



# Sunscreen Activities of Bark *Artocarpus heterophyllus* against Ultraviolet Ray (Sun Protection Factor) in Lotion Formula

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## Abstract

Sunscreen lotion is used to prevent the skin from ultraviolet radiation, which can cause various diseases, such as acne, burning, redness, swelling, wrinkling, and skin cancer. Natural sunscreen lotions contain chemical compounds that have relatively long conjugated double bonds or the presence of hydroxyl groups. The result of the maceration of *Artocarpus heterophyllus* bark produced ethanol and methanol extracts, based on gas chromatography-mass spectrometry characterization, both extracts contained straight and cyclic chain compounds which had conjugated double bonds. The number of double-bonded compounds in ethanol extract is more than in methanol extract. Sun protection factor (SPF) value of ethanol extract lotion formula is greater than SPF value of methanol extract lotion formula, the SPF value ethanol extract lotion formula at concentration 2; 2.5; 5; 7.5; and 12% were consecutive:  $29.801 \pm 0.224$ ;  $32.797 \pm 0.161$ ;  $33.808 \pm 0.165$ ;  $34.580 \pm 0.295$ ; and  $35.015 \pm 0.169$ , (SPF value of negative control:  $0.435 \pm 0.2839$  and positive control,  $31 \pm 0.0284$ ). SPF value of methanol extract lotion formula for concentration 2; 2.5; 5; 7.5; and 12% was  $14.407 \pm 0.010$ ;  $26.549 \pm 0.476$ ;  $30.274 \pm 0.208$ ;  $32.031 \pm 0.302$ ; and  $31.942 \pm 0.324$ . Each extract SPF value is higher than the SPF value of the lotion formula. The result of testing the physical properties of the lotion formula shows that the lotion type is o/w, the lotion viscosity ranges from 2450 cP to 4780.0 cP meet Standar Nasional Indonesia (SNI) standards. The pH test results ranged from 6.020 to 7.845 meets SNI. The spreading power of the lotion ranges from 4.70 to 6.75 cm. The adhesive strength of the lotion ranges from 16 to 41 s.

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Keywords: Sunscreen; *Artocarpus heterophyllus*; Sun protection factor; Lotion

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## Introduction

Skin is the first protector system of the human body from the external threat. However, in excess level, the system can be broken [1]. The high exposure on the external body by heavy metal [2], [3], pathogen [4], [5], and radiation [6] can impair the skin protector. In a tropical country like Indonesia, the exposure of sunlight radiation is inevitable. The sun shines throughout the year. Even in summer, it shines brightly until the temperature reaches 36°C. This hot weather can cause skin dehydration which can have an impact on the skin that becomes dry and prone to sunburn.

Sunlight consists of various electromagnetic radiation, one of which is ultraviolet, which can excite electrons in the skin material from the ground state to the excitation state [7]. This induces the formation of abnormal tissue and ravages a skin protection system. There are several diseases that are caused by skin protection disorder that are eczema [8], rash, dermatitis [9], [10], skin cancer [11], and so on. To avoid the diseases caused by ultraviolet exposure, the skin needs to have external protection, sunscreen.

Sunscreen is one product that has the ability to absorb or reflect sunlight and protect the body

from sunburn [12]. Lotion can moisturize the skin, prevent scaly, and dull skin also prevent the danger of ultraviolet (UV) A and UV B for skin health. Because of the sensitivity, the active compound to use in the product that is applied in skin media should be natural. The natural product offers a good choice. It has no side effects, safer [12], and green chemistry [13]. Moreover, the natural product also provides many medicinal benefit such as antibacterial [14], [15], [16], antimicrobial [17], antibiofilm [18], antipyretics [19], dental therapeutic treatment [20], wound healing [21], and antioxidant [22]. The use of synthetic active ingredients, in addition to being able to stimulate the skin resulting in irritation, can cause other things, including disruption of the nasal mucous membranes, cancer, nerve cells, and other disorders [22].

In sunscreen purposes, antioxidant ability plays an important role in the photoprotective activity. The active compound needs to have conjugated double bonds or hydroxyl groups. One of the plants containing these characters is *Artocarpus heterophyllus* plants [23]. *A. heterophyllus* has several pharmaceutical values. The leaves are traditionally used as medicine for wounds. The stem is used to cure anemia, asthma, dermatitis, diarrhea, cough, and as expectorants [24]. The roots are used to treat skin diseases and asthma, fever, diarrhea [25], fungal infections, and skin disorders [26].

