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Research Article

In Vitro Determination of Sun Protection Factor of Water Extract of *Aerodramus fuciphagus* from Central Kalimantan

Dita Ayulia Dwi Sandi [1*]
Eka Fitri Susiani [1]
I Ketut Adnyana [2]
Pratiwi Wikaningtyas [2]

[1]Department of Pharmacy, Sekolah Tinggi Ilmu Kesehatan Borneo Lestari, Banjarbaru, South Kalimantan, Indonesia

[2]Department of Pharmacology-Clinical Pharmacy, Bandung Institute of Technology, Bandung, West Java, Indonesia

[*]email:
ditaayulia@stikesborneolestari.ac.id

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Sun Protection Factor
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Abstract

Sunscreen is a cosmetic substance that has the ability to reflect or absorb sunlight actively. It can prevent skin irritation due to UV rays. One of the natural ingredients with a sunscreen effect is the Edible-nest swiftlet's (*Aerodramus fuciphagus*) nest (ESN). This study aimed to determine the value of the sun protective factor (SPF) of the ESN water extract. The ESN water extract solution with variation concentration, this is 2000, 2500, 5000, 6000, and 7000 ppm, were measured by spectrophotometric UV-Vis at wavelength 290-375 nm with 5 nm intervals to determine the value of SPF, percentage of erythema transmission (%Te), and percentage of pigmentation transmission (%Tp) of ESN water extract. The result showed that the ESN water extract's SPF values at the concentration 2000, 2500, 5000, 6000, and 7000 ppm were 7.80; 9.68; 18.75; 20.58; and 22.24. The value of %Te of each concentration were 15.60±0.19; 10.03±0.42; 1.24±0.04; 0.81±0.01 and 0.56±0.01. While the value of %Tp of each concentration was showed the sunblock category. In conclusion, the ESN water extract from Central Kalimantan at the concentration of 6000 ppm has potential in ultraviolet protection against the skin in the ultra category with sunblock category mechanism. Further, it can be developed into sunscreen cosmetics from natural ingredients.

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INTRODUCTION

The effect of sunlight (UV light) on the skin will damage cells, causing wrinkles, causing skin color and texture change. The negative effect of sunlight can be reduced by using sunscreen[1]. Sunscreen is a cosmetic substance that has functions to reflect or absorb sunlight. It can prevent skin irritation due to UV rays[2]. Sunscreens can absorb sunlight at a wavelength of 290–320 nm for UVB about 85% but can reflect sunlight at a wavelength of more than 320 nm for UVA[3]. The active ingredients of sunscreens in FDA-approved are generally inorganic and organic. The primary inorganic materials in use are zinc oxide (ZnO) and titanium dioxide (TiO_2), but they are photostable and require much application to achieve maximum effect[4]. Meanwhile, benzophenone is a UVA organic material that protects against UV B and UVA. However, benzophenone is photolabile, and its oxidation can disrupt the antioxidant system[5]. Other materials of natural origin can be used; one of them is an edible bird's nest.

Edible-nest swiftlet's nest (ESN) has been used traditionally in Asia for their health benefits. Produced by swallow species (*Aerodramus fuciphagus*), it is commonly found in Asian countries such as Thailand, Indonesia, and Malaysia[6]. Indonesia is the largest ESN-producing

country. Several regions in Indonesia, especially Sumatra and Kalimantan, have a high quality of the ESN[7]. Edible-nest swiftlet's nest is commonly used as an antioxidant, anti-inflammatory, and cosmetic8. Several studies showed ESN as a tonic stimulant effect and accelerate wound healing in diabetes mellitus patients[9-11].

A sunscreen contains compounds that can protect the skin from the adverse effects of sunlight[12]. One of the sunscreen mechanisms to protect the skin from the negative effect of sunlight is to inhibit the production of free radicals caused by UV rays and prevent endogenous antioxidants[13]. The ESN water extract could increase the activity of the enzyme superoxide dismutase (SOD), which can neutralize free radicals[14]. Superoxide dismutase is an endogenous enzymatic antioxidant with a very strong effect as a body defense against free radicals[15]. This study aimed to determine the value of the sun protective factor (SPF) of the ESN water extract.

