Determination of Sun Protection Factors (SPF) of Red Dragon Fruit (Hylocereus polyrhizus) extract cream

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Abstract. Red dragon fruit (Hylocereus polyrhizus) has bioactive compounds such as phenols, flavonoids, and betacyanin that can work as active ingredients for sunscreen. The purposes of this study were to determine the SPF value and physical characteristics of red dragon fruit flesh extract cream. The concentrations of red dragon fruit extract used were 0.07% (F1), 0.14% (F2) and 0.28% (F3). SPF value of this cream determine by UV-Vis spectrophotometer. Evaluation of the physical characteristics of the cream includes organoleptic characteristics, homogeneity, pH, physical stability, spread diameter, adhesiveness, and cream type. The results show there was a difference in SPF values in the group given the extract. F1 has the highest SPF value, namely 1.291 ± 0.007. The evaluation of physical characteristics produced a good cream preparation that met the requirements of the physical characteristics of the cream.

1 Introduction

Sunlight exposure (UV Spectrum) is divided into three groups based on wavelength. Wavelengths of 200-290 nm are UV-C rays. The wavelength of 290-320 nm is UV-B light. The wavelength of 320-400 nm is UV-A light. Not all UV radiation from the sun can reach the earth's surface. UV-C rays, which have the greatest energy, cannot reach the earth's surface because they are absorbed by the ozone layer [1]. Ultraviolet light can have several negative effects on the skin [2]. UV rays can damage skin cells, loss of elasticity or reduced, redness of the skin accompanied by itching, sunburn, reddened and swollen leg skin [3,4]. In addition, UV rays can cause diseases, such as cataracts, skin cancer, and can trigger the growth of cancer cells [5,6]. One of the efforts to minimize direct and chemical sun exposure is by using sunscreen.

A plant that has potential as a sunscreen is red dragon fruit. Red dragon fruit (H. polyrhizus) extract contains high antioxidant activity with photoprotective characteristics. Antioxidant compounds such as phenolics and flavonoids found in dragon fruit as sun protection factors in UVA and UVB photoprotection [7]. The results of the study (Hylocereus polyrhizus (F.A.C Weber) Britton & Rose) showed that red dragon fruit has antioxidant

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activity of 67.45 ppm. High antioxidant activity will be supported by the many bioactive compounds contained in the extract. Phenolic compounds have the potential as sunscreens because their chromophore groups can absorb UV rays both UV A and UV B, thus reducing the intensity of sun exposure on the skin. In addition, antioxidant compounds such as flavonoids, betacyanin, anthraquinones and cinnamates in sunscreen preparations can increase photoprotective activity and prevent diseases caused by UV radiation [8,9]. Total flavonoid Content (TFC) of red dragon fruit flesh without the maceration process is 14.24 ± 0.14 [10]. The purpose of this study was to determine the physical characteristics and SPF value of red dragon fruit flesh extract cream. SPF value and evaluation of the physical characteristics of red dragon fruit flesh extract cream includes organoleptic characteristics, homogeneity, pH, physical stability, spread diameter, adhesiveness, and cream type. This research is in accordance with one of the 17 sustainable development goals (SDGs) for 2030 declared by both developed and developing countries at the UN General Assembly in September 2015, namely point (3) Healthy and Prosperous Life.

2 Material and Methods

2.1 Tools and Materials

The tools used for this research are blender, cutter, cutting board, watch glass, 1 L beaker, analytical balance, porcelain cup, pot, stove, wooden spoon, 50 mL beaker, aluminum foil, spatula, stirring rod, drop pipette, mixer, and pH indicator. Tools used in the evaluation of physical characteristics and SPF test of red dragon fruit extract cream include: pH meter, object glass, 50 gram weights, Brookfield viscometer, UV-Vis spectrophotometry.

The materials used in this study were red dragon fruit extract 0.07%, 0.14%, 0.28%, cetyl alcohol 2 grams, glycerin 8 grams, stearic acid 10 grams, Triethanolamine 0.4 grams, methyl paraben 0.18 grams, propyl paraben 0.02 grams, BHT 0.15 grams, propylenglycol 0.15 grams, liquid paraffin 3 grams, oleum rossae 2 drops, ethanol and distilled water Ad 100.

