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Green Solvent-Based Extraction of *Muntingia calabura* L. Flower and Its Sunscreen Activity Assessed by UV–Vis Spectrophotometry

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ABSTRACT: Sunscreen agents can be derived from natural sources, one of which is Jamaica cherry (*Muntingia calabura* L.), a plant known to contain various bioactive compounds such as tannins, polyphenols, flavonoids, and saponins. This study aimed to determine the sun protection factor (SPF), percent erythema transmission (%Te), and percent pigmentation transmission (%Tp) of *M. calabura* flower extract obtained through a green solvent-based extraction method. The extract was prepared using Microwave-Assisted Extraction (MAE) with variations in temperature and extraction time. Absorbance measurements were carried out using UV–Vis spectrophotometry within two wavelength ranges: 290–320 nm (UVB region) for erythema and 320–370 nm (UVA region) for pigmentation. The results showed that at a concentration of 50 µg/mL, the extract exhibited an SPF value of 3.596, categorized as minimal protection. At 100 µg/mL, the SPF increased to 11.488, corresponding to maximum protection. Further increases in concentration to 150, 200, and 250 µg/mL resulted in SPF values of 17.708, 17.995, and 21.500, respectively, all classified as ultra protection. The %Te values decreased with increasing concentration, indicating improved protective activity. At 50 µg/mL, the %Te was 38.03% (no sunscreen activity), while at 100 µg/mL it decreased to 11.17% (suntan category). At higher concentrations of 150, 200, and 250 µg/mL, the %Te values were 2.29%, 2.37%, and 1.03%, respectively, all categorized as ultra protection. Similarly, the %Tp values at concentrations of 50, 100, 150, 200, and 250 µg/mL were 24.25%, 15.60%, 23.94%, 23.40%, and 15.75%, respectively, all falling within the sunblock category. In conclusion, increasing the concentration of *M. calabura* flower extract significantly enhances SPF while reducing %Te and maintaining effective %Tp values, indicating its strong potential as a natural sunscreen agent.

KEYWORDS: Green extraction; phytochemical; SPF; spectrophotometry; sunblock.

1. INTRODUCTION

Indonesia is well known for its extensive use of medicinal plants in addressing various health problems. Traditional Indonesian medicine encompasses a wide range of herbal remedies derived from knowledge of medicinal plant utilization that has been passed down through generations. One plant with potential as a sunscreen agent is kersen (*Muntingia calabura* L.). This plant is rich in bioactive compounds beneficial to human health, which are present in its leaves, flowers, and fruits (Zahara & Suryady, 2018). The flowers of *M. calabura* contain various phytochemical constituents, including tannins, polyphenols, flavonoids, and saponins (Tahir et al., 2022). In addition, kersen flowers exhibit antioxidant activity as free radical scavengers and have been reported to possess potential as natural sunscreen agents (Kuntorini et al., 2015). Natural sunscreen compounds can be derived from various plant parts, such as rhizomes, fruits, seeds, flowers, leaves, roots, and sap (Tahir et al., 2022).

Previous research by Tahir et al. (2022) demonstrated that the ethanol extract of *M. calabura* flowers exhibited high sunscreen activity, with a sun protection value (SPF) of 41.6 at a concentration of 0.05%. Furthermore, the study indicated that increasing extract concentration led to higher SPF values. In this study, extraction was carried out using a green solvent-based approach through Microwave-Assisted Extraction (MAE). The MAE method was selected due to its advantages, including higher energy efficiency, shorter extraction time, optimal extraction performance, and reduced solvent consumption (Sari et al., 2020). Distilled water was used as the extraction solvent, as it is considered a green solvent due to its non-toxic and non-flammable nature, low cost, wide availability, and safety for consumption (Santi et al., 2016). The application of distilled water in MAE has been shown to be effective in extracting various bioactive compounds from natural sources.

Supporting studies have demonstrated the effectiveness of MAE compared to conventional methods. Amaranti et al. (2021) reported that pectin extraction from Bali orange peel using a combination of distilled water and MAE produced high-quality pectin in a shorter time. Similarly, Daniswara et al. (2017) found that microwave-based extraction methods were faster and more efficient than Soxhlet extraction. Based on these considerations, an in vitro evaluation of the sunscreen activity of *M. calabura* flower extract using a green solvent was conducted using UV–Vis spectrophotometry. The evaluation included determination of the Sun Protection Factor (SPF) as a universal parameter of sunscreen

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effectiveness against UV radiation, as well as measurement of percent erythema transmission (%Te) and percent pigmentation transmission (%Tp) as additional indicators of photoprotective activity.

2. EXPERIMENTAL SECTION

2.1. General

The tools used in this study included a microwave oven for Microwave-Assisted Extraction (MAE), an analytical balance for weighing samples, and standard laboratory equipment for filtration and evaporation processes. The extraction procedure involved weighing 1 g of sample, adding 20 mL of distilled water, and subjecting the mixture to microwave treatment at varying times (1, 5, and 10 min) and temperature settings (low, medium-low, and medium). The resulting solution was then filtered and evaporated until a dry extract was obtained.