The ethanol extracts of *A. heterophyllum* showed the antioxidant activity to capture free radicals with inhibition concentration 50% (IC<sub>50</sub> is 410 µg/ml). This provides a photoprotective ability of a sunscreen to prevent disease. The extract also showed a tyrosinase inhibitor activity. This finding provides an additional benefit as a skin lightening agent [27], [28], [29], [30].

There are several sunscreen products found in the market, which are lotion, gel, spray, foam, and stick, but the lotion form is the best one. This form can also be functioned as a skin moisturizer. Furthermore, it is applicable because it is not dense [31]. In this research, *A. heterophyllum* bark extract was used as an active material to make sunscreen. The compound in the extract was identified by gas chromatography-mass spectrometry (GC/MS). The sun protection factor (SPF) determination was used as an indicator of sunscreen ability.

## Materials and Methods

### Plant material

*A. heterophyllum* bark taken in Lhoknga Aceh Besar District, Indonesia. Lotion-making material (cetyl alcohol, stearic acid, lanolin, glycerin, methylparabens, triethanolamines, and aqua distillates), n-hexane, ethanol 96%, and methanol, reagents for phytochemicals (Liebermann–Burchard, Dragendorff, etc.), purchased from the Rudang store in Medan, North Sumatra.

### Spectroscopic investigation

Characterized of the extract was measured using a Shimadzu of GC-MS QP 2010 Ultra, electric balance (Mettler Toledo, Japan), spectrophotometer of 1240 Shimadzu UV-VIS mini, rotary evaporator, pH meter 710 A Thermo electron Orion, Thermo scientific HAAKE Viscotester C Viscometer, scatter power test equipment, and glassware.

### Phytochemical screening

The method used for testing the phytochemicals can be found in phytochemical methods, a guide to modern techniques of plant analysis [31].

### Extraction of ethanol extract and methanol extract from *A. heterophyllum* stem bark

The amount of 1725 kg of dry *A. heterophyllum* bark samples was mashed and macerated with solvents. This research uses two solvents, namely, ethanol and methanol, ethanol solvent will extract the semipolar compounds, while methanol solvent extracts polar compounds. Maceration is done for 3 × 24 h,

then the extract is filtered and concentrated using a rotary evaporator. The results of the maceration of *A. heterophyllum* bark using ethanol solvent obtained ethanol extract as much as 27 g (1.56%) and methanol extract as much as 12 g (0.69%). The ethanol extract and methanol extract were characterized by GC-MS, the sunscreen activity was tested by measuring the SPF, then the physical properties were tested.

### Making formula lotion from ethanol extract and methanol extract of *A. heterophyllum* bark

Ethanol extract lotion formula and methanol extract lotion formula, from *A. heterophyllum* bark extract with cetyl alcohol, stearic acid, lanolin, glycerin, triethanolamine, methylparaben, and aqua ad 100, are in Table 1.

**Table 1: The formula of lotion preparation (with modification) [32], [33]**

No	Material	Composition (%)				
		0.5	0.5	0.5	0.5	0.5
I	Cetyl alcohol	0.5	0.5	0.5	0.5	0.5
	Stearic acid	3	3	3	3	3
	Lanolin	1	1	1	1	1
II	<i>Artocarpus heterophyllum</i> stem bark extract	2	2,5	5	7,5	12
	Glycerin	2	2	2	2	2
III	Methylparaben	0.1	0.1	0.1	0.1	0.1
	Triethanolamine	0.75	0.75	0.75	0.75	0.75
	Aquades	90.65	90.15	87.65	85.5	80.65

Weighed all the necessary ingredients, part (I, from Table 1), materials are inserted into a porcelain cup and is melted over a water bath to a temperature of 70°C. Part (II, from Table 1) is dissolved in hot Aqua. Then, part (III) is inserted in porcelain in a hot state, then added part (I) into section (II) with constant stirring until the temperature drops. At 45°C added ethanol and methanol extract with concentration: 2; 2,5; 5; 7.5; and 12% [34] that has been mixed with glycerin (II, from Table 1) while stirring until homogeneous. It is then fed into the appropriate container [35].

