

SUN PROTECTION FACTOR TEST OF *Moringa oleifera* LEAF EXTRACT CREAM COMBINED WITH NIACINAMIDE

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ABSTRACT

Moringa (Moringa oleifera) is a plant that contains many antioxidants such as flavonoids, tannins, and polyphenols that can be used to fight free radicals. The addition of niacinamide to moringa leaves processed into cream is expected to optimize the use of moringa leaves. The purpose of this study was to test the physical and organoleptic properties, as well as the SPF value of moringa leaf cream combined with niacinamide. In addition, it was to determine the content of bioactive compounds in moringa leaves. This study was an experimental study. Moringa leaf extract was made by maceration using 70% ethanol with a ratio of 1:6. The independent variables in this study were the concentrations of niacinamide, namely 3% (F1), 4% (F2), and 5% (F3). The dependent variables were the physical properties of the cream (pH, adhesion, spreadability, viscosity, and sun protection factor (SPF)). The SPF value was tested using a UV-Vis spectrophotometer. Next, a cycling test was conducted at temperatures of 4°C and 40°C, including organoleptic, homogeneity, pH, adhesion, and spreadability tests. Based on the physical and organoleptic it is known that the cream falls into the oil-in-water (O/W) category, with a pH range of 4.0-7.0, adhesion >4 seconds, spreadability with a range of 5-7 cm, and a viscosity value of 4,000-50,000 mPa.s. The maximum sun protection factor (SPF) value of the moringa leaf extract cream combined with niacinamide was found in F2 at a concentration of 4%, with a value of 3.178.

Keywords: *Moringa leaf extract, Physical Properties, SPF*

1. INTRODUCTION

Indonesia is a tropical country located on the equator. Indonesia's location on the equator means that the region receives high-intensity sunlight. Exposure to sunlight can cause skin damage due to ultraviolet (UV) radiation (Rahmawati et al., 2018). The skin is a thin layer of tissue that forms the body's natural integumentary system. The skin functions as a barrier to protect the body from external and internal factors that can trigger unwanted biological responses. Prolonged exposure to sunlight without protection can cause skin damage, which can lead to skin cancer, degeneration, and premature aging due to the presence of free radicals (Merin et al., 2022).

Free radicals are foreign substances that enter the body and damage the immune system (Islamiyati et al., 2024). Compounds that have the ability to counteract the effects of free radicals are antioxidant compounds. Antioxidant compounds can be used to fight free radicals, such as UV radiation, because antioxidants can transfer additional electrons to stabilize free radicals. Compounds that can prevent or inhibit oxidation in fats, nucleic acids, or other molecules are called antioxidants (Riskianto et al., 2021). Antioxidants play an important role as natural

moisturizers because of their ability to protect the skin from damage caused by free radicals. These substances help maintain the integrity of the skin layer by preventing the oxidation of lipids, which are important for moisture. Additionally, antioxidants also play a role in repairing damaged skin tissue and stimulating cell regeneration, keeping the skin moisturized and healthy (Michalak, 2022). Various types of plants can be used as sources of antioxidants, one of which is moringa (*Moringa oleifera*).

Moringa is a plant that contains phytochemicals such as tannins, flavonoids, alkaloids, triterpenoids/steroids, and saponins. In addition, moringa leaves are rich in active compounds, including methionine, cysteine, calcium, ascorbic acid, vitamins A, B, and C, as well as phenolic compounds (Shalini & Arora, 2021). Various studies have shown that flavonoids act as antioxidants that can alter or reduce free radicals and also act as anti-free radicals. According to Taebenu et al. (2023), the chromophore group in moringa leaves has the ability to absorb UV radiation at any wavelength. Moringa leaf extract is widely used in skin care products because it has moisturizing and antioxidant properties and has anti-aging effects that support skin health and help reduce the symptoms of premature aging.

