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The Effects of Aloe Vera Gel Addition on the Effectiveness of Sunscreen Lotion

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ABSTRACT

Aloe vera is one of the medicinal plants that are heavily used in the pharmaceutical industry, especially in cosmetics. The aloe plant that is cultivated in Indonesia to supply this industry is *Aloe chinensis Baker*. This research is to determine the effects of *Aloe vera* gel extract on the effectiveness of sunscreen lotion. The steps taken included *Aloe vera* gel extraction, flavonoid absorption test, sun protection factor (SPF) value measurement, pH test, viscosity test, homogeneity test, and organoleptic evaluation. The extract was added to the base sunscreen formulation at five different concentrations. UV-Vis spectrophotometry at 290 – 320 nm was performed on the preparations to determine their SPF values. The highest SPF value of 10.21 was found in the preparation containing 20% *Aloe vera* gel extract. This value falls within the national industrial standard for sunscreen SPF value range of 2 – 60. The research showed that a higher concentration of *Aloe vera* gel extract increased the pH, with the most elevated pH at 7.0 for the preparation containing 20% Aloe gel vera extract. This value also falls within the national pH standard for sunscreen of 4.5 – 8.0. The higher concentration of *Aloe vera* gel extract also increased the dispersive amount of the sunscreen preparation, with the highest value of 5 cm resulting from 20% *Aloe vera* gel extract addition. This research showed that the increased addition of *Aloe vera* gel extract resulted in higher SPF value.

Keywords: *Aloe chinensis Baker*, *Aloe vera* gel; sun protection factor; sunscreen

ABSTRAK

Lidah buaya adalah salah satu tanaman obat yang banyak digunakan dalam industri farmasi, terutama di bidang kosmetik. Tanaman lidah buaya yang dibudidayakan di Indonesia untuk memasok kebutuhan industri adalah Aloe jenis Chinensis Baker. Penelitian ini bertujuan untuk mengetahui pengaruh ekstrak gel lidah buaya terhadap efektivitas lotion tabir surya. Langkah-langkah yang diambil adalah ekstraksi gel lidah buaya, uji serapan flavonoid,

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pengukuran nilai sun protection factor (SPF), uji pH, uji viskositas, uji homogenitas, dan evaluasi organoleptik. Ekstrak ditambahkan ke formulasi tabir surya dasar pada lima konsentrasi yang berbeda. Spektrofotometri UV-Vis pada panjang gelombang 290-320 nm dilakukan pada persiapan untuk menentukan nilai SPF tabir surya aloe vera. Nilai SPF tertinggi sebesar 10,21 ditemukan dalam sediaan yang mengandung 20% ekstrak gel lidah buaya. Nilai ini termasuk dalam Standar Industri Nasional (SNI) untuk kisaran nilai SPF tabir surya 2-60. Penelitian menunjukkan bahwa konsentrasi yang lebih tinggi dari ekstrak gel lidah buaya meningkatkan pH, dengan pH tertinggi pada 7,0 untuk preparasi yang mengandung 20% ekstrak lidah buaya. Nilai ini juga berada kisaran standar pH nasional untuk tabir surya 4,5-8,0. Semakin tinggi konsentrasi ekstrak gel Aloe vera juga meningkatkan nilai dispersif sediaan tabir surya, dengan nilai tertinggi 5 cm yang dihasilkan dari penambahan 20% ekstrak lidah buaya. Penelitian ini menunjukkan bahwa penambahan ekstrak gel lidah buaya menghasilkan nilai SPF yang lebih tinggi.

Kata kunci: aloe chinensis baker; gel aloe vera; sun protection factor; sunscreen

1. Introduction

Indonesia is geographically a tropical country, where it receives a large amount of sun radiation (Wasitaatmadja, 2010). This radiation can be beneficial to health, but also has adverse effects, especially from the ultraviolet (UV) at 290–400 nm (Amilum et al., 2013). The degree of skin damage depends on the frequency and length of skin exposure to the sun rays. Skin natural defense in humans can be overwhelmed by excessive UV radiation from the sun. Therefore, there is a need to reinforce this defense, and one of the methods is the use of sunscreen lotions (Soeratri, 2005).

