After that, it was transferred into 10 mL vial to be measured using UV-Vis spectrophotometer.

### b. Calibration of UV-Vis Spectrophotometer

The calibration was done by adding 1 mL of analytical pro ethanol into the cuvette, then inserting the cuvette into the UV-Vis spectrophotometer to be calibrated.

### c. Sample absorption measurement

The diluted solution was measured for absorbance every 5 nm in the 290-320 nm wavelength range using UV-Vis spectrophotometer with analytical pro ethanol as the blank solution.

SPF value observation data at various wavelengths is calculated based on the following formula (Lestari & Prajuwita, 2021):

$$SPF = CF \times \sum_{290}^{320} EE(\lambda) \times I \times Abs. \quad (1)$$

The CF is a correction factor (10), the EE value is the erythema spectrum, while I is the light intensity spectrum. The EE x I value is constant and is shown in **Table 2**. Abs is the absorbance value of the sample measured by the UV-Vis spectrophotometer.

**Table 2.** EE x I value at wavelength 290-320 nm (Puspitasari & Setyowati, 2019)

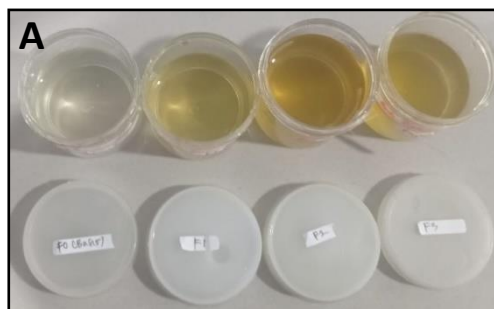
Wavelength (nm)	EE x I
290	0.0150
295	0.087
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180

### 3. RESULT AND DISCUSSION

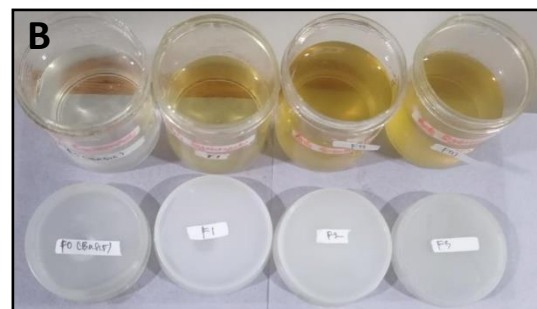
The data collected were primary data from the evaluation results of the methanol extract of cemba leaf sunscreen gel preparation, namely organoleptic, homogeneity, pH, spreadability, adhesion, and viscosity test using the accelerated stability method before and after testing, as well as absorbance data of the gel preparation. The data from the sample solution absorption measurements are tabulated and collected, then the SPF value was determined. The data has been collected was then processed statistically using Statistical Product and Service Solution (SPSS) with the paired sample T-Test method.

#### 3.1 Physical Stability Test Results

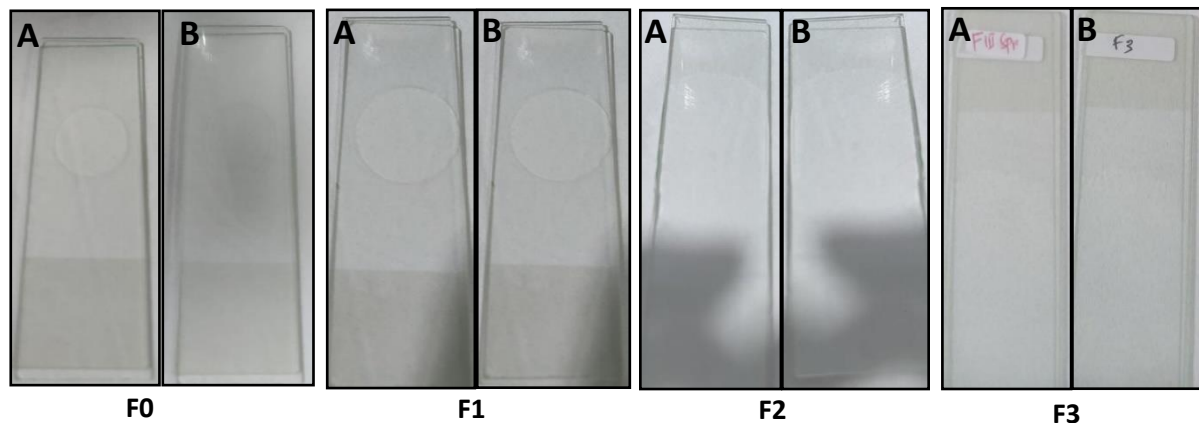
Organoleptic examination showed no changes in color, consistency, or aroma before and after the cycling test (**Figure 1**). All preparation formula tested had a slightly thick consistency and had a characteristic leafy odor with a slightly yellowish color except for F0 which did not contain extracts. The higher the extract concentration, the more yellow-brown the color of the preparation will be.