2.2 Research Procedures

2.2.1 Preparation of Red Dragon Fruit Extract

The flesh of the red dragon fruit is cut into 4 equal parts using a knife and separated from the skin. Then the flesh was cut into smaller pieces. The flesh was placed in a beaker glass and weighed using an analytical balance. Then, the pieces of red dragon fruit flesh were mashed using a juicer for ± 5 minutes. Next, the dragon fruit juice was poured into a large porcelain cup. Next, the heating pot was filled with water up to half and heated using a stove. The porcelain cup containing red dragon fruit was placed in the heating pot and stirred with a wooden spoon for ± 5 hours until a texture then thickened. The red dragon fruit extract was put into a glass beaker and weighed for yield calculation. The last step, the red dragon fruit extract is stored by covering it with aluminum foil and rubber, then stored in a refrigerator with a temperature of 4o C [11].

2.2.2 Extract Yield Calculation

Extract yield is calculated based on the ratio of the final weight (weight of the extract produced) to the initial weight (weight of the cell biomass used) then multiplied by 100% [12]. The yield was calculated with the formula.

$$Yield(\%) = \frac{initial\ weight}{final\ weight} x100\% \quad (1)$$

2.2.3 Cream Formulation

All cream ingredients were weighed using analytical scales with the composition of dragon fruit extract 0.07% (F1), 0.28% (F2), 0.14% (F3). Detail of 3 formulas were showed in Table 1.

Table 1. Formulation of Red dragon fruit extract in M/A cream

Material	Formula 1	Formula 2	Formula 3
Red dragon fruit extract	0,07 %	0,14 %	0,28 %
Cetyl alcohol	2 grams	2 grams	2 grams
Stearic acid	2 grams	2 grams	2 grams
Glycerin	8 grams	8 grams	8 grams
Tritanolamin	0.4 grams	0.4 grams	0.4 grams
Methyl paraben	0.18 grams	0.18 grams	0.18 grams
Propylene paraben	0.02 grams	0.02 grams	0.02 grams
BHT	0.15 gam	0.15 grams	0.15 grams
Propylene glycol	0.15 grams	0.15 grams	0.15 grams
Liquid paraffin	3 grams	3 grams	3 grams
Oleum rossae	2 drops	2 drops	2 drops
Aquades ad	100	100	100

2.2.4 Sun Protection Factor (SPF) Test

The cream was taken as much as 0.5 g, then diluted with ethanol up to 10 mL. The UV-Vis spectrophotometer was calibrated first using ethanol as much as 1 mL put into the cuvette. The solution in the cuvette was made a test absorption curve with a wavelength between 290-320 nm, ethanol was used as a blank. Then the average absorbance (Ar) was determined with an interval of 5 nm. The absorbance results of each solution concentration were recorded, then the SPF value was calculated using Equation 2 [13].

$$SPFspectrophotometric = CF\ x\ \Sigma EE\ 320\ 290\ (\lambda) x\ I\ (\lambda) x\ Abs\ (\lambda) \quad (2)$$

Description :
EE : Erythemal effect spectrum
I : Solar intensity spectrum
Abs : Absorbance of sunscreen product
CF : Correction factor

Table. 2 Classification of SPF Values and Sunscreen Protection

SPF Value	Sunscreen Criteria
2-4	Maximum protection
4-6	Medium protection
6-8	Extra protection
8-15	Maximum protection
≥15	Ultra protection