Aloe vera is one of the medicinal plants that are widely used in the pharmaceutical industry, especially in cosmetics. Studies have shown that *Aloe vera* produces various biologically active compounds that have pharmacological benefits (Marwati and Hermani, 2006). Those active compounds include aloin, emodin, gum, essential oil, and other substrates (Hendrawati and Nugrahani, 2018). In the cosmetic industry, *Aloe vera* is used as the main ingredient in sunscreen lotion, facial creams, moisturizers, soaps, makeups, perfume, and other beauty and toiletry products.

Sunscreen lotion is a cosmetic product that is used topically to prevent and reduce the harmful effects of sunrays. For a compound to be considered a screening agent, it must be able to absorb the sunrays at the wavelengths of 2800-3200^{0}A. Moreover, to be commercially viable, these compounds must not produce an offensive odor and be transparent (Hamdani, 2011). An effective sunscreen must be able to absorb 85% of UVB (290-320 nm) but pass through UVA (>320 nm) (Suryanto, 2012).

The mechanisms of sunscreen action in providing skin protection, according to Lavi (2013) are:

1. Sunscreen molecules absorb the energy of UV rays, which undergo excitation from the ground state to an excited state.
2. When the excited molecules return to a lower state, they will release lower energy than the energy needed for the excitation.

3. Therefore, the high energy UV will have less energy because of the absorption by the sunscreen chemicals.
4. The lowered UV ray energy will have less or no effect on skin sunburn.

A previous study by Pratiwi and Husni (2017) demonstrated that *Aloe vera* gel extract could be used in sunscreen lotion. They further explained that *Aloe vera* gel extract contains Brady kinase enzyme and acemannan polysaccharide that has been known to provide UV protection.

Sun protection factor (SPF) is the most common criterion to measure the effectiveness of cosmetic emulsion products in skin protection from UV radiation. The SPF value of a substance can be achieved in vitro by measuring the absorbency under the curve (AUC) of the material divided by the interval of the wavelengths (Suwarmi, 2012). The standard in Indonesia for sunscreen is no less than an SPF value of 4 (McCoy, 2010).

Based on those studies, the questions to be answered are: does *Aloe vera* gel contains compounds that can be used as skin protection against UV rays, and how effectively does *Aloe vera* gel extract in sunscreen lotion. The objectives of this research are, therefore: 1. To determine the sunscreen characteristics of *Aloe vera* gel, and 2. To determine the effects of *Aloe vera* gel extract on the effectiveness of sunscreen lotion. In this study, the SPF test and spectrophotometer were tested in testing the impact of the addition of Aloe vera gel in the efficacy of sunscreen lotion.

2. Research Methodology

2.1 Materials

The main ingredient in this trial is *Aloe vera* gel extract that had been obtained from the cleaning and peeling of *Aloe vera* leaves and followed by water removal. *Aloe vera* was purchased from farmers around West Java with a type of *Aloe vera Chinensis Baker*. The sunscreen lotion base was made from Part A, containing stearic acid, cetyl alcohol, and liquid paraffin, and Part B, containing triethanolamine (TEA), glycerin, methylparaben, and distilled water.

2.2 Procedures

2.2.1 Production of *Aloe vera* gel extract

Aloe vera leaves were washed and cleaned. The gel was obtained by removing the rind the *Aloe vera*. The gel was then put in the blender, and the resulting puree was filtered to collect the extract.

2.2.2 Sunscreen base preparation

Part A was prepared by mixing stearic acid, cetyl alcohol, and liquid paraffin on a hotplate set at 65–70 °C. Part B was prepared by mixing methylparaben, glycerin, and TEA in distilled water on a hotplate at 65-70 °C. After complete mixing, Part B was slowly added to Part A to form an emulsion. *Aloe vera* gel extract was added to the emulsion. The formula of sunscreen is listed in Table 1 while procedure to prepare the sunscreens is shown in Figure 1.