**Figure 1.** Organoleptic Observation Results Before Cycling Test



**Figure 2.** Organoleptic Observation Results After Cycling Test



**Figure 2.** Homogeneity Observation Results; A. Before Cycling Test, B. After Cycling Test

Homogeneity testing looks for the presence or absence of particles or substance that have not been blended homogeneously in order to determine how mixable the preparation ingredients are. Coarse grains indicate that the preparation made is not homogeneous because the components are not dispersed (Akbar et al., 2021). When viewed in **Figure 2**, the results of the homogeneity examination of all preparation formulas before and after the cycling test show a homogeneous formula. This is indicated by the absence of coarse grains when the preparation is applied to transparent glass. If the preparation is declared homogeneous, it can be assumed that each application of the preparation will contain the same level of active substance. Therefore, the homogeneity of the preparation affects the effectiveness of the preparation (Yadnya Putra et al., 2020).

The pH test was carried out to see the acidity level of the gel preparation. Topical preparations are formulated in such a way as to meet the appropriate pH range because pH affects the stability of the preparation, drug solubility, and the potential of the preparation to cause skin irritation. The pH of the sunscreen gel preparation must be in accordance with the pH requirements range of topical preparations (4.5-7), where if the pH is too alkaline it will cause scaly skin and if the pH is too acidic it will cause infection (Cendana et al., 2021). Based on **Table 3**, the pH value of all sunscreen gel formulations that have been made has changed after the cycling test. This can be caused by the auto-oxidation reaction caused by the presence of light and oxygen and several other factors such as temperature and humidity. However, the increase in pH is still within the range of skin pH values for topical preparations (Akbar et al., 2021).

**Table 3.** The pH Test Observation Results

Formula	Before Cycling Test	After Cycling Test	<i>p</i>
F0	6.20	5.81	0.116
F1	6.29	5.41	
F2	5.27	5.56	
F3	6.73	6.57	

F0 is a gel base formula and negative control that did not contain cemba leaf extract. F1, F2, and F3 are sunscreen gel formulas that contain cemba leaf extract, each in concentrations of 0.5%, 1%, and 1.5%.  $p > 0.05$  indicates there is no significant difference in pH value between before and after the cycling test.

Viscosity testing aims to determine the viscosity value of preparation to flow. The test results in **Table 4** show that the higher the extract concentration in the preparation, the higher viscosity. After storage using the cycling test method, the viscosity value in all formulas decreased but were still within the good gel viscosity range, namely 2000-4000 cPs. The temperature, storage condition, and excipients employed all affect how much the viscosity or thickness decreases following the cycle test. When the preparation is at a high temperature, there will be a decrease in the binding power of the thickener which causes the preparation to tend to experience a change in consistency to become more liquid. Likewise, for hygroscopic excipients such as propylene glycol, the longer the cycling test, the preparation will be more liquid because more water is bound (Angelia et al., 2022). Based on statistical analysis, the change in viscosity is not significant ( $p > 0.05$ ) so the viscosity of the gel can be said to remain stable after the cycling test.

**Table 4.** The Viscosity Test Observation Results

Formula	Before Cycling Test (cPs)	After Cycling Test (cPs)	<i>p</i>
F0	2350	2250	0.055*
F1	3220	3180	
F2	3700	3680	
F3	4000	3890	

F0 is a gel base formula and negative control that did not contain cemba leaf extract. F1, F2, and F3 are sunscreen gel formulas that contain cemba leaf extract, each in concentrations of 0.5%, 1%, and 1.5%.  $p > 0.05$  indicates there is no significant difference in pH value between before and after the cycle test.

Spreadability testing aims to determine the ability of preparation to spread when applied to the skin. The spreadability of a gel is said to be good if the gel can be easily applied to the skin without strong pressure. Good spreadability is in the range of 5-7 cm and shows a semi-solid consistency which is comfortable when used (Irianto et al., 2020). In **Table 5**, it can be seen that the spreadability of the gel increased after the cycling test but was still within the range of good spreadability requirements. Statistical analysis also showed that the spreadability did not change significantly after the cycling test ( $p > 0.05$ ).