This study will formulate a moringa leaf extract cream with a combination of niacinamide. There are two ways that creams protect the skin from ultraviolet rays: by reflecting UV radiation and by absorbing UV rays before they reach the skin. The cream moisturizes the skin, making it feel soft, and is very easy to apply to the entire body. To enhance the cream's functionality, additional ingredients such as niacinamide are needed. Niacinamide is vitamin B3, which can help balance skin tone, tighten and minimize pores, and protect the skin from the effects of UV radiation (Hartini & Haqq, 2024). Niacinamide can also reduce redness caused by sunburn and help heal areas that are exposed to the sun too often. A 5% concentration of niacinamide can treat hyperpigmentation and redness on the face (Ziklo et al., 2024). In this study, moringa leaf cream will be combined with niacinamide as an ingredient in the cream. Niacinamide enhances ceramide synthesis to strengthen the skin barrier, which is prone to damage due to UV-induced dehydration. Moringa extract acts on the “front lines” by neutralizing UV-induced free radicals, while niacinamide acts on the “back lines” by repairing stressed cells and preventing the effects of post-UV exposure. Most previous studies have focused solely on the efficacy of single extracts in absorbing UV radiation. This study offers a novel approach by integrating *Moringa oleifera* extract and focusing on the comprehensive effects of UV protection (antioxidant) designed for the stability of a safe combination of natural and synthetic ingredients.

The ability of a cream to protect the skin can be determined by an SPF test. This study examined the potential of a cream containing moringa leaf extract combined with niacinamide to protect the skin from UV rays. The SPF value of the cream formula can be used to indicate the effectiveness of the cream. SPF is defined as the ratio of UV radiation required to reach the minimal erythema dose (MED) with and without cream protection. The objectives of this study were to test the physical and organoleptic properties, as well as the SPF value of moringa leaf cream combined with niacinamide through in vitro testing and to determine the content of bioactive compounds in moringa leaves.

2. METHOD

2.1. Tools

Evaporating dish, water bath, mortar, rotary evaporator, filter paper, dropper pipette, spatula, stirring rod, reaction tube (Pyrex), 50 ml beaker glass (Pyrex), analytical balance, pH meter (Hanna), object glass and Brookfield viscometer, 50 g and 100 g weights. The instrument used to measure the absorption of samples by UV light with a wavelength of 290-320 nm is a UV-Visible spectrophotometer.

2.2. Materials

Moringa leaves used in this study were obtained from Wonokerso, Hargobinangun, Pakem, Sleman Regency, Daerah Istimewa Yogyakarta Province, Indonesia. To ensure accurate identification, the plant specimens were verified at Biology Laboratory, Universitas Ahmad Dahlan

Several materials were used for cream formulation including 70% ethanol, stearic acid, liquid paraffin, cetyl alcohol, glycerin, span 80, tween 80, nipagin, nipasol, rose oil, titanium dioxide, distilled water, and 3%-5% niacinamide, gelatin, FeCl₃, 10% NaCl, and NaCl.

2.3. Moringa Leaf Preparation

Moringa leaves are separated from the branches and air-dried without direct exposure to sunlight. The air-dried leaves are then dried in an oven at 50°C for 3 hours. Once dry, the leaves are blended into a powder. The resulting powder is sifted again to obtain an excellent moringa powder.

Moringa leaf extract was prepared using the maceration method. A 70% ethanol solution was used to extract moringa leaf powder at a ratio of 1:6. A total of 500 g of powder was dissolved in 3,000 ml of solvent and left for 72 hours (replaced every 24 hours for 3 days). Filtering was carried out using filter paper. The extraction results were concentrated using a vacuum rotary evaporator. After evaporation, the extraction results were placed in a water bath at a temperature of 50°C until a thick moringa leaf extract was obtained.

The concentrated moringa leaf extract obtained was weighed and the yield was calculated.

$$\% \text{ Yield} = \frac{\text{Extract Weight}}{\text{Initial Weigh of Simplisia}} \times 100\%$$

(Thangaiah et al., 2024).