### Measurement of SPF value

The method for the absorption of sunscreen agents is determined based on spectrophotometric analysis [36]. A lotion sample weighing 0.5 g is dissolved in 25 mL 96% ethanol (20,000 ppm). The absorbance of samples was measured with a UV spectrophotometer every 5 nm over a wavelength range of 290 nm–320 nm with 96% ethanol as a blank. Calculation of SPF values according to using the following equation [37]. The result of calculation SPF values showed in Table 2.

**Table 2: Relationship between erythemogenic effect and radiation intensity at each wavelength**

Wavelength (nm)	EE × I
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180
Total	1

$$SPF = CF \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times A(\lambda)$$

Where: Erythema Effectiveness (EE) – erythema effect spectrum; I – solar intensity spectrum; Abs – absorbance of sunscreen product; CF – correction factor (= 10). The values of EE × I are constants [36].

### Testing the physical properties of the lotion

Tests for physical properties of lotions include tests for lotion type, spreadability, stickiness viscosity, and pH.

### Lotion type test

The type of emulsion of a pharmaceutical preparation is classified as o/w (oil in water) if the preparation has an electrical conductivity marked by the movement of the ampere meter needle which has a deviation while the preparation which does not provide a deviation of the needle in the ampere meter and does not produce an electric current is classified into type emulsion o/w [38].

### pH test

The pH test of the lotion was carried out using a pH meter that had been calibrated with an equimolar buffer of pH 7 and a potassium hydroxy phthalate buffer of pH 4. The electrodes were dipped in preparations that had been diluted with distilled water (1 part lotion diluted with 9 parts distilled water), indicated by the pH meter. The pH measurement of the lotion is carried out using a pH meter 710 A + Thermo electron corporation Orion.

### Viscosity test

The value of viscosity will affect the spread of formulations on the skin [39]. The lotion viscosity was measured using a Thermo Scientific HAAKE Viscotester Viscometer C.

### Scattering test

Lotion weighing 0.5 g is placed in the middle of a large round glass. On top of the lotion is placed another round glass and ballast so that the weight of the round glass and ballast is 100 g, allowed to stand for 1 min, then note the distribution diameter.

### Adhesion test

A total of 0.2 g of lotion formulation is placed on a glass plate preparation. The other glass plate was pressed together on the glass that had been given

lotion until it was fused and placed with a weight of 50 g for 5 min [40].

## Results and Discussion

### Phytochemical testing

Phytochemical testing is carried out on the presence of triterpenoids, steroids, flavonoids, alkaloids, and saponins. The phytochemical test results of ethanol extract and methanol extract can be seen in Table 3.

**Table 3: Phytochemical test results of fresh stem bark, ethanol extract, and methanol extract of bark *Artocarpus heterophyllus***

Secondary metabolites	Testing method	Fresh bark	Methanol extract	Ethanol extract	Characteristics
Alkaloids	Mayer's reagent	+	+	+	Red sediment Chocolate deposition brown sediment
	Wagner's reagent	+	+	+	
Steroids	Dragendorff reagents	+	+	+	Sediment Red
	Liebermann–Burchard reagent	–	–	–	
Triterpenoid	Liebermann–Burchard reagent	+	+	+	Red
	Shuffle	+	+	+	
Saponin	FeCl <sub>3</sub> reagent	+	+	+	Stable foam ± 30 s
Phenolic	0.5 g of mg powders and HCl	+	+	+	Black Brownish-yellow
		+	+	+	

(-) Negative presence of secondary metabolites, (+) Positive presence of secondary metabolites.

Based on Table 3, fresh bark, ethanol extract, and methanol extract of *A. heterophyllus* stem bark, positively contain secondary metabolites of alkaloids, triterpenoids, flavonoids, and saponins, and do not contain steroids.

The existence of secondary metabolites of alkaloids, triterpenoids, flavonoids, and saponins in ethanol and methanol extracts because these secondary metabolites can dissolve into the two solvents. The presence of compounds with conjugated double bonds such as flavonoids shows a reddish color with Mg powder and HCl solvents [41]. This compound can absorb ultraviolet radiation. According to the literature, *A. heterophyllus* contains many flavonoids or conjugated double-bonded compounds [42].