Table 1. The compositions of the tested sunscreens

Ingredient	Formula (%)				
	FA	FB	FC	FD	FE
Stearic Acid	2.5	2.5	2.5	2.5	2.5
Liquid Paraffin	7	7	7	7	7
Cetyl Alcohol	0.5	0.5	0.5	0.5	0.5
Glycerin	5	5	5	5	5
Methyl Paraben	0.05	0.05	0.05	0.05	0.05
TEA	1	1	1	1	1
Distilled Water	83.95	78.95	73.95	68.95	63.95
Aloe vera gel extract	0	5	10	15	20

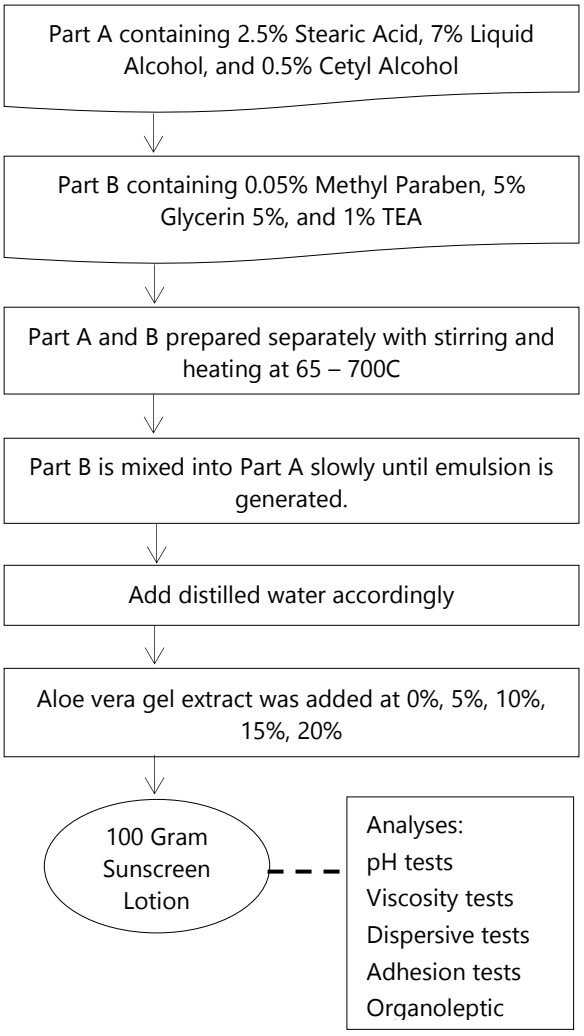

Figure 1. The flowchart for the sunscreen lotion preparation

2.2.3 Determination of SPF value

The sunscreen lotion preparation containing the *Aloe vera* gel extract was dissolved in a solvent of ethanol: water with the ratio of 3:1, and placed in a hot water bath. The solution was centrifuged to separate pellet materials from the supernatant. Absorbency tests were conducted on the supernatant using a spectrophotometer UV-Vis every 5 nm at the wavelength of 290-320 nm. The calculations for the SPF value are presented in Eq. (1).

$$A = \log 10\ SPF \quad (1a)$$

$$SPF = 10^{A} \quad (1b)$$

Note: A = Absorbency (Yuliani, 2010)

Table 2. Absorbency test of different sunscreen lotion

Concentration (%)	Absorbency
0	0.639
5	0.726
10	0.758
15	0.983
20	1.009

2.2.4 Physical tests and observations of the sunscreen preparations added with *Aloe vera* gel extract

The part of *Aloe vera* that is commonly used is the juicy gel inside the leaf. This gel composes of 96% water and 4% solids containing 75 biologically active compounds. *Aloe vera* gel is multi-beneficial because it contains 17 amino acids, aloin, emodin, resin, lignin, saponin, anthraquinones, vitamins, minerals, and so on. *Aloe vera* is used in the pharmaceutical industry in the form of gel, powder, or extract (Ismiyati et al., 2017). This extract was added to the sunscreen base preparations at different concentrations.

The physical tests and observations of the sunscreen preparations included the changes in pH, viscosity, color, and odor, as well as organoleptic evaluations and SPF determinations. The results of these tests were compared to the national standards (SNI 16-4399-1996) set by the Government.