Description :

Initial weight of simplisia : Weight of leaves separated from twigs.

Extract weight : Weight of extract obtained

after performing the evaporation process in a water bath until a thick extract is produced.

2.4. Phytochemical Test

2.4.1. Identification of flavonoid compounds

Thin-layer chromatography (TLC) was used to identify flavonoid compounds. A 1 ml sample was placed in a test tube and mixed with Mg powder and concentrated HCl solution. If a red or orange color appeared, it indicated a positive reaction (Majid et al., 2020).

2.4.2. Identification of tannin and polyphenols

A total of 0.3 g of moringa leaves extract (MLE) was added with 12 ml of heated distilled water, mix, and then let it sit at room temperature. Next, add 2-4 drops of 10% NaCl, stir, and filter. The filtrate is then divided into three 4 ml portions, labeled as solutions A, B, and C. Solution A is used as a blank. For tannin test, solution B is mixed with 5 ml of gelatin solution and 5 ml of 10% NaCl solution. Then it is shaken until homogeneous. The presence of tannin is indicated by the formation of a white precipitate (Majid et al., 2020). For the Ferric chloride test, 1 ml of FeCl₃ solution is added to solution C. After adding the FeCl₃ solution, the color changes to blue-green to black, indicating the presence of polyphenolic compounds (Majid et al., 2020).

2.4.3. Cream Formulation

The prepared ingredients are separated into two categories, ingredients for the oil phase and ingredients for the water phase. The oil phase ingredients consist of liquid paraffin, stearic acid, nipasol, cetyl alcohol, span 80, titanium dioxide, and 3%, 4%, and 5% niacinamide (Table 1). These ingredients are placed in a porcelain dish and heated in a water bath at 70°C until melted. Then the water phase (aquadest, glycerin, nipagin, and tween 80) is heated in a water bath at 70°C until melted.

After both phases are complete, the oil phase is transferred to a mortar and the water phase is added and mixed thoroughly using a mixer until homogeneous. Moringa leaf extract is mixed into the cream base, then niacinamide is added at concentrations of 3% (F1), 4% (F2), and 5%

(F3), along with titanium dioxide and oleum rosae. As a control, a moringa leaf extract cream without niacinamide addition is prepared (control).

Table 1. Formula of Moringa Leaf Extract with Niacinamid

Material Name	Amount (% b/b)			
	F1	F2	F3	Control
Ethanollic Extract of Moringa Leaves	2%	2%	2%	2%
Stearic Acid	3 gr	3 gr	3 gr	3 gr
Cetyl Alcohol	0.6 gr	0.6 gr	0.6 gr	0.6 gr
Span 80	0.45 gr	0.45 gr	0.45 gr	0.45 gr
Tween 80	1.05 gr	1.05 gr	1.05 gr	1.05 gr
Glycerin	2.25 gr	2.25 gr	2.25 gr	2.25 gr
Liquid Paraffin	0.6 gr	0.6 gr	0.6 gr	0.6 gr
Nipagin	0.054 gr	0.054 gr	0.054 gr	0.054 gr
Nipasol	0.006 gr	0.006 gr	0.006 gr	0.006
<i>Oleum rosae</i>	12 drops	12 drops	12 drops	12 drops
Titanium Dioxide	0.21 gr	0.21 gr	0.21 gr	0.21 gr
Aquadest	Add 50	Add 50	Add 50	Add 50
Niacinamide	3%	4%	5%	-

2.5. Evaluation of the Physical Properties of Moringa Leaf Cream and Niacinamid

2.5.1. Organoleptic test

The organoleptic test of the final cream product continued with examining the physical appearance of the cream product, including its visible color, texture by applying it to a watch glass, and smell using the sense of smell. This test was conducted by six people to observe the physical condition of the cream.

2.5.2. Homogeneity test

The homogeneity test is conducted by applying a quantity of moringa leaf cream to an object glass and then spreading it evenly. If the object glass does not contain any coarse particles, the cream is considered homogeneous.