### The compound in the ethanol and methanol extract of *A. heterophyllus* bark

Chemical compounds were being analyzed with the NIST1 Lab. 4 Library in MS. Chemical compounds contained in ethanol extract of *A. heterophyllus* with the composition as shown in Table 4;

The compound in the ethanol extract of *A. heterophyllus* stem bark contains compounds that have double bonds such as phenol, 3,5-bis (1,1-dimethylethyl)-; 2- (4-Ethyl-2-acetoxy-5-methoxyphenyl) acetic acid, methyl ester; retinal; phthalic acid monoethyl ester; methyl 7,8-octadecadienoate; methyl hexadec-9-enoate; 9-Hexadecenoic acid, methyl ester, (Z)-; Methyl 10-trans,

12-cis-octadecadienoate -; 9-Octadecenoic acid, methyl ester, (E)-; phytol; 9,12-Octadecadienoic acid (Z, Z) -; cholesterol margarate; gamma.-Linolenic acid, methyl ester; Cholest-22-ene-21-ol, 3,5-dehydro-6-methoxy-, pivalate; hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester; and Bis(2-ethylhexyl) phthalate.

**Table 4: Chemical compounds contained in ethanolic extract of *Artocarpus heterophyllus* stem bark (from gas chromatography-mass spectrometry)**

No.	Area	Similarity	Name
1	0.24	85	Phenol, 3,5-bis(1,1-dimethylethyl)
2	0.33	73	2-(4-Ethyl-2-acetoxy-5-methoxyphenyl)acetic acid, methyl ester
3	1.03	76	Retinal
4	0.60	82	Phthalic acid, monoethyl ester
5	0.86	82	Methyl 7,8-octadecadienoate
6	0.43+0.85	84	Methyl hexadec-9-enoate
7	0.33	82	9-Hexadecenoic acid, methyl ester, (Z)-
8	17.73	93	Methyl 10-trans,12-cis-octadecadienoate
9	14.00	91	9-Octadecenoic acid, methyl ester, (E)-
10	1.25	89	Phytol
11	4.48	90	9,12-Octadecadienoic acid (Z,Z)-
12	8.94	77	Cholesterol margarate
13	0.68	78	gamma.-Linolenic acid, methyl ester
14	1.74	71	Cholest-22-ene-21-ol, 3,5-dehydro-6-methoxy-, pivalate
15	0.63	76	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester
16	2.14	94	Bis(2-ethylhexyl) phthalate

These compounds with double bonds can function to reduce the energy of the sun on the object if the object is coated with these compounds [7].

Chemical compounds in methanol extracts of the bark of *A. heterophyllus* with the composition which is analyzed with the NIST Willey Library in MS, as shown in Table 5, are obtained.

**Table 5: The chemical compounds contained in methanol extracts of the bark of *Artocarpus heterophyllus* (from gas chromatography-mass spectrometry)**

No.	Area	Similarity	Name
1	0.60	89	Phthalic acid, butyl undecyl ester
2	0.46	83	6,9-Octadecadienoic acid, methyl ester
3	0.38	82	6-Octadecenoic acid, methyl ester, (Z)-
4	1.40	77	Phthalic acid, butyl 2-(2-nitrophenyl)ethyl ester
5	1.97 5.21 9.82	84	Cholest-5-en-3-ol (3.beta.)-, carbonochloridate
6	3.72	77	.beta.-Sitosterol acetate
7	11.87	94	Methyl 10-trans,12-cis-octadecadienoate
8	14.69	92	9-Octadecenoic acid, methyl ester, (E)-
9	0.72	90	Phytol
10	0.72	84	9,12-Octadecadienoic acid (Z,Z)-
11	2.67	92	Oleic Acid
12	1.37	92	Bis(2-ethylhexyl) phthalate

The methanol extract of *A. heterophyllus* stem bark contains both straight and cyclic chain compounds, compounds that are thought to function as sunscreens are chemical compounds that have conjugated double bonds. In the methanol extract of *A. heterophyllus*, there are several compounds that have isolated and conjugated double bonds, the compounds are as follows: Phthalic acid, butyl undecyl ester. 6,9-Octadecadienoic acid, methyl ester; 6-Octadecenoic acid, methyl ester, (Z)-; phthalic acid, butyl 2-(2-nitrophenyl)ethyl ester; Cholest-5-en-3-ol (3.beta.)-, carbonochloridate; .beta.-Sitosterol acetate; Methyl 10-trans,12-cis-octadecadienoate; 9-Octadecenoic acid, methyl ester, (E)-; phytol; 9,12-Octadecadienoic acid (Z,Z)-; oleic acid; and Bis(2-ethylhexyl) phthalate.