2.2.5 Evaluation of The Physical Characteristics of The Cream

- Organoleptic Test
  The organoleptic test of the cream was carried out by examining the physical appearance of the cream preparation including color, texture, and odor on a watch glass.
- Homogeneity Test
  The homogeneity test was carried out by means of a number of red dragon fruit creams applied to the object glass and then leveled. The cream is declared homogeneous if there are no coarse grains on the glass object.
- pH test
  The pH test aims to determine the safety of the cream preparation when used so that it does not irritate the skin. Weighed as much as 1 gram of cream extract and diluted with 10 mL of distilled water. Then the pH is measured using a universal pH by dipping a hard universal pH into the solution.
- Spread Diameter Test
  The cream was weighed as much as 1 gram, then placed on a glass plate, then added with a load of 50 grams, the load was allowed to stand for 1 minute, then the actual diameter was measured. Next added a load of 100 grams and allowed to stand for 1 minute. Measure the diameter of the spreading cream.
- Adhesion Test
  The adhesion test was carried out by placing 1 gram of cream on a glass plate. Then, put another glass plate on top of the sample and place the test equipment. Giving 50 grams free for 5 minutes. The stopwatch is turned on to count the time it takes when the glass plate is released. Next, the same treatment was carried out at a load of 100 grams.
- Viscosity Test
  The viscosity of the cream was measured with a Brookfield LV Viscometer and each formula was replicated three times. The red dragon fruit extract cream preparation was put into a beaker, then the spindle was installed and the rotor was run. The viscosity results were recorded after the viscometer needle showed a stable number.
- Physical Stability Test
  Storage at low temperature. Red dragon fruit extract cream samples were stored at low temperature (4±2°C) for 28 days. Then organoleptic observations (color change, odor, homogeneity), as well as pH measurements with observations made every week for 4 weeks. Viscosity measurements were taken on day 0 and day 21.

  Storage at room temperature. Samples of red dragon fruit extract cream were stored at room temperature (28±2°C) for 28 days, then organoleptic observations (changes in color, odor, homogeneity), as well as pH measurements with observations made every week for 4 weeks.

  Storage at high temperature. Red dragon fruit fruit extract cream samples were stored at high temperature (40±2°C) for 28 days. Then, organoleptic observations (changes in color, odor, homogeneity), as well as pH measurements with observations made every week for 4 weeks.
- Emulsion Type Test
  Determination of the emulsion type of the preparation is done by adding a little methyl blue to the preparation, if it dissolves when stirred, the emulsion is of the oil-in-water type. However, if it does not dissolve when stirred, the emulsion is of the water-in-oil type.

2.3 Data Analysis

Data analysis using one way ANOVA to determine the difference of the average SPF value of cream preparations obtained against the concentration of extracts used.

3 Results and Discussion

3.1 Red dragon fruit extract yield

In this study, a thickening process was carried out to extend the storage time of the samples during the study. Thickening is a process to reduce the water content of the sample. The aim is to extend the storage time of the sample to make it more durable. Thickening is done by raising the temperature of the product to the boiling point with a certain length of time. The results of the thickened extract of red dragon fruit juice are as follows.

Fig.1. Results of red dragon fruit extract

The results of the calculation of the yield of red dragon fruit extract can be seen in the following table.

Table 3. Red dragon fruit yield results

Materials used	Wet weight	Weight of extract	Yield
Red dragon fruit	540 grams	60 grams	11,11%

The calculation of yield in the study aims to determine the ratio of the weight of the product obtained to the weight of the raw materials used [14]. The extract yield is associated with the amount of bioactive compounds present in plants where the higher the extract yield, the more bioactive compounds are attracted by the solvent [15–17]. The yield value is related to the amount of bioactive content contained in plants [18]. The results of the calculation of the yield of red dragon fruit juice that has thickened obtained a weight of 11.11%. The % yield results have met the requirements of the Indonesian Herbal Pharmacopoeia which is ≥ 10%. The yield of juice is said to be qualified if it exceeds 10% [19].

Based on the results obtained, the thick extract of red dragon fruit flesh has met the yield requirements with a value of more than 10%. The thick extract of red dragon fruit juice is stored in a refrigerator with a container and covered with aluminum foil. Storage at this temperature is done to prevent microbial growth so that it lasts longer.

3.2 SPF Value

Determination of SPF value using UV-Vis spectrophotometry by measuring the sample in the wavelength range of 290-320 nm. This method indicates the ability as a photoprotection against sunlight, especially UV-B, which can have an impact on the skin that penetrates the epidermis layer such as redness, burning, and erythema. Classification of SPF (Sun Protection Factor) values and sunscreen protection categories and results of literature studies SPF values as follows.

SPF value obtained in the control formula is 0.618. Detail data of SPF value is shown in Table 4. this shows that the SPF value does not meet the SPF category requirements so that it cannot protect the skin from sun exposure.