2.5.3. pH test

The purpose of the pH test is to determine the safety level of the cream when used so that it does not irritate the skin. One gram of moringa leaf extract cream is weighed and then diluted using 10 ml of distilled water. Next, the pH is measured using a pH meter by dipping the pH meter into the solution.

2.5.4. Spread test

Weigh 1 g of cream, place it on a glass plate, add a 50 g weight, leave it for 1 minute, then measure the diameter. Add a 100 g weight, leave it for 1 minute, and measure the diameter.

2.5.5. Adhesion test

1 g of cream is placed on a glass plate. Then, another glass plate is placed on top of the sample and the testing device is placed on top. Apply a load of 50 g for 5 minutes. Use a stopwatch to calculate the time required when the glass plate is removed. Next, repeat the same procedure with a load of 100 g.

2.5.6. Viscosity test

The viscosity of the cream was measured using an NDJ-5S Digital Rotary Viscometer and the formula was replicated three times. The moringa leaf cream preparation was poured into a beaker, then spindle number 4 was installed, the speed was set to 12 rpm, and the rotor was activated. The viscosity results appeared and were recorded after the viscometer needle pointed to a constant number.

2.5.7. Physical stability test

The cycling test method was used to test the physical stability of the cream. The cycling test was conducted for six cycles. The cream stability test was conducted at a temperature of 4°C throughout one cycle, then transferred to an oven at a temperature of 40°C for 24 hours. The

physical condition of the preparation was compared before and after. pH, viscosity, and organoleptic properties were observed on day 0 and day 12 as parameters (Rezky Putri et al., 2023).

2.5.8. Emulsion type test

The type of emulsion in cream products is determined by adding a small amount of methyl blue to the product. If it dissolves when stirred, the emulsion is an oil-in-water type. However, if it does not dissolve when stirred, the emulsion is a water-in-oil type.

2.5.9. Determination of SPF value

Take 0.5 g of cream and dilute it with ethanol to 10 ml. Add 1 ml of ethanol to the cuvette to calibrate the UV-Vis spectrophotometer. Ethanol is used as a blank, and an absorption curve with wavelengths between 290 and 320 nm is produced using the solution in the cuvette. Then, at 5 nm intervals, the average absorption value (Ar) is calculated. Equation one is used to obtain the SPF value after the absorption values for each solution concentration are recorded.

Each formula was tested for SPF three times. The data obtained was processed and the SPF value was calculated based on the Mansur method (Damayanti et al., 2024).

$$\text{SPF spectrophotometric} = \text{CF} \times \sum \text{EE } 320 \text{ } 290 (\lambda) \times \text{Abs } (\lambda)$$

Description:

EE : Erythematous effect spectrum

Abs : Absorbance of sunscreen product

CF : Correction factor (10)

I : Solar intensity spectrum

2.6. SPF calculation

The SPF value of the cream was analyzed using the EE x I value at the wavelength. The EE x I constant is presented in Table 2.

Table 2. EE x I Constants at Wavelength

No	Wavelength	EE x I
1	290	0.0150
2	295	0.0817
3	300	0.2874
4	305	0.3278
5	310	0.1864
6	315	0.0839
7	320	0.0180
Total		1

3. RESULTS AND DISCUSSION

In this study, moringa leaves were extracted to extract and separate compounds from the mixture. Moringa leaves were extracted by raising the temperature of the product to its boiling point for a certain period of time. The results of the moringa leaf extraction are as follows (Figure 1).



Figure 1. Results of Moringa Leaf Extract

The weighing results showed that the wet weight of the moringa leaves was 1.333 grams, and the weight of the extract was 238.5 grams, resulting in a yield of 17.89%.

3.1. Physical Property of *Moringa oleifera* Cream

3.1.1. Cream homogeneity

The cream homogeneity test was conducted by observing the cream preparation applied to the object glass to see whether there were any coarse particles. The test results showed that creams F1, F2, F3, and the control were homogeneous.