These compounds have a double bond that can function as a protective material for the human body from daylight because the double bonds (especially

conjugated) can reduce the ultraviolet energy that reaches the surface of the skin coated with these compounds.

### Test results for the measurement of SPF value of ethanol extract and methanol extract from *A. heterophyllus* bark

Sunscreen is one of the cosmetic preparations that can be used to help the body's defense mechanism from UV radiation, UV radiation which can cause reactions to the skin, including acne, burning, redness, swelling, wrinkling, etc., [43]. The efficacy of sunscreen is usually expressed by the SPF, which is defined, as the UV energy needed to produce a minimum erythema dose on protected skin, divided by the UV energy needed to produce MED on non-skin protected. A minimal erythemal dose (MED) is defined as the lowest time interval or a dose of UV irradiation sufficient to produce minimal and clear erythema on unprotected skin [43], [44]. The higher the SPF, the more effective the product is in preventing sunburn.

$$\text{SPF} = \frac{\text{Minimalery the madoseinsun screen - protected skin}}{\text{Minimalery the madoseinnonsun screen - protected skin}}$$

*In-vitro* approaches are generally of two types: (1) Measurement of absorption or transmission of UV radiation through sunscreen product films on quartz plates or membranes and (2) methods in which the characteristics of sunscreen absorption are determined based on spectrophotometric analysis [36]. A very simple mathematical equation for estimating solar protection factors by *in-vitro* methods using UV spectrophotometry has been developed by Mansur *et al.* [37]. The main advantage of *in vitro* testing is that it is a fast, objective, and cost-effective methodology. *In vitro* testing can be used as a formulation material to identify new compounds, optimize existing formulas and as an initial formula before *in vivo* testing in humans.

SPF test results of extracts and lotions from ethanol extract and methanol extract of *A. heterophyllus* bark with a concentration of 2; 2.5; 5; 7.5; and 12% are in the following Table 6.

**Table 6: SPF value of extract and lotion formula from ethanol extract and methanol extract of *Artocarpus heterophyllus* bark**

Concentration (%)	SPF of extract		SPF formula lotion	
	Ethanol	Methanol	Ethanol	Methanol
2	36.276 ± 0.657	19.312 ± 0.029	29.801 ± 0.224	14.407 ± 0.010
2,5	37.472 ± 0.074	29.990 ± 0.344	32.797 ± 0.161	26.549 ± 0.476
5	37.806 ± 0.357	31.114 ± 0.565	33.808 ± 0.165	30.274 ± .208
7.5	38.023 ± 0.641	31.304 ± 0.329	34.580 ± 0.295	32.031 ± 0.302
12	39.839 ± 0.162	33.156 ± 0.102	35.015 ± 0.169	31.942 ± 0.324

SPF: Sun protection factor.

A comparison of the SPF value of the extract and lotion of ethanol extract and methanol extract above can be illustrated as in Figure 1.

Based on Table 6, (Figure 1), the SPF value of ethanol extract and its lotion is relatively higher than the SPF value of methanol extract and its lotion. This is due to the amount of conjugated double compound in ethanol extract is greater than that in methanol extract.

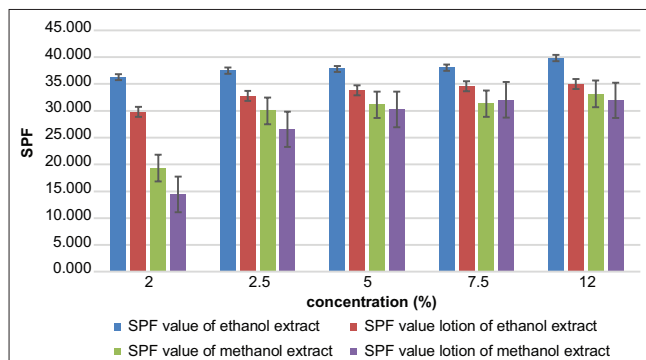


Figure 1: Comparison of the sun protection factor (SPF) value of the extract and the SPF value of the ethanol extract lotion formula and the methanol extract lotion formula

Compounds that have conjugated double bonds have the power to reduce UV energy that effects of the human body, the existence of long conjugated double bonds causes the formation of new orbitals, which can reduce UV energy to regions to longer wavelengths (to visible or infrared areas), so there is no formation of free radicals. Another mechanism is to capture free radicals that are formed, so they become neutral.

