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The Potential UV-B Filter of Gel Preparation Containing Ethanol Extract of Bidara Arab Leaf (*Ziziphus spina-christi*) Cultivated in Indonesia

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ABSTRACT

Bidara arab leaf (*Ziziphus spina-christi*) contains flavonoids, saponins, triterpenoids, alkaloids, steroids, and lipids that may act synergistically as natural UV filters. Flavonoids are highlighted for their ability to absorb UVA and UVB light, while other compounds may enhance photoprotection. Previous studies reported that its ethanol extract contains 1.53% flavonoids and exhibits strong antioxidant activity (LC_{50} = 90.96 ppm). To formulate gel preparations containing *Bidara Arab* leaf ethanol extract and evaluate their physicochemical properties, sun protection factor (SPF), and photoprotective efficacy against UV-B–induced erythema. The extract was incorporated into gel at concentrations of 2.5% (F1), 5% (F2), and 10% (F3). Physicochemical tests included organoleptic assessment, pH, viscosity, and spreadability. In vitro SPF was determined using UV-Vis spectrophotometry. In vivo testing involved UV-B–irradiated mice, and erythema was scored to assess protection. All gels met standard parameters (pH 5.34–6.51; viscosity 10.352–15.459 cP; spreadability 5.2–5.8 cm). SPF values were 19.26 (F1), 20.22 (F2), and 20.50 (F3), indicating medium UV-B protection. Erythema scores in all extract-treated groups were 0, with erythema areas of 0.50 mm^2, 0.38 mm^2, and 0.19 mm^2, respectively—significantly lower than in the blank gel (3.96 mm^2) and untreated control (7.51 mm^2) (p<0.01). Bidara arab leaf extract gel (2.5–10%) shows medium SPF protection and effectively prevents UV-B–induced erythema in mice. These findings support its potential as a natural sunscreen agent.

INTRODUCTION

Sunlight has benefits for humans, namely in the process of synthesizing Vitamin D, and can also kill bacteria. However, excessive exposure to sunlight over a long period can also damage the skin layer. About 10% of solar radiation is ultraviolet (UV) light which can cause sunburn and can penetrate the epidermis and dermis layers, thereby triggering premature aging of the skin (Nopiyanti & Wulandari, 2021). The harmful effects of ultraviolet (UV) exposure can be minimized by using sunscreen preparations that effectively absorb and reflect sunlight, thereby providing long-term benefits, particularly in preventing skin damage caused by free radicals and UV radiation (Wolf *et al*., 2003). Antioxidant qualities can be seen in natural sunscreens made from natural components such plant-based phenolic compounds. Flavonoids, which belong to the phenolic chemical group, have conjugated double bonds and chromophores that enable them to absorb UVA and UVB rays, making them potential candidates for sunscreen agents (Shovyana & Zulkarnain, 2013). Bidara arab leaf

has various types of secondary metabolite compounds, such as alkaloids, saponins, steroids, flavonoids, and lipids which have the potential to act as a sunscreen (Asgarpanah & Haghighat, 2012). Based on the results of research conducted by Kusriani dan Machter (2015), determining the levels of total phenolic compounds and antioxidant activity of bidara extracts, leaf, fruit, and seeds showed that the total phenolic levels in leaf extracts, fruit extracts, and seed extracts respectively were 7.192% ± 0.0198; 5.115% ± 0.0052; and 11.409% ± 0.0195. The LC50 values for the antioxidant activity of leaf extract, fruit extract, and seed extract were 127.87 ppm, 315.09 ppm, and 205.85 ppm. The extract that has the highest phenol content was seed extract with a content of 11.409% ± 0.0195. The extract that has the best antioxidant activity was leaf extract with an LC50 value of 127.87 ppm (Kusriani & Machter, 2015). Research conducted by Haeria and Andi (2016), concluded that the ethanol extract of Bidara arab leaf had a total flavonoid content of 1.5312% and had strong antioxidant activity because it is in the value range of 50-100 ppm with an LC50 value of 90.9584 ppm (Haeria & Andi, 2016). Apart from that, Murniyati *et al*. (2021) has also formulated and tested the anti-free radical activity of a Bidara arab leaf ethanol extract gel preparation using the DPPH method. Gel formulations containing Bidara arab leaf ethanol extract at concentrations of 4%, 5%, and 6% met the required standards for physical characteristics evaluation. These gel preparations were categorized as weak antioxidants, with LC_{50} values of 1679.874 ppm, 1203.636 ppm, and 998.736 ppm, respectively (Murniyati *et al*., 2021). Based on the potential of Bidara arab leaf this study will be-conducted to investigate the value of sun protection factor (SPF) of gel-containing Bidara arab leaf extract through in vitro and in vivo studies. It is hoped that the results obtained can be used as information for developing cosmetic products made from natural products.