3.1.2. Cream pH

A pH test is conducted to determine the acidity level of a preparation, especially moringa leaf cream preparations combined with niacinamide. The pH value of the cream preparation must be the same as the pH of the skin so as not to irritate the skin surface. A good pH range is between 4.0 and 7.0 (Lumentut et al., 2020). The test was conducted using a pH indicator, and the results are shown in Table 3.

Table 3. pH test result

Cream	Average±SD
Moringa leaf cream	6.86 ± 0.082
Moringa leaf cream + niacinamid 3%	6.75 ± 0.055
Moringa leaf cream + niacinamid 4%	6.78± 0.133
Moringa leaf cream + niacinamid 5%	6.75±0.055

Based on Table 3, the average pH is classified as good because it is above 4.0. The highest pH value of 6.78 was found in the moringa leaf cream + 4% niacinamide. Meanwhile, the lowest average pH of 5.73 was found in the moringa leaf cream without niacinamide. Statistical show that there is no significant difference in pH values between treatment groups.

3.1.3. Cream type

The cream type test aims to determine whether the cream produced is of the oil-in-water (O/W) or water-in-oil (W/O) type. The cream type test is carried out by adding methyl blue. This method is performed by observing whether the cream preparation becomes uniformly blue after the addition of methyl blue. The results of the cream type test show that all cream formulas are oil-in-water (O/W) type. This is because the cream becomes homogeneously blue when methyl blue is added.

3.1.4. Spreadability

The spreadability test can be performed by weighing 1 gram of cream preparation and placing it on a glass plate. Then, add weights of 50 g and 100 g and leave for 1 minute before measuring the spread diameter. The spreadability of the cream preparation is listed in Table 4.

Table 4. Cream spreadability

Formula	Burden	Average± SD
F1	50g	4.78 ± 0.25
F2	50g	4.71 ± 0.36
F3	50g	4.53 ± 0.31
Control	50g	6.53 ± 0.22
F1	100g	5.11 ± 0.15
F2	100g	5.11 ± 0.11
F3	100g	4.96 ± 0.10
Control	100g	7.05 ± 0.23

Description:

F1: Moringa leaf extract cream formulation with 3% niacinamide combination

F2: Moringa leaf extract cream formulation with 4% niacinamide combination

F3: Moringa leaf extract cream formulation with 5% niacinamide combination

Control: Moringa leaf extract cream formulation without niacinamide.

Based on Table 4, the highest spreading power average was 7.05 cm for moringa leaf cream without niacinamide at a load of 100g. Meanwhile, the lowest spreading power average was

4.53 cm for moringa leaf cream + 4% niacinamide at a load of 50g. Based on the SPSS test, it was found that the spreadability data of the cream was normally distributed and homogeneous because >0.05 , so the ANOVA test was used to determine whether there were significant differences between each treatment. Based on the ANOVA test results, the significance value at a load of 50g was 0.756 and at a load of 100g was 0.050, which means >0.05 , so $p > 0.05$ H_0 is accepted, which indicates that there is no significant difference among the treatment groups.

Some of the moringa leaf extract cream formulas meet the standards, while others do not meet SNI. The spreadability test value that meets SNI No. 06-2588 is 5-7 cm. This is because fluctuations in stearic acid concentration affect the spreadability of the cream. The higher the stearic acid content, the higher the viscosity of the cream, thereby reducing its spreadability and being affected by the weight of the load applied. For moringa leaf cream with a load of 50g, the values are F1; 4.78 cm, F2; 4.71 cm, F3; 4.53 cm, and control; 6.53 cm. Meanwhile, for moringa leaf cream with a load of 100g, the values were F1; 5.11, F2; 5.11, F3; 4.96, and control; 7.05 cm. From this, only the control formulation at a load of 50g and F1, F2, and control at a load of 100g met the spreadability standard. According to (Moraes & Janssen, 2025), a good spreadability test for cream ranges from 5 to 7 cm.