The difference in SPF value also occurs in each extract and its lotion, the SPF value of ethanol extract is greater than the SPF value of the ethanol extract lotion formula, as well as the SPF value of methanol extract is greater than the SPF of methanol extract lotion formulation. This is due to the extract containing active compounds with large concentrations that function as sunscreen, whereas the lotion has decreased the concentration of active compounds, due to dilution by lotion media.

#### Testing of physical properties of ethanol extract lotion and methanol extract lotion

The results of the determination of the type of emulsion of lotion formulation of ethanol extract and methanol extract showed that the lotion type is o/w, indicated by the deviation of the ampere meter needle which indicates the electrical conductivity of the lotion formulation. This type of emulsion has many advantages, including being easily rinsed with water and not sticky when used.

It is very important to measure the viscosity of lotion formulation; this is useful to see the level of viscosity of lotion formulations. The lotion viscosity value can be influenced by substances added to the lotion formulation. The value of viscosity will affect the spread of formulations on the skin [39]. The lotion formulation viscosity was measured every week for 1 month of storage, the viscosity value of methanol extract lotion and ethanol extract lotion ranged from

2450 cP to 4780.0 cP (the measurement results of the formulation viscosity value of 2–12% had met the semi-solid preparation standard based on (Standar Nasional Indonesia, SNI, Indonesian National Standards) 16-4399-1996 which is in the range of values between 2000 and 50,000 cP [45].

The pH of lotion testing is done every week for 1 month of storage. The results of pH testing of both ethanol extract lotion and methanol extract lotion ranged from 6.020 to 7.845, indicating the pH of the lotion is still acceptable, according to SNI 16-4399-1996 where the lotion that can be used for the skin is a lotion that has a pH range of 4.5–8.0 [45].

The spread testing of lotion formulation can be used as a benchmark to see the spread formulation on the skin. The spreading power of the lotion of ethanol and methanol extract ranges from 4.70 to 6.75 cm. According to research that has been done by Zulkarnain *et.al.* [46], semi-solid preparations that are comfortable when used to the skin are formulations which have a dispersion diameter ranging from 5–7 cm or equivalent to 19.6–38.46 cm<sup>2</sup>. The sample which has a spreading capacity below 5 cm is a formulation of 12% ethanol extract lotion at weeks 2, 3, and 4.

The lotion formulation adhesion test was carried out to see the length of time of the formulation attached to the skin. A good formulation is one that has not too low and not too high adhesion. The adhesion of ethanol extract ranged from 16 to 23 s for lotion methanol extract ranged from 16 to 41 s. Hence, this lotion qualifies because it has an adhesion of more than 4 s [46].

## Conclusions

Ethanol and methanol extracts can be processed into sunscreen lotions that have an SPF value in the ultracategory. The SPF value of ethanol extract lotion is relatively higher than the SPF value of methanol extract lotion. The SPF value of extract of each sample is higher than the SPF value of lotion for each ethanol extract and methanol extract.

Methanol and ethanol extracts contain compounds that are conjugated in double conjugation, but ethanol extract contains more of these compounds than methanol extracts.

The SPF lotion value of ethanolic extract of bark of *A. heterophyllus* at concentrations, 2, 2.5, 5, 7.5, and 12% was: 29.801 ± 0.224; 32.797 ± 0.161; 33.808 ± 0.165; 34.580 ± 0.295; and 35.015 ± 0.169, while the SPF value of negative control was: 0.435 ± 0.2839; and positive control, 31 ± 0.0284, and the value of SPF of the methanol extract lotion was 14.407 ± 0.010; 26.549 ± 0.476; 30.274 ± 0.208; 32.031 ± 0.302; and 31.942 ± 0.324.

The results of testing the physical properties of the lotion showed that the lotion type is m/a, lotion viscosity ranges from 2450 cP to 4780.0 cP. Test results for pH ranged from 6.020 to 7.845. The spreading power of the lotion ranged from 4.70 to 6.75 cm, the stickiness of the lotion ranged from 16 to 23 s. Generally speaking, the physical properties of methanol extract lotion and ethanol extract lotion are in accordance with SNI.

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