METHODS

Materials

The materials used in this study were Bidara arab leaf (*Ziziphus spina-Christi*) taken a sample of leaves that are old obtained from Bukit Raya District, Pekanbaru, Riau, Indonesia, 70% ethanol, Aristoflex® AVC, glycerin, propylene glycol, nipagin, nipasol, aqua distillata obtained from pharmacy faculty and health science, Abdurrab University, and ICR strain mice aged 2 months and weighing 20-30 g. The equipment used was a pH meter (one Med) , Spectrophotometer (Thermo Scientific), Viscometer (Brookfield), calipers, and UV Lamp (Exotera) and other glass equipment.

Methods

Plant Determination

The bidara plant used in the study was identified at the Faculty of Biology at Riau University No: 472/UN19.5.1.1.3-4.1/TU.00.01/2023, spesies :Ziziphus spina-christi (L) Wild.

Extraction of Bidara arab leaf

Six kilograms of Bidara arab leaf were cleaned and diced. The air drying method was used to dry the sample. At room temperature (25°C), Bidara arab leaf was extracted using 70% ethanol solvents in a maceration process.To obtain a viscous extract, 750 grams of Bidara arab leaf were macerated with 3000 ml of 70% ethanol filter in a dark bottle at room temperature for 2x24 hours and evaporated using a rotary evaporator.

Preeliminary Phytochemical Screening of Extact Ethanol Bidara arab leaf

Following the procedures previosuly described, general test for the presence of alkaloids, tannins, saponin, flavonoids, triterpenoid and phenol (Kumalasari & Andiarna, 2020).

Formulation of Bidara arab leaf Extract Gel Preparation

Table 1. Bidara arab leaf Gel Formulation

Ingredients	Formula I	Formula II	Formula III
Bidara arab leaf	2.5 g	5 g	1 g
Aristoflex AVC	1.68 g	1.8 g	1.68 g
Glycerin	15 g	15 g	15 g
Propilen glikol	9.8 g	9.8 g	9.8 g
Nipagin	0.2 g	0.2 g	0.2 g
Nipasol	0.2 g	0.2 g	0.2 g
Aqua purificata	Ad100 g	Ad100 g	Ad100 g

The gel Bidara arab leaf was made into three different formulas with extract concentration ratios of 2.5%, 5%, and 10%, as shown in Table 1. Aqua purificata was added to the mortar,

followed by Aristoflex® AVC and stirring (mixture I). Nipagin and nipasol were combined in a glass beaker, then aqua purificata was added, the mixture was heated and homogeneously stirred until no coarse grains were visible, and glycerin and propylene glycol were added. Bidara arab leaf extract is added and thoroughly mixed (Mixture II). In a mortar, combine mixtures I and II and gently stir until a gel forms (Sumule *et al*., 2021).

Physicochemical Evaluation of Bidara arab leaf Extract Gel Preparation

The physicochemical evaluation included organoleptic, homogeneity, pH determination, gel spreadability, and viscosity. The organoleptic test has an impact on the acceptability of the preparation as well as the physicochemical change parameters. The organoleptic test's color, smell, and texture were visually observed. The color, scent, and texture of the organoleptic test were visually observed. The pH was measured using a digital pH meter, and visual inspection was used to check for homogeneity and the presence of coarse particles. The Brookfield Viscometer was used to determine viscosity, and weights were added after putting gel between two glass slides to determine gel spreadability (Saptarini & Hadisoebroto, 2020).

The Calculation of the Gel Preparation's SPF Value for Bidara arab leaf Extract

Table 2. EE and I constants for the calculation of *in vitro* SPF

λ (nm)	$EE(\lambda)x\ I\ (\lambda)$
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180

The extract's SPF value was determined in vitro using UV-Vis spectrophotometry within the UV-B range (290–320 nm), at 5 nm intervals, conducted in triplicate. The blank was a 70% ethanol solutuon. In a 10 mL volumetric flask, the preparation was weighed to 0.5 grams and dissolved in ethanol (Indriarini *et al*., 2021). The Mansur equation no 1 is used to calculate the SPF value, which is as follows:

$$SPF = \text{CF}\ \ x \sum_{290}^{320} EE\ x\ Ix\ Abs(\lambda) \qquad [1]$$

Where EE = Erythemal Effect Spectrum; I = Light Spectrum Intensity; Abs = Sunscreen Product Absorption; and CF = 10 (Correction Factor) (Natarajan *et al*., 2025) The constanta EE and I were pre-define according to Table 2.