Table 4. SPF Value

Sample	SPF Value
Control	0.618 0.023[a]
F1	1.291 0.007[b]
F2	1.085 0.012[b]
F3	1.072 0.003[b]

Red dragon fruit extract cream contains glycerin and propylene glycol where glycerin does not contain chromophores which absorb UV radiation at wavelengths >290 nm [20]. The propylene glycol compound does not have a UV active chromophore so it does not provide an absorbance response. The presence or absence of a chromophore group can affect the readings in UV-Vis spectrophotometry because chromophores are functional groups that absorb ultraviolet and visible radiation as shown by the absorbance results. In testing the negative control SPF value, the resulting absorbance response can be caused by the cuvette or test equipment being less clean and there being impurities in the test [21].

The statistical results showed that the One Way ANOVA parametric test obtained a significance value of 0.000>0.05 which indicated that the SPF value of each formula was significantly different. therefore the Post Hoc LSD test was continued. The Post Hoc LSD test showed the presence of asterisks in all groups which explained that each group had a significant difference from the other groups. The control cream had a significant difference from the 0.07%, 0.14% and 0.28% extracts. The 0.07% extract had a significant difference against the control. The 0.14% extract had a significant difference against the control extract. The 0.28% extract had a significant difference against the control.

3.3 Organoleptic Characteristics

Organoleptic test aims to analyse the quality of the cream using five senses which include color, shape, texture, smell, on the preparation of dragon fruit flesh extract cream. The results of the organoleptic test on dragon fruit flesh extract cream are showed in Table 5.

Table 5. Organoleptic Characteristics of Red Dragon Fruit Cream

Organoleptic Characteristics	K	F1	F2	F3
Color	White	Pale pink	Light pink	Dark pink
Odor	Typical	Typical	Typical	Typical
Homogeneity	Homogeneous	Homogeneous	Homogeneous	Homogeneous
Shape	Semi-solid	Semi-solid	Semi-solid	Semi-solid
Texture	Soft	Soft	Soft	Soft
pH	6	5,3	5	5

- Color & Odor
  The organoleptic test results in Table 5 shows each formula has a different color. The color difference is influenced by the concentration of the extract contained. Extraction will affect the organoleptic characteristics of red dragon fruit flesh which makes the color of the preparation more attractive. F1 produces a pale pink color, F2 light pink and F3 dark pink. This is because red dragon fruit flesh extract has a red color, so it affects the color of the cream made. The more red dragon fruit flesh extract given, the more intense the color and thicker the resulting preparation. The addition of oleum rossae affects the odor of the cream preparation, which has a distinctive odor.
- Homogeneity
  The homogeneity test aims to determine whether the cream preparation made contains solid or non-solid particles and has been mixed evenly or not. This is in order to meet the characteristics of a good cream preparation, namely having a soft mass and not containing coarse particles so that when applied to the skin it feels soft and evenly distributed. The homogeneity test results obtained are as follows.

  Table 5 shows that the sunscreen cream formulations of Hylocerus polyrhizus dragon fruit flesh extract are all homogeneous. This is in accordance with the requirements of Indonesian Pharmacopoeia edition III, where the cream must show a homogeneous composition, and no solid particles are felt. This is because at the time of making the cream continuously stirred constantly and homogeneously so that the resulting cream does not contain particles of solid material. Based on these results, it shows that the active ingredients and other ingredients have been well mixed homogeneously, so that the resulting therapeutic effect will be even better
- pH
  The pH test aims to determine the level of acidity or basicity of dragon fruit flesh extract cream. This is because if the pH of a topical preparation is too acidic or alkaline it will cause irritation and discomfort when used. The pH test was replicated 3 times using a pH indicator, and the test results show pH all.

  Table 5 shows the results of the pH test of red dragon fruit flesh extract cream and several variants of red dragon fruit extract concentrations have a pH between 5-6. The pH is still in the normal pH range of the skin which is 4.5-6.5 [22]. The control cream preparation without red dragon fruit extract has a pH of 6. The cream with 0.07% red dragon fruit extract active ingredient (F1) has a pH of 5.3. Meanwhile, the preparation of red dragon fruit extract cream with a concentration of 0.14% (F2) has a pH of 5 and a concentration of 0.28% (F3) has a pH of 5. Increasing the concentration of red dragon fruit flesh extract in F2 and F3 can reduce the pH of the preparation. Both of these are because red dragon fruit flesh extract contains compounds such as polyphenols, flavonoids, and ascorbic acid which are acidic. So that there are differences in the active substances of the extract and the higher the concentration of red dragon fruit extract, the lower the pH of the preparation.