**Table 5.** The Spreadability Test Observation Results

Formula	Before Cycling Test (cm)	After Cycling Test (cm)	<i>p</i>
F0	5.6	6.4	0.420*
F1	5.6	6.5	
F2	6.4	6.2	
F3	5.4	6.2	

F0/K (-) is a gel base formula and negative control that did not contain cemba leaf extract. F1, F2, and F3 are sunscreen gel formulas that contain cemba leaf extract, each in concentrations of 0.5%, 1%, and 1.5%.  $p > 0.05$  indicates there is no significant difference in pH value between before and after the cycle test.

The purpose of the adhesion test is to measure the sticking strength of the gel preparation which is carried out to determine the ability of preparation to adhere to the skin surface. Adhesion of a gel preparation is said to be good if it is more than 1 seconds (Irianto et al., 2020). In all formulations, there was a decrease in adhesion after the cycling test. This occurs due to the influence of temperature and storage, but still within the adhesion test requirements. The results of statistical analysis showed no significant difference in adhesion before and after the cycling test (**Table 6**).

**Table 6.** The Adhesion Test Observation Results

Formula	Before Cycling Test (second)	After Cycling Test (second)	<i>p</i>
F0	4.26	4.05	0.389*
F1	4.18	4.11	
F2	4.37	4.28	
F3	4.43	4.34	

F0 is a gel base formula and negative control that did not contain cemba leaf extract. F1, F2, and F3 are sunscreen gel formulas that contain cemba leaf extract, each in concentrations of 0.5%, 1%, and 1.5%.  $p > 0.05$  indicates there is no significant difference in pH value between before and after the cycle test.

The SPV value was calculated based on the absorbance measured on the UV-Vis spectrophotometer of each formula at a wavelength of 290-320 nm in order to determine the sunscreen potential in the manufacture of cemba leaf extract gel. The wavelength is the range of UVB light wavelengths that have a major effect on the skin. Excessive UVB rays can cause several skin problems, such as redness, pigmentation, and even skin cancer in the long term. SPF (Sun Protecting Factor) is a universal indicator that explains the effectiveness of a product or substance that is UV protector. The higher the SPF value of a product or active substance, the more effective it is to protect the skin from the effects of UV light (Widyawati et al., 2019). The results of the SPF value calculation for the cemba leaf extract gel preparation at 2000 rpm concentration can be seen in **Table 7**.

**Table 7.** The SPF Value Calculation Results

Formula	Concentration (rpm)	SPF Value	Protection Category*
F0	2000	0.960377	Minimal
F1	2000	31.9912	Ultra
F2	2000	43.2325	Ultra
F3	2000	43.31687	Ultra
K (+)	2000	43.24363	Ultra

\*Based on Food and Drug Administration (FDA)

The calculation of the resulting SPF value can be influenced by the compound's absorbance of UV radiation with compounds that have conjugated bonds (chromophores) that can absorb UV radiation at certain wavelength. It is known that cemba leaves contain flavonoid and tannin compounds which both have chromophore groups. From the data obtained, it can be seen that the higher the extract concentration in the gel preparation, the higher the SPF value. The higher the SPF value, the more effective the sunscreen activity. When compared between F0 which is only a gel base with F1, F2, and F3 which contain cemba leaf extract, it is clear that F0 has an SPF value in the minimal protection category, while the formula containing cemba leaf extract (F1, F2, F3) is classified in the ultra protection category. This proves that the metabolite compounds contained in cemba leaves can act as sunscreens.

## 4. CONCLUSION

Cemba leaf extract (*Acacia rugata* (Lam.) Fawc. Rendle) can be used as an active substance in sunscreen gel preparation that meet quality requirements and physically stable with an SPF value of  $> 15$  (ultra protection category) in formulas with concentration of 0.5%, 1%, and 1.5%. The higher the concentration of cemba leaf extract in the gel preparation, the higher the SPF value. With this results, the use of cemba leaves as a typical plant of Enrekang, can be further improved, not only as a cooking spice as has been known by the surrounding community, but can increase the plant value as a raw material for medicine/cosmetics so that this plant can be further cultivated. One of the limitations of this study is that the color of the sunscreen gel preparation of cemba leaf extract is less appealing because it still matches the extract's color. This can be fixed in future research by optimizing the formula and conducting supporting tests to further develop safe natural sunscreen products.

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