3.1.5. Cream Adhesion

Adhesion testing is conducted to determine how long it takes for the cream preparation to adhere to the skin (Table 5). The longer it takes, the longer the drug will remain effective. The adhesion requirement is >4 seconds (Sari & Islamiyati, 2023).

Table 5. Cream Adhesion

Formula	Burden	Average $\pm$ SD
F1	50g	14.56 $\pm$ 6.16 ^a
F2	50g	10.96 $\pm$ 6.00 ^b
F3	50g	9.87 $\pm$ 2.45 ^b
Control	50g	9.49 $\pm$ 9.11 ^b
F1	100g	20.79 $\pm$ 9.32 ^a
F2	100g	13.34 $\pm$ 16.03 ^b
F3	100g	10.45 $\pm$ 2.84 ^c
Control	100g	10.74 $\pm$ 8.96 ^c

Description: treatments with the same notation or letter indicate no significant difference based on the ANOVA test

F1: Moringa leaf extract cream formulation with 3% niacinamide concentration

F2: Moringa leaf extract cream formulation with 4% niacinamide concentration

F3: Moringa leaf extract cream formulation with 5% niacinamide concentration

Control: Moringa leaf extract cream formulation without niacinamide

Based on the average data from the adhesion test obtained from F1, F2, F3, and Control at a load of 50g, namely F1 with an average value of 14.56 seconds, F2 with an average of 10.96 seconds, F3 with an average of 9.87 seconds, and Control with an average of 9.49 seconds. Meanwhile, the adhesion strength at a load of 100g was as follows: F1 with an average of 20.79 seconds, F2 with an average of 13.34 seconds, F3 with an average of 10.45 seconds, and F4 with an average of 10.74 seconds. The longest adhesion time was F1 at a load of 50g for 14.56 seconds, while at a load of 100g it was 20.79 seconds for F1. The adhesion of the cream has a good range, from which the active ingredients in the cream can be absorbed well.

The results of the adhesion test during the cycling test (cycles 1-6) (Table 6) showed increases and decreases influenced by the storage temperature. This was similar to the spreadability test, in which temperature affected the viscosity of the cream. The lower the viscosity of the cream preparation, the greater its spreadability, but its adhesion decreased. Based on the correlation test, a value of 0.313 was obtained, meaning that the significance value is >0.05 . Therefore, it can be concluded that there is no significant difference between

before and after the cycling test in the adhesion test. The adhesion test results for F1, F2, F3, and the control during the cycling test met the test standards. According to Sari & Islamiyati (2023), for topical application, a sufficient time of more than 4 seconds is required.

Table 6. Adhesion test results Cycling test

Formula	Burden	Before Cycling Test (second)	After Cycling Test (seconds)
F1	50g	8,55	40.05
F2	50g	25,92	13.20
F3	50g	14,68	34.76
Control	50g	9,72	9.47
Average		14,71	24.37
F1	100g	38,10	33
F2	100g	17,33	13.77
F3	100g	24,18	23.12
Control	100g	13,42	31.86
Average		23,25	25.43

3.1.6. Physical Stability

Physical stability testing aims to determine the physical stability of moringa leaf extract cream with a combination of 3%, 4%, and 5% niacinamide. Stability testing was conducted over six cycles (12 days) using the cycling test method. The method used to determine the stability of a product is the cycling test. In this physical stability test, two different temperatures were applied, namely a minimum temperature of 4°C and a maximum temperature of 40°C during one cycle (24 hours) with a total of 6 cycles of preparation (Malik et al., 2020).

3.1.7. Organoleptic properties

The purpose of the organoleptic test is to examine the color, aroma, and texture of the cream using human senses. The organoleptic test of the cream uses a stability test (cycling test) for 6 cycles or 12 days. The organoleptic test results are attached in Table 7.