3. Results and Discussion

3.1 Results of pH tests

Acidity tests were performed to ascertain that the pH of the sunscreen preparations met the Government standard SNI 16-4399-1996. The tests utilized litmus paper and pH meter. The results showed that the pH values of Aloe-vera-containing preparations of sunscreen lotions fell within the Government standard of an average physiological level of 4.5-8.0, as shown in Table 3.

Table 3. Results of pH tests on the *Aloe vera* sunscreen preparations

Sunscreen	pH	National Standard (SNI 16-4399-1996)
A	6.7	
B	6.8	
C	6.9	4.5-8.0
D	7.0	
E	7.0	

The addition of *Aloe vera* gel extract changed the pH of the sunscreen lotion. Previous research showed that a higher concentration of *Aloe vera* gel extract increased the pH of sunscreen preparations (Hendrawati et al., 2018). Our results show a significant correlation (R^2 = 0.9412) between the concentrations of *Aloe vera* gel extract and pH values of sunscreen lotion, as presented in Figure 2.

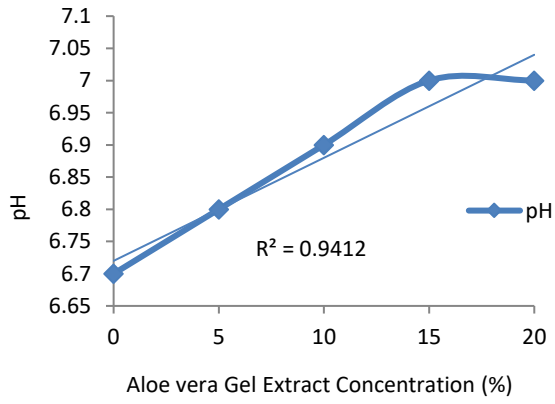

Figure 2. The effects of *Aloe vera* gel extract concentration on the pH of the sunscreen lotion

3.2 Results of Viscosity tests

The viscosity analyses were performed on Brookfield Viscometer at Bea dan Cukai Jakarta laboratory. Viscometer measures the torque needed to turn a spindle inside a solution. The viscosity has a positive linear correlation with the rotational speed of the spindle and related to the size and geometry of the spindle. The results from the viscosity tests are presented in Table 4.

Table 4. Results of viscosity tests on the *Aloe vera* sunscreen preparations

Sunscreen	Viscosity (cP)	Method
A	80.7	
B	85.5	
C	97.2	133/BPIB/IK/MT
D	106.0	
E	121.2	

Further analyses show that concentration of *Aloe vera* gel extract has a linear correlation to viscosity of solution. The result is shown in Figure 3.

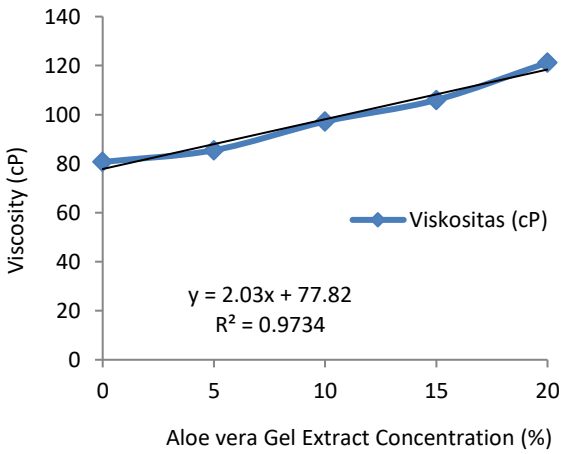

Figure 3. The effects of *Aloe vera* gel extract concentration on the viscosity of the sunscreen lotion

The equation obtained from the above graph is presented in Eq. (2).

$$y = 2.03x + 77.82 \quad (2)$$

y represents viscosity and *x* represents the concentration of *Aloe vera* gel extract. Eq. (2) has R^2= 0.973. This figure shows that a higher concentration of *Aloe vera* gel extract increases the viscosity of the sunscreen preparations.

3.3 Results of organoleptic evaluations

Organoleptic evaluations were performed to observe the consistency characteristics of the sunscreen lotion at different concentrations of *Aloe vera* gel extract. These characteristics include odor, color, and texture. These evaluations were performed using our senses (Hendrawati et al., 2018) and the results are presented in Table 5.