2.2. Sample preparation

The collected kersen flower (*Muntingia calabura* L.) samples were cleaned of adhering impurities and subsequently air-dried without direct sunlight exposure for approximately one week. The dried samples were then ground using a blender to obtain kersen flower powder (Tahir et al., 2022). Extraction was carried out using the MAE method, in which 1 g of the powdered sample was mixed with 20 mL of distilled water. The mixture was then subjected to microwave treatment at varying extraction times (1, 5, and 10 minutes) and temperature settings (low, medium-low, and medium). Following extraction, the resulting solution was filtered and further evaporated to obtain a dry extract.

2.3. Sunscreen activity assay

Cherry blossom extract (*Muntingia calabura* L.) was weighed at 5 mg and dissolved in 5 mL of ethanol. The solution was then diluted to obtain a series of concentrations, namely 50, 100, 150, 200, and 250 µg/mL. Each prepared solution was analyzed for absorbance using a UV–Vis spectrophotometer within wavelength ranges of 290–320 nm and 320–370 nm at 5 nm intervals. The obtained absorbance data were subsequently used to calculate the Sun Protection Factor (SPF), percentage of erythema transmission (%Te), and percentage of pigmentation transmission (%Tp) (Namirah & Qonitah, 2024).

2.4. Data Analysis

The effectiveness of a sunscreen product can be demonstrated, among other things, by its Sun Protection Factor (SPF) value. The SPF value of a sunscreen product can be measured in vitro using the following equation: (Damaranie Dipahayu, 2019).

SPF spectrophotometer = CF ∑320290 EE(E) X(E) XAB(E)

Notes:
CF : Correction factor
EE : Erythemal effect spectrum
I : Solar intensity spectrum
Abs : Sample absorbance

a. Absorbance is measured at wavelengths of 290, 295, 300, 305, 310, 315, and 320 nm.
b. The absorption values obtained are multiplied by the EE x I value for each wavelength.
c. The results of multiplying absorption by EE x I are summed.
d. The sum is multiplied by the correction factor, which is 10, to obtain the SPF value of the formulation.

The EE x I value is a constant. Its values for wavelengths from 290 to 320 nm and every 5 nm interval have been determined as shown in the table below: (Suhaenah et al., 2019).

To calculate the percentage of erythema transmission and the percentage of pigmentation transmission, the following equation can be used: (Furi et al., 2023).

a) $\%\,Te = \frac{\sum(T\ x\ Fe)}{\sum Fe}$

b) $\%\,Tp = \frac{\sum(T\ x\ Fp)}{\sum Fp}$

Notes:
Te : Percentage of erythema transmission
Fe : Erythema flux
Tp : Percentage of pigmentation transmission
Fp : Pigmentation flux.

3. RESULTS AND DISCUSSION

Excessive sun exposure can cause harmful effects on the skin, including erythema, pigmentation, and premature aging. The severity of these effects depends on factors such as the duration and frequency of exposure, the intensity of sunlight, and individual skin sensitivity (Anggraeni *et al*., 2024). When exposure exceeds the skin's natural protective capacity, additional protection is required, such as the use of sunscreen. Sunscreen is a formulation containing chemical compounds capable of absorbing, scattering, or reflecting ultraviolet (UV) radiation, thereby protecting the structure and function of the skin from its damaging effects (Oktaviasari & Zulkarnain, 2017). The effectiveness of sunscreen is commonly evaluated based on the SPF, percentage of erythema transmission (%Te), and percentage of pigmentation transmission (%Tp). The SPF value reflects the ability of a substance to protect the skin from UV radiation, with higher values indicating greater protection. The %Te represents the proportion of UV-B radiation (approximately 292–317 nm) transmitted through the sunscreen, indicating the potential to cause erythema or skin redness. Meanwhile, the %Tp indicates the transmission of UV-A radiation (320–375 nm), which is associated with skin pigmentation or darkening. One plant with potential as a natural sunscreen agent is kersen, particularly its flowers, which were used in this study. The research procedure involved sample collection through flower harvesting, followed by cleaning, drying, and processing into powder, which was subsequently extracted using the MAE method. The yield of extraction result shown in the **Table 1**.

Table 1. Cherry blossom (*Muntingia calabura* L) extraction based on MAE method

Sample	Extraction weight (gram)	Yield (%)
0.34 g	1 g	34

Samples of cherry blossom extract were prepared as test solutions in five concentration series, namely 50, 100, 150, 200, and 250 µg/mL, using ethanol as the solvent and blank (**Table 2**). The solutions were then measured for absorbance using UV-Vis spectrophotometry at wavelengths of 290–320, 292–317, and 320–370 nm with 5 nm intervals. The results obtained were then used to calculate the SPF value, erythema transmission, and pigmentation transmission.

Table 2. SPF values of cherry blossom extract (*Muntingia calabura* L) at several concentration levels.