Table 7. Organoleptic properties of moringa leaf extract cream

Formula	Before Cycling Test			After Cycling Test		
	Color	Smell	Texture	Color	Smell	Texture
F1	Light green	Characteristic rose oil	semi-solid	Light green	typical kelor	Semi-solid
F2	Light green	Characteristic rose oil	Semi-solid	Light green	typical kelor	Semi-solid
F3	Light green	Characteristic rose oil	Semi-solid	Light green	typical kelor	Semi-solid
Control	Light green	Characteristic rose oil	Semi-solid	Light green	typical kelor	Semi-solid

Before the cycling test (cycle 0) and during the cycling test (cycles 1-6) in the organoleptic test, there were no differences. F1, F2, F3, and Control had a light green color, a characteristic oleum roseae odor, and a semi-solid texture. After undergoing a cycling test for 6 cycles, the F1, F2, F3, and control cream preparations did not undergo any changes in color, odor, or texture, leading to the conclusion that F1, F2, F3, and control creams met the physical stability requirements.

3.1.8. Cream Homogeneity

The results of the homogeneity test before and during the cycling test can be seen in Table 8.

Table 8. Homogeneity test results

Cream	Homogeneity (Before cycling test)	Homogeneity (After cycling test)
F1	Homogen	Homogen
F2	Homogen	Homogen

F3	Homogen	Homogen
Control	Homogen	Homogen

The preparation in the cream must be homogeneous and free from particles or granules that are still clumped together. The results of the homogeneity test before and after the cycling test showed that the cream preparation of moringa leaf extract with a combination of 3%, 4%, and 5% niacinamide was homogeneous because there were no granules when applied to the hand. Homogeneity tests conducted both before the cycling test (cycle 0) and during the cycling test (cycles 1–6) showed that the cream's structure remained homogeneous. Furthermore, no separation occurred between the aqueous and oil phases, thereby meeting the stability test standards.

3.1.9. pH Test After Cycling Test

The pH measurement aims to determine whether the cream is safe and does not irritate the skin when applied. The pH test results after the cycling test are attached in [Table 9](#).

Table 9. pH test after cycling test

Cream	Cycle					
	1	2	3	4	5	6
Moringa leaf cream	7.7	7.6	7.8	6.2	5.8	5.6
Moringa leaf cream + niacinamid 3%	7.3	7.5	7.7	6.1	5.8	5.6
Moringa leaf cream + niacinamid 4%	7.2	7.6	7.8	5.9	5.7	5.6
Moringa leaf cream + niacinamid 5%	7.2	7.6	7.7	6.2	6.0	5.8
Average	7.3	7.5	7.7	6.1	5.8	5.6

According to ([Lumentut et al., 2020](#)), the pH requirement for a good topical preparation is in accordance with the natural pH of the skin, which is 4.0-7.0. The test results showed an increase in pH in the second and third cycles and a decrease in the fourth, fifth, and sixth cycles. The decrease in pH value may be due to the separation of substances in the cream preparation that occurs during the cycling test, specifically the decomposition of unsaturated fatty acids from the oil phase of the cream. Based on the correlation test, a value of 0.461 was obtained, meaning that the significance value is >0.05 . Therefore, it can be concluded that there is no significant difference between before and after the cycling test in the pH test. The pH values in the F1, F2, F3, and control cream tests indicate that the cream preparations are within the acceptable pH range.

3.1.10. Spreadability Test After Cycling Test

The results of the spreadability test after the cycling test can be seen in [Table 10](#).