MATERIALS AND METHODS

Materials

Edible-nest swiftlet's nest from Central Kalimantan was determined as *Aerodramus fuciphagus* from Research Center for Biology, Indonesian Institute of Sciences (No. 2400/IPH.1.02/KS.02.03/VII/2019), distilled water (Bratachem), double-distilled water (Brataco), and sucrose (Merck).

Methods

Each of 250 g of the ESN (**Figure 1**) was dissolved in 7.4 L of double-distilled water. They were homogenized by stirring for 30 minutes and then heated for 30 minutes at 45°C. The solution was filtered using filter paper. The filtrate was freeze-drying (lyophilization) with freeze-dry (Eyela®) until the ESN water extract was obtained, that was 10.8 g (4.3165%).

Figure 1. Edible-nest swiftlet's nest from Central Kalimantan

The ESN water extract was made at the concentration of 2000, 2500, 5000, 6000, and 7000 ppm using distilled water. The test concentration selection was based on the preliminary test results. The small concentration was used showed a very small SPF value and did not have the potential to be developed as a sunscreen, whereas if the large concentration were used would not be efficient in using research materials.

Determination of SPF value, percentage of erythema transmission (%Te), and percentage of pigmentation transmission (%Tp) were measured sample absorbance using spectrophotometer UV-Vis (PG Instruments Limited®) at wavelength 290-375 nm with interval 5 nm. The sample absorbance was multiplied by EE x I for each interval. The value of EE x I for each interval can be seen in **Table I**. Meanwhile, to determine the SPF value, the following **Formula 1** is used:

$$\mathrm{SPF} = \mathrm{CF}\ X\ \sum_{290}^{320} \mathrm{EE}\ (\lambda) \times \mathrm{I}\ (\lambda)\ \times \mathrm{ABS}\ (\lambda) \ldots [1]$$

CF = Correlation Factor (10); EE = Erythema Efficiency; I = Solar Simulation Spectrum

Table I. The EE x I value at wavelength 290-320 nm

Wavelength/λ (nm)	EE* x I
290	0.02
295	0.08
300	0.29
305	0.33
310	0.19
315	0.08
320	0.02
Total	**1**

*EE = erythemal effect

The %Te and %Tp values for each concentration of ESN water extract were determined using Formula **2**, **3**, and **4**.

$$A = -log\ T \ldots [2]$$

A = absorbance; T = transmission value

$$\%\ (Te) = \frac{\sum Ee}{\sum Fe} = \frac{\sum(T \times Fe)}{\sum Fe} \ldots [3]$$

$$\%\ (Tp) = \frac{\sum Ep}{\sum Fp} = \frac{\sum(T \times Fp)}{\sum Fp} \ldots [4]$$

T = Transmission
Fe = erythema flux at a certain wavelength
Ee = The amount of erythema flux that is continued by sunscreen
Fp = Pigmentation flux at a certain wavelength
Ep = The amount of pigmentation flux that sunscreen continues.

RESULTS AND DISCUSSION

Sun Protection Factor was defined as an indicator that describes a substance's effectiveness to protect skin from UV rays. This value describes a sunscreen's ability to a protective effect on the skin from UV rays[16]. The SPF value of ESN water extract could be seen in **Table II**. The concentration of 2500; 5000; 6000, and 7000 ppm of ESN water extract had the ability as sunscreen in the maximum and ultra category. The lowest concentration of ESN water extract had the ability as sunscreen in the ultra category was 5000 ppm has an SPF value of 18.75 means that the sunscreen can protect the skin for 18.7 x 10 minutes = 187 minutes from the UV light. The highest concentration of ESN water extract had the ability as sunscreen in the ultra category was 7000 ppm has an SPF value of 22.24 means that the sunscreen can protect the skin for 22.2 x 10 minutes = 222 minutes from the UV light. The higher concentration, the higher the SPF value of ESN water extract (**Figure 2**).