In-Vivo Sunscreen Activity

The effects of erythema in animals were observed to allow to conduct the in vivo test. All protocols for handling these animal tests were approved by the ethics committee of Abdurrab University (number 107/KEP-UNIVRAB/X/2023). The six groups used in the animal tests were three rats in each of the following: positive control, negative control, and three treatment groups. Positive controls included commercial product gel spf and negative controls included basic gel. All mice were shaved 2x2 cm long, and the gel Bidara arab leaf formula (1 g/1.33 cm2) (Yanti Eff *et al*., 2018) was applied to such a site on the back surface mice. UVB irradiation was administered one hour after the mice were applied with the gel at a distance of 30 cm (Wulandari, 2017) for 1x48 hours using an uv lamp (Exo-terra) to achieve a UVB spectral radiance of 100 W/cm^2. The erythema score was calculated on a scale of 0 to 4. Score 0 indicates no erythema; score 1 indicates minor erythema (diameter ≤25.00 mm); score 2 indicates clearly defined erythema (diameter 25.10-30.00 mm); score 3 indicates medium erythema (diameter 30.10-35.00 mm); and score 4 indicates sever erythema (diameter≥35) (Yanti Eff *et al*., 2018).

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RESULT

Preeliminary phytochemical screening of extact ethanol Bidara arab leaf

Phytochemical Screening Test was conducted to qualitatively determine the metabolite compounds present in the extract. The tests carried out included: flavonoids, alkaloids, saponins, tannins, phenol, steroid tests. The results of extract ethanol Bidara arab leaf screening as shown in Table 3. Phytochemical screening of the ethanol extract of Bidara arab leaf revealed the presence of flavonoids, saponins, tannins, and triterpenoids, while alkaloids were not detected. These compounds may contribute to photoprotective effects: flavonoids act as UV absorbers and antioxidants; tannins and triterpenoids offer anti-inflammatory benefits; and saponins can enhance skin penetration and stability of formulations.

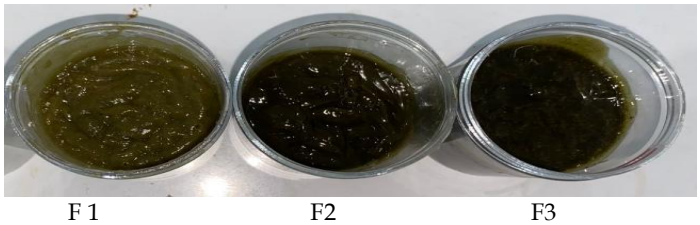
Table 3. Preeliminary Phytochemical Screening of Extact Ethanol Bidara arab leaf

No.	Identification	Reagents	Result
1	Flavonoid	Ethanol + FeCl3	Black color is formed (+)
2	Alkaloid	Mayer	No yellow precipitate forms (-)
		Dragendorff	No orange precipitate formed (-)
		Wagner	No brown precipitate forms (-)
		Bouchardat	No brown precipitate forms (-)
3	Saponin	Aquadest	Stable foam is formed (+)
4	Tannin	Boiled + FeCl3	A brownish green color forms (+)
5	Triterpenoid	CHCl3+H2SO4 (P)	A brown ring forms (+)

Note:
(+) indicates the presence of the compound
(–) indicates the absence of the compound

Physicochemical evaluation of Bidara arab leaf Extract Gel Preparation

The gel formulation containing Bidara arab leaf extract had a soft consistency, was dark green in colour, and smelled herbally. As revealed in Figure 1, the dark green colour of these gels follows the gel's colour, and Formula III exhibited a deeper and more intense green color than formulas II and I. The absence of coarse particles in the gel preparation indicated that the preparations were homogeneous. Table 4 presents the pH value, viscosity, and gel spreadability measurements.