3.4 Spread diameter Test

The spread diameter test aims to determine the ability of the cream to spread on the skin. The spread diameter test is conducted to determine whether the cream can spread on the skin quickly and provide therapeutic effects. The wider the spread of the cream, the easier it is to apply to the skin so that the absorbance of the active substance is maximized. The results of the spread diameter test can be seen in Table 6. Based on table 6, it is known that the cream spread diameter test in each formula shows different values. The highest spread diameter

test with a 50 gram load was shown in formula 2 with a concentration of 0.14% red dragon fruit extract. This shows that the formula has a wider contact between the active substance and the skin, while the smallest spread diameter value is in the base formula. In the control formula, an average value of 5.5 cm was obtained, in formula 1 an average value of 5.8 cm was obtained, in formula 2 an average of 5.6 cm was obtained, in formula 3 an average of 5.7 cm was obtained. At 100g load, the average diameter of spread diameter was obtained, namely in the control formula 5.7 cm, formula I 5.7 cm, formula II 5.6 cm, and formula III 5.7 cm. The surface area of the cream with a load of 50g obtained an average of 23.75 cm in the control, formula I 26.40 cm, formula II 24.62 cm, formula III 25.50 cm. While at 100g load, the average surface area is obtained in the control formula 25.50 cm, formula I 25.50 cm, formula II 24.52 cm, formula III 24.62 cm. Based on the above results, the dragon fruit peel extract cream formula (Hylocerus polyrhizus) has met the standard of a good spread diameter test, namely with 5-7 cm and a surface area of 19.635 cm2 to 38.465 cm2 [23]. The denser / thicker the cream preparation, the more difficult it is to spread. Spread diameter is inversely proportional to viscosity, the greater the viscosity, the smaller the spread diameter [24]. The spread diameter is also influenced by the amount of load given, that the greater the load, the wider the spread diameter.

Table 6. Results of Spread diameter Test

Formula	Diameter (cm)		Radius (cm)		Surface area	
	50g	100g	50g	100g	50g	100g
Control	5,5	5,7	2,75	2,85	23,75	25,50
F1	5,8	5,7	2,9	2,85	26,40	25,50
F2	5,6	5,6	2,8	2,8	24,62	24,52
F3	5,7	5,7	2,85	2,8	25,50	24,62

The statistical results show that in the normality test the value of the spread diameter of red dragon fruit extract cream 50g load shows a significance value, the average spread diameter in the experiment is 0.409>0.05 so that the data is normally distributed, followed by a homogeneity test which shows a significance value of 0.475>0.05 so that the data is homogeneously distributed, therefore the data can be analyzed using parametric One Way ANOVA, the significance value is 0.628>0.05 which indicates that the spread diameter of each formula is not significantly different. At 100g load shows a significance value, the average spread diameter in the experiment is 0.28>0.05 so that the data is normally distributed, followed by a homogeneity test which shows a significance value of 0.83>0.05 so that the data is homogeneously distributed, therefore the data can be analyzed using parametric One Way ANOVA, a significance value of 0.964>0.05 is obtained which indicates that the SPF value of each formula is not significantly different.

3.5 Adhesion Test

The adhesion test was conducted to determine the length of time the dragon fruit flesh extract cream (Hylocerus polyrhizus) adhered to the skin, so that the expected therapeutic effect could be achieved. The longer the topical preparation adheres to the skin, the longer it also provides a therapeutic effect. The standard for a good adhesion test is more than 1 second [23]. The results of the adhesion test can be seen in the table below.

Table 7. Adhesion Test

Cream	Stickiness Load 50 g	Stickiness Load 100 g
Control	8,14	12,17[a]
F1	5,34	5,59[b]
F2	7,8	11,27[a]
F3	5,47	6,8[b]

Based on Table 7, it is known that the results of the adhesion test of red dragon fruit extract cream at a load of 50g in Control 8.14 seconds, F1 5.34 seconds, F2 7.8 seconds, F3 5.47 seconds. In the 100g load adhesion test, Control 12.17 seconds, F1 5.59 seconds, F2 11.27 seconds, F3 6.8 seconds. This s in accordance with the standard of a good adhesion test which is more than 1 second [23]. The adhesion of dragon fruit skin extract cream (Hylocerus polyrhizus) has a good adhesion time so that it can adhere longer when applied to the surface of the skin and is expected to provide a longer therapeutic effect.