Table II. The value of SPF of ESN water extract

λ (nm)	EE x I	EE x I x Absorbance (ppm)				
		2000	2500	5000	6000	7000
290	0.02	0.02± 0.2x10^{-7}	0.02± 3.6x10^{-7}	0.04± 1.9x10^{-7}	0.04± 0.5x10^{-7}	0.04± 0.9x10^{-7}
295	0.08	0.08± 4.5x10^{-7}	0.09± 0.6x10^{-5}	0.18± 4.5x10^{-7}	0.2± 0.6x10^{-6}	0.21± 0.2x10^{-5}
300	0.29	0.24± 0.6x10^{-5}	0.30± 6.1x10^{-5}	0.59± 4.8x10^{-5}	0.63± 0.3x10^{-5}	0.7± 0.6x10^{-5}
305	0.33	0.25± 0.6x10^{-5}	0.31± 6.9x10^{-5}	0.6± 1.6x10^{-5}	0.67± 0.3x10^{-5}	0.72± 0.1x10^{-4}
310	0.19	0.13± 0.2x10^{-5}	0.16± 0.2x10^{-4}	0.31± 0.7x10^{-6}	0.35± 0.6x10^{-5}	0.36± 0.3x10^{-5}
315	0.08	0.05± 0.3x10^{-6}	0.07± 0.3x10^{-5}	0.13± 1.8x10^{-5}	0.15± 0.7x10^{-6}	0.15± 0.9x10^{-7}
320	0.02	0.01± 0.3x10^{-7}	0.01± 0.9x10^{-7}	0.03± 0.5x10^{-7}	0.03± 0.8x10^{-8}	0.03± 0.2x10^{-7}
SPF		7.8± 0.05	9.68± 0.18	18.75± 0.06	20.58± 0.03	22.24± 0.06
Ability		**Extra**	**Maximal**	**Ultra**	**Ultra**	**Ultra**

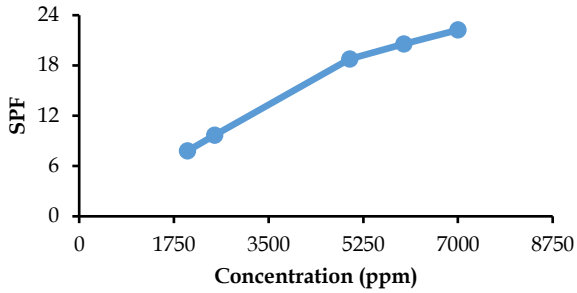

Figure 2. Sun Protection factor of the ESN water extract

The ESN contains epidermal growth factor (EGF); when binds to the epidermal growth factor receptor (EGFR), it would increase the formation of protein skeletons and activate STAT5B through translocation of the nucleus pathway to make the protein formation process occurred[8,17]. The protein that was formed would be hydrolyzed into peptides. Peptides consist of a series of amino acids that acted as antioxidants due to the presence of phenol groups in amino acids[18]. Phenol compounds had potential as sunscreens because of chromophore groups that could absorb ultraviolet, reducing their intensity on the skin[19]. The ESN water extract could increase the activity of the enzyme SOD, which could neutralize free radicals. Superoxide dismutase was an endogenous enzymatic antioxidant with a very strong effect as a body defense against free radicals[20,21]. One of the mechanisms of sunscreen to protect the skin from the harmful effects of sunlight was by absorbing UV of sunlight[22].

Natural chemicals like polyphenols (flavonoids, tannins), carotenoids, anthocyanidins, few vitamins, fixed oils, volatile oils from vegetables, fruits, medicinal plant parts (leaves, flowers, fruits, berries), algae, and lichens were more effective than synthetic chemicals which were due to their long term beneficial effects especially against free radical generated skin damages along with UV-rays blocking. All of these possess strong antioxidant activity. Most of them had moisturizing and cooling (aloe vera juice, fixed oils), antimicrobial (volatile oils), wound healing and anti-inflammatory (polyphenols like

curcumin), anticancer (tannins and resveratrol), anti-aging or cell rejuvenating (anthocyanidins, carotenoids, vitamins) type of activities too[23]. The ESN water extract had a moisturizing and whitening effect, including wound healing, based on our previous research[11,24].