Table 10. Spreadability test results

Formulation	Burden	Spread test (cm)					
		Cycle					
		1	2	3	4	5	6
F1	50g	5.5	5.5	5.6	5.6	7.0	7.3
F2	50g	5.3	4.6	4.1	4.0	5.0	4.5
F3	50g	5.2	4.4	4.5	4.4	5.5	5.5
Control	50g	7.0	6.5	7.5	6.7	6.5	7.0
Average		5.75	5.25	5.42	5.17	6.0	8.1
F1	100g	5.8	5.7	6.0	6.0	7.5	8.0
F2	100g	6.0	5.8	4.3	4.3	4.8	5.5
F3	100g	6.2	5.0	4.6	4.9	5.0	5.7
Control	100g	8.3	8.5	7.8	7.0	7.0	7.5
Average		6.57	6.25	5.67	5.55	6.07	6.67

The results of spreadability testing during the cycling test (cycles 1-6) showed an increase and decrease influenced by the storage temperature. Temperature changes affect the viscosity of the cream, which can alter its spreadability. In addition, this may also be caused by the concentration of niacinamide added. The higher the concentration added, the more concentrated the cream preparation will be, thereby affecting the decrease in spreadability (Lumentut et al., 2020). Based on the correlation test, the results of the spread power test after the cycling test were 0.813 at a load of 50g and 0.361 at a load of 100g, meaning that the significance value was >0.05 . Therefore, it can be concluded that there was no significant difference between before and after the cycling test in the spread power test. The spreadability test of the cream after the cycling test on formulas F1, F2, F3, and the control met the standards for good cream spreadability. A good cream spreadability test is between 5-7 cm (Moraes & Janssen, 2025).

a. Viscosity test results

The viscosity test is conducted to determine the thickness of the preparation obtained. Viscosity is measured using a NDJ5S digital rotary viscometer with a 12rpm spindle. Viscosity is the ability of a liquid to resist deformation due to friction or tensile forces. The requirements for good viscosity are 4,000 cPs-50,000 mPa.s based on SNI 16-4399-1996 (Soba, 2018). Viscosity differences are influenced by several factors, including changes in the dispersion phase conditions, dispersion medium, emulsifiers, other additives, or environmental conditions.

Based on the viscosity test data in Table 11, it is known that F1 has an average of 28.04 mPa.s, F2 has an average of 32.64 mPa.s, F3 has an average of 50.60 mPa.s, and the control has an average of 10.53 mPa.s, which shows that the cream resistance is not too thin and not too thick. All formulas have high viscosity values, ranging from 3,000 to 40,000 mPa.s. These results indicate that the cream has moderate resistance and meets cream quality standards. There are differences between the 3% extract and the 4% extract, 5% extract, and control. The 4% extract has a significant difference compared to the 3%, 5%, and control extracts. The 5% extract has a significant difference compared to the 3%, 4%, and control extracts. The control extract has a significant difference compared to the 3%, 4%, and 5% extracts.

Table 11. Viscosity test results

Formulation	Average $\pm$ SD
F1	Homogen
F1	28.04 ^c $\pm$ 1.804,83
F2	32.64 ^b $\pm$ 1.118,22
F3	50.60 ^a $\pm$ 1.512,75
Control	10.53 ^d $\pm$ 738.02

Statistical tests indicate that all formulas in the normality test show a normal distribution with a p value >0.05 , namely F1 0.463, F2 0.523, F3 0.943, and F4 0.193. Subsequently, a homogeneity test was conducted, yielding results indicating that the data are homogeneously distributed, followed by ANOVA. The ANOVA test for viscosity yielded a significance value of 0.000, meaning there are significant differences among the formulas. The LSD post hoc test indicated that there were notation symbols in all groups, meaning each group had significant differences compared to the other groups. There were differences between the 3% extract and the 4% extract, the 5% extract, and the control. The 4% extract had significant differences compared to the 3%, 5%, and control extracts. The 5% extract showed a significant difference compared to the 3%, 4%, and control extracts. The control extract showed a significant difference compared to the 3%, 4%, and 5% extracts.

b. SPF Test of Moringa Leaf Extract Cream

The SPF value can be determined in vitro using a UV-Vis spectrophotometer and a wavelength of 290-320. This wavelength replaces the wavelength of sunlight. The method developed by Mansur can be used to calculate the SPF value, which is the absorption value taken in the range of 290-320 nm with an interval of 5 nm. The addition of niacinamide does not directly increase the SPF value because the substance's maximum absorption spectrum is at