Statistical results showed that in the 100g load adhesion test, analyzed using parametric One Way ANOVA shows a significance value of 0.000>0.05 was obtained, indicating that the SPF value of each formula was significantly different, therefore the Post Hoc LSD test was continued. The Post Hoc LSD test shows the presence of asterisks in all groups which explains that each group has a significant difference from other groups. The control cream had a significant difference to 0.07% (F1) and 0.28% (F3) extracts. The 0.07% extract (F1) had a significant difference against the control and 0.14% extract (F2). Extract 0.14% (F2) had a significant difference against extract 0.07% (F1) and extract 0.28% (F3). Extract 0.28% (F3) had a significant difference against the control and extract 0.14% (F2).

3.6 Cream Type Test

The cream type test show that all of cream have an oil-in-water (M/A) cream type, this can be seen from the cream that can blend with the added methylen blue. The variation in the emulgator concentration ratio used had no effect on the type of cream emulsion produced. M/A type cream is a cream made by dispersing the oil component into the water component. It is easily washed off with water and if used on the skin there will be evaporation and an increase in the concentration of a water-soluble drug so that it will encourage absorption into the skin tissue [25]. The oil-in-water cream type can provide a hydrating effect on the skin, and is preferred by users. The hydration effect can increase skin permeability so that drug penetration increases and reduces the risk of inflammation [24].

3.7 Viscosity Test

Viscosity testing using a Brookfield DV2T viscometer with spindle no.64 and a speed of 50 rpm. The spindle used until the spindle limit is dipped into the sample, because this can affect the viscosity number that appears on the Brookfield viscometer screen.

Table 12. Viscosity Test Results

Sample	Viscosity Value
Control	656,12 28,16[a]
F1	91,55 ± 0,66[b]
F2	95,38 ± 2,70[b]
F3	105,29 ± 3,54[b]

The control formula has a viscosity value with an average of 656.12 28.16 Cp. In formula 1, 0.07% extract has a lower viscosity value than the base formula which is 91.55 ± 0,66. In formula 2, 0.14% extract has a higher viscosity value than formula 1 0.07% extract, namely with an average value of 95.38 ± 2.70 Cp. The highest viscosity value is in formula 3 0.28% extract with an average value of 105.29 ± 3.54 Cp. The greater the concentration of red dragon fruit flesh extract, the higher the viscosity value. According to SNI 16-4399-1996, the standard viscosity of a good sunscreen cream preparation ranges from 2000-50,000 Cp, so the four formulas do not meet the requirements of good viscosity standards .

The statistical results showed that the parametric One Way ANOVA test obtained a significance value of 0.000>0.05 which indicated that the SPF value of each formula was significantly different. therefore the Post Hoc LSD test was continued. The Post Hoc LSD test showed the presence of asterisks in all groups which explained that each group had a significant difference from the other groups. The control cream had a significant difference from the 0.07%, 0.14% and 0.28% extracts. The 0.07% extract had a significant difference against the control. The 0.14% extract had a significant difference against the control extract. The 0.28% extract had a significant difference against the control.

4 Conclusion

Formulation of red dragon fruit flesh extract cream formulas I, II and III concentrations of 0.07%, 0.14% and 0.28% have good physical characteristics because they meet the requirements on the evaluation of physical characteristics, organoleptics, homogeneity, pH, spread diameter, adhesion. The results of determining the SPF value obtained, namely the control obtained SPF results of 0.618 0.023, formula 1 concentration 0.07% obtained SPF value 1,291 ± 0.007, formula 2 concentration 0.14% obtained SPF value 1,085 ± 0.012, formula 3 concentration 0.28% obtained SPF value 1,072 ± 0.003. The red dragon fruit extract cream preparation formula does not meet the standard category of sunscreen protection value because it has a value below 2. The SPF value of the red dragon fruit flesh extract cream preparation has increased but still does not meet the standard as a good sunscreen cream.

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