The SPF values from other natural chemical like volatile oils were between 1 and 7. Peppermint oil (SPF 6.688) and tulsi oil (SPF 6.571) had the best SPF values[25]. One of the ingredients of animal origin was propolis extract; propolis was collected by bees from plants and then mixed with their saliva. Based on the research of Sinala and Salasa[26], the ethanol extract of propolis had a minimum level of protection from UV at a concentration of 400 ppm (SPF value 2.8108) and ultra protection level at a concentration of 1800 ppm (SPF value 16.465). The ESN water extract had an ultra protection level at a concentration of 5000 ppm (SPF value 18.75± 0.06) (**Table II**).

The value of %Te and %Tp of ESN water extract could be seen in **Table III**. The value of %Te of ESN water extract was defined as an indicator to determine erythema in skin due to the effect of UV light. While, the value of %Tp of ESN water extract was defined as an indicator to determine the change in skin color due to the effect of UV light[27].

The ESN water extract concentration of 2000 ppm had the mechanism as sunscreen in the fast tanning category, which means it had the smallest ability to absorb UV B and UV A rays. The ESN water extract concentration 2500 ppm had the mechanism as sunscreen in the sun tanning standard category, which means it could absorb at least 85% of UV B radiation and absorb a little UV A. While, the ESN water extract concentration 5000 ppm had the mechanism as sunscreen in the extra protection category, means it could protect the skin by absorbing 95% of UV B radiation so that it further protects the skin from the causes of skin erythema. The higher concentration, the lower the %Te and %Tp value of ESN water extract (**Figure 3**). The ESN water extract concentration 6000 and 7000 ppm had the mechanism as sunscreen in the sunblock category, which means it could protect the skin from UV radiation which causes erythema and pigmentation.

Table III. The value of %Te and %Te of ESN water extract

Concentration (ppm)	% Te	Category	% Tp	Category
2000	15.61± 0.19	Fast tanning	34.64± 0.25	Sunblock
2500	10.03± 0.42	Suntan standard	26.61± 0.56	Sunblock
5000	1.24± 0.04	extra protection	8.17± 0.11	Sunblock
6000	0.81± 0.01	Sunblock	5.6± 0.06	Sunblock
7000	0.56± 0.01	Sunblock	5.54± 0.01	Sunblock

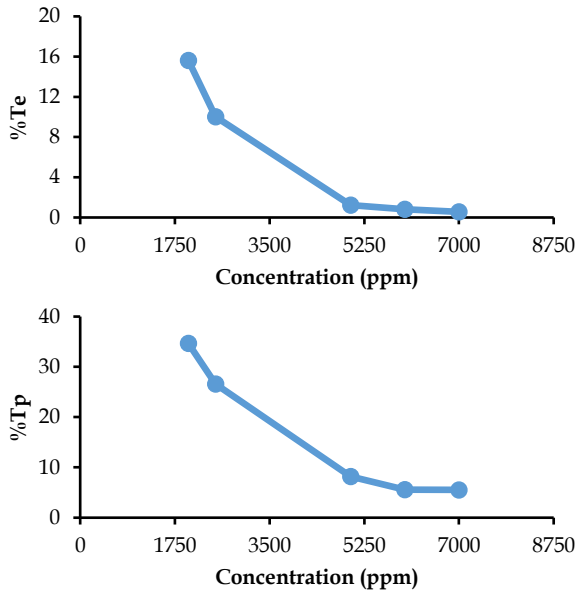

Figure 3. %Te and %Tp value of the ESN water extract

CONCLUSION

The ESN water extract from Central Kalimantan at the concentration 6000 ppm have potential in ultraviolet protection against the skin in the ultra category with sunblock category mechanism, and for further can be developed into sunscreen cosmetics from natural ingredients.

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AUTHORS' CONTRIBUTION

Dita Ayulia Dwi Sandi: Conceptualization, data curation, investigation, formal analysis, writing - original draft. **Eka Fitri Susiani**: Methodology, project administration, validation, writing - review & editing. **I Ketut Adnyana**: Supervision, Writing - review & editing. **Pratiwi Wikaningtyas**: Resource, Writing - review & editing.

DATA AVAILABILITY

All data are available from the authors.

CONFLICT OF INTEREST

There are no conflicts of interest.

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