Sample	concentration (µg/mL)	SPF value	SPF category
Sample of cherry blossom extract (*Muntingia calabura* L)	50	3.596	minimal
	100	11.488	maximal
	150	17.708	ultra
	200	17.995	ultra
	250	21.5	ultra

Description:
SPF strength classification (Warnida et al., 2024)
a. Minimum : SPF 2–4
b. Moderate : SPF 4–6
c. High : SPF 6–8
d. Maximum : SPF 8–15
e. Ultra : SPF ≥ 15

Based on the SPF measurement results using Mansur's equation, the SPF value of cherry blossom extract (*Muntingia calabura* L) at a concentration of 50 µg/mL is 3.596, which falls into the minimal protection category, meaning it provides very limited protection against UVB rays that cause sunburn. This means that sunscreen with an SPF of 3.596 will protect the skin for 30 minutes under direct sunlight. At a concentration of 100 µg/mL, the SPF value is 11.488, providing maximum protection against sunburn (sunburn caused by UVB rays) and causing little to no tanning (darkening of the skin due to UVB rays). This means that sunscreen with an SPF of 11.488 protects the skin for 110 minutes under direct sunlight, and a concentration of 150 µg/mL corresponds to an SPF value of 17.708, which falls into the ultra-protection category, offering higher protection against UVB rays that cause sunburn. This means that sunscreen with an SPF of 17.708 protects the skin for 170 minutes under direct sunlight, and a concentration of 200 µg/mL is 17.995 (*ultra protection*). meaning that sunscreen with an SPF of 17.995 protects the skin for 170 minutes under direct sunlight, and a concentration of 250 µg/mL yields an SPF of 21.5 (*ultra protection*), meaning that sunscreen with an SPF of 21.5 protects the skin for 210 minutes under direct sunlight. The higher the concentration used, the better the SPF value obtained. The classification of SPF categories is as follows: SPF 2–4 (minimal protection), SPF 4–6 (moderate protection), SPF 6–8 (extra protection), SPF 8–15 (maximum protection), and SPF ≥ 15 (ultra protection) (Warnida et al., 2024).

From the testing, the erythema transmission at concentrations of 50, 100, 150, 200, and 250 µg/mL were 38.03%, 11.17%, 2.29%, 2.37%, and 1.03%, respectively. The categories for evaluating sunscreen erythema transmission are as follows: <1 (sunblock), 1–6 (ultra protection), 6–12 (suntan), and 10–18 (fast tanning). Based on **Table 3**, the erythema

transmission value at a concentration of 50 µg/mL does not fall into the sunscreen category because the erythema transmission obtained is greater than 18%. This indicates that the extract cannot protect the skin from UV-B rays, while at a concentration of 100 µg/mL, it falls into the tanning category, meaning the sunscreen allows approximately 6% to 12% of UVB rays to penetrate the skin, so there is still sufficient exposure to cause tanning (skin darkening) but provides sufficient protection against erythema (redness or sunburn) and offers moderate protection suitable for normal skin that is not overly sensitive to sunlight. Concentrations of 150, 200, and 250 µg/mL fall into the ultra-category, meaning that the sunscreen or extract can absorb 94% to 99% of UVB rays (erythema transmission percentage between 1% and 6%), so only a small amount of UVB rays penetrate the skin. This protection effectively prevents erythema (skin redness caused by sunburn) (Sayuti, 2017).

Table 3. Erythema transmission value

Sample	Concentration (µg/mL)	Value transmission of erythema	SPF category
Sample of cherry blossom extract (*Muntingia calabura* L)	50	38.03%	-
	100	11.17%	suntan
	150	2.29%	ultra
	200	2.37%	ultra
	250	1.03%	ultra

Based on the results for pigment transmission values at concentrations of 50, 100, 150, 200, and 250 µg/mL (**Table 4**), the pigment transmission values obtained were 24.25%, 15.60%, 23.94% 23.40%, and 15.75%, which fall into the sunblock category, meaning they have the ability to provide complete protection for the skin from sun exposure.

Table 4. Pigmentation transmission value

Sample	Concentration (µg/mL)	Value transmission of pigmentation	Sunscreen categories
Sample of cherry blossom extract (*Muntingia calabura* L)	50	24.25%	sunblock
	100	15.60%	sunblock
	150	23.94%	sunblock
	200	23.40%	sunblock
	250	15.75%	sunblock

4. CONCLUSION

Based on the results of this study, it can be concluded that cherry blossom extract (*Muntingia calabura* L.) prepared using a green solvent exhibits significant sunscreen activity. At concentrations of 50, 100, 150, 200, and 250 µg/mL, the SPF values were 3.596 (minimal protection), 11.488 (maximum protection), and 17.708, 17.995, and 21.500 (ultra protection), respectively. The percentage of erythema transmission (%Te) decreased with increasing concentration, with values of 38.03% (no sunscreen activity), 11.17% (sunburn category), and 2.29%, 2.37%, and 1.03% (ultra protection), respectively. Similarly, the percentage of pigmentation transmission (%Tp) ranged from 24.25% to 15.75% across all concentrations, consistently falling within the sunblock category. Overall, the increase in extract concentration significantly enhanced SPF while reducing %Te and maintaining effective %Tp values, indicating that *M. calabura* flower extract has strong potential as a natural sunscreen agent.

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