Table 5. Results of organoleptic evaluations on the *Aloe vera* sunscreen preparations

Sunscreen	Odor	Color	Texture
A	Fragrant	Milky White	Soft
B	Fragrant	Milky White	Soft
C	Fragrant	Milky White	Soft
D	Fragrant	Milky White	Soft
E	Fragrant	Milky White	Soft

The organoleptic evaluations showed that there was no significant difference among the five preparations. The test involved a respondent panel obtaining the cream with the tips of their fingers and applying it on the skin of their hands. There was, however, a tendency in which preference decreased with increased addition of *Aloe vera* gel extract (Hendrawati et al., 2018). The members of the testing panel prefer cream with a thicker consistency.

3.4 Results of spectrophotometry

The sunscreen preparations were dissolved in a solvent of ethanol: water at 3:1. A Spectrophotometer UV-Vis was used to measure the solutions' absorbancy at a wavelength range of 290-320 nm. The results are presented in Table 6.

Table 6. Results of Spectrophotometry on the *Aloe vera* sunscreen preparations

Sunscreen	Wavelength	Absorbency
A	290 – 305 nm	0.639
B	290 – 305 nm	0.726
C	290 – 305 nm	0.758
D	290 – 305 nm	0.983
E	290 – 305 nm	1.009

3.5 Results of SPF value tests

The measurement of SPF value is the primary method to determine the effectiveness of the sunscreen formulation. Sunscreen is used to aid the body's natural defense against the danger of the Sun UV radiation by absorbing, reflecting, and dispersing sunrays.

These absorbency results from Table 6 were used to determine the SPF values using the previously described formula. All preparations yielded SPF values above the national standard for minimal SPF value of 4, as presented in Table 7.

Table 7. Results of SPF value tests on the *Aloe vera* sunscreen preparations

Sunscreen	SPF	National Standard (SNI 16-4399-1996)
A	4.36	Minimal 4
B	5.32	
C	5.37	
D	9.62	
E	10.21	

A higher concentration of *Aloe vera* gel extract yielded a higher SPF value. The effect of *Aloe vera* gel extract addition in the SPF value of the sunscreen lotion can be seen in Figure 4.

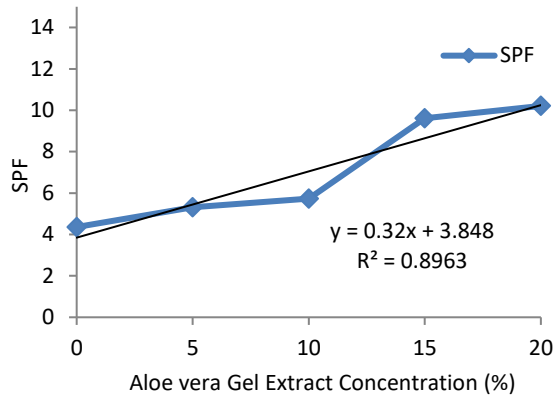

Figure 4. The effects of *Aloe vera* gel extract concentration on the SPF value of the sunscreen lotion

The equation for Figure 4 is presented in Eq. (3).

$$y = 0.32x + 3.848 \quad (3)$$

y and represent the SPF value and the concentration of *Aloe vera* gel extract, respectively. Eq. (3) has R^2= 0.896. These results indicate that a higher concentration of *Aloe vera* gel extract increases the SPF value of the sunscreen preparations. The SPF values obtained in this research range from 4.36 to 10.21, which are higher than the national standard (SNI 16-4399-1996) that requires the SPF value of sunscreen lotion to be at least 4.

4. Conclusions

This research demonstrated that *Aloe vera* gel extract could be added to sunscreen lotion and function as protection against negative effects of sunray exposure. Test results showed that the addition of *Aloe vera* gel extract yielded pH and SPF values within the national standard SNI 16-4399-1966. The highest SPF value of 10.21 was obtained from 20% *Aloe vera* gel extract. SPF value has a significant correlation with the concentration of *Aloe vera* gel extract; y = 0.32x + 3.848 with R^2 = 0.8963.

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