F 1 F2 F3

Figure 1. Physical appearance of Bidara arab leaf Extract Gel Preparation

Table 4. Physical and chemical characteristics of Bidara arab leaf extract gel preparation

Formula	Colour	Homogenity	pH	Viscosity (cPs)	Spreadability (cm)
I	Dark green	Homogenous	5,336±0.194	15459±380.02	5,2 ± 0.264
II	Dark green	Homogenous	5,599±0.068	14948±374,73	5,566 ± 0.305
III	Dark green	Homogenous	6,512±0.128	10352,33±96,11	5,833 ± 0.416

The pH, viscosity, and dispersion values of the different Bidara arab leaf Extract Gel Preparation concentrations FI (2,5% extract ethanol Bidara arab leaf), FII (5% extract ethanol Bidara arab leaf), and FIII (10% extract ethanol Bidara arab leaf) were all different. As revealed in Table 4, no significant difference in pH value was observed throughout all concentrations of Bidara arab leaf extract gel preparation. The pH values of the Bidara arab leaf extract gel formulations were within the acceptable range for skin tolerance (4–7) and complied with the pH requirements for sunscreen products (Kusriani & Machter, 2015). The viscosity values of the gel preparations were within the acceptable range for topical gels, which typically range from 2000 to 40000 cP (SNI 16-4399-1996).

According to the measurements, the viscosity of all formulations Bidara arab leaf extract gel preparation fits into the viscosity range. The spreadability of gel preparations is defined as the gel's ability to spread through the skin's surface. When applied to the skin, good spreadability enables the diffusion of a gel; good spreadability differs across 5-7 cm (Saryanti & Zulfa, 2017). Formula I had the lowest spreadability value, which increased with the addition of the ethanol Bidara arab leaf extract. The spread test results for Bidara arab leaf extract gel preparation show a value of 5.2–5.8 cm (Table 4), indicating that gel all formulas have high spreadability.

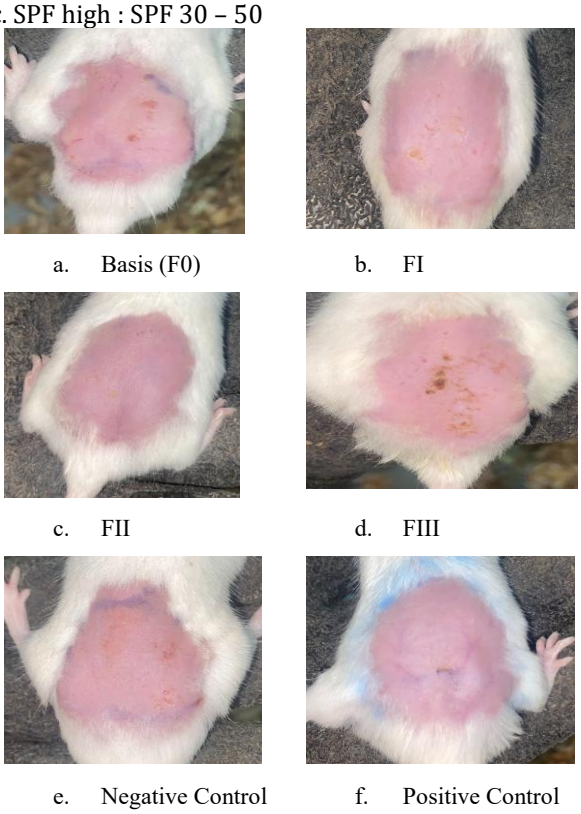
Determination SPF Value and UV protection effectivity test Bidara arab leaf extract gel preparation

Table 5 shows the results of the SPF value measurement, the protected categories of Bidara arab leaf extract gel preparation, and the erythema in vivo sunscreen activity use score. Scores of erythema are shown in Table 6. Statistical analysis showed a significant difference in erythema area between the groups (p = 0.001). This indicates that the application of Bidara arab leaf extract gel significantly reduced erythema formation compared to the negative and base controls, demonstrating its photoprotective effect against UV-B radiation.

Table 5. SPF Value Bidara arab leaf extract gel preparation

Formula (50.000 ppm)	Value SPF	Protection Categories
I	19,263	Medium
II	20.221	Medium
II	20.504	Medium

Information: Classification SPF (Anderson, 2011)
a. SPF low: SPF 2 - 11
b. SPF medium: SPF 12 - 29
c. SPF high : SPF 30 – 50



a. Basis (F0) b. FI
c. FII d. FIII
e. Negative Control f. Positive Control

Figure 2. Erythema formation on dorsal skin of mice after UV-B exposure. (a) Base gel (without extract) shows mild erythema (reddish area); (b) F1 (2.5% extract), (c) F2 (5%), and (d) F3 (10%) show no visible erythema; (e) Negative control (no gel) shows prominent erythema (broad reddish lesion); (f) Positive control (commercial sunscreen) shows no visible erythema.

Table 6. Erythema degree score in each treatment group

Formula	The average erythema area	Score of Erythma	Sig
F0	3.964 ± 2.32	1	
F1	0.4985 ± 0.17	0	
F2	0.3802 ± 0.11	0	0.001
F3	0.1877 ± 0.25	0	
Negative Control	7.511 ± 5.16	1	
Positive Control/Commercial Product	0.3582 ± 0.24	0	

DISCUSSION

The increasing preference for natural-based sunscreens stems from public perception that herbal ingredients are safer and have fewer side effects than synthetic chemicals (Hendrawati *et al*., 2020). Bidara (*Ziziphus spina-christi*) leaf extract, known to contain flavonoids, saponins, tannins, and triterpenoids, offers promising potential as a natural photoprotective agent. Although this study did not directly measure antioxidant capacity, previous research has shown that Bidara arab leaf extract has strong antioxidant activity with an LC_{50} value of 90.96 ppm (Haeria & Andi, 2016), and the presence of flavonoids was confirmed through phytochemical screening.

The gel formulations containing 2.5%, 5%, and 10% Bidara arab leaf ethanol extract achieved SPF values of 19.26, 20.22, and 20.54, respectively. These results fall within the medium protection category (SPF 12–30), as defined by the FDA monograph (Golmohammadzadeh *et al*., 2011). The SPF values were relatively close between concentrations, indicating that increasing the extract concentration above 2.5% does not significantly enhance UV-B protection. This suggests that the minimum effective dose may already be achieved at 2.5%, which is advantageous from both cost and formulation perspectives. In vivo testing confirmed that Bidara arab leaf gel preparations at all tested concentrations prevented erythema formation following UV-B exposure (290–320 nm), with erythema scores of 0. This indicates the gel's photoprotective efficacy, likely mediated by the presence of bioactive compounds such as flavonoids, which are known to absorb UV radiation and inhibit inflammation pathways.

The protective effect is likely mediated by the extract's phenolic content, especially flavonoids, which can absorb UV radiation in the 290–400 nm range due to their aromatic ring structures (Cefali *et al*., 2016). Additionally, flavonoids are known to inhibit key inflammatory pathways triggered by UV-B exposure, including the downregulation of NF-κB, COX-2, and pro-inflammatory cytokines such as IL-1 and TNF-α (Dewanti *et al*., 2020; Panche *et al*., 2016). This dual function as both UV filter and anti-inflammatory antioxidant supports the observed prevention of erythema in the treated groups. Supporting this Shnawa *et al*., (2022) demonstrated that *Ziziphus spina-christi* extract possesses strong antioxidant capacity through hydrogen peroxide scavenging and contributes to the bioreduction of metal ions in nanoparticle synthesis. The extract's rich phenolic content, including flavonoids, was shown to protect cells from oxidative stress, indicating broader biomedical potential beyond photoprotection. The ability to counteract reactive oxygen species (ROS) further strengthens the rationale for its use in topical formulations exposed to UV radiation. Although this study did not include molecular analysis or histopathological observation, the absence of erythema and the moderate SPF values provide strong preliminary evidence of photoprotective activity. Further research is recommended to explore antioxidant quantification, UVA protection, and long-term formulation stability to support product development using *Ziziphus spina-christi* as a natural sunscreen agent.

CONCLUSIONS

The gel preparations containing *Bidara* arab (*Ziziphus spina-christi*) leaf ethanol extract at concentrations of 2.5%, 5%, and 10% were confirmed to be effective as sunscreen agents. These concentrations refer to the amount of extract contained in the gel formulation. The SPF values obtained from the in vitro test were 19.263, 20.221, and 20.504, respectively, which fall into the medium protection category. In vivo testing also showed that all three formulas did not induce erythema and effectively inhibited the acute effects of UV-B exposure, indicating good photoprotective potential.

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AUTHORS' CONTRIBUTIONS

Dini Mardhiyani: Conceptualization, methodology, data analysis, writing – original draft. Aswatul Ulya: Investigation, data curation, and writing – review & editing. Eni Yanti Wulan Desri: Supervision, validation, and resources. Gendis Purno Yudanti: Formal analysis and visualization. Muslim Suardi: Project administration and literature review. Vonny Kurnia Utama: Data collection and statistical analysis. Kony Putriani: Laboratory work and formulation development. Isna Wardaniati: In vivo testing and ethical approval coordination.

CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICAL CONSIDERATION

This study involving animal testing was conducted following ethical guidelines and approved by the ethics committee of abdurrab university with approval number 107/kep-univrab/x/2023. All procedures were carried out to minimize animal suffering and followed standard laboratory animal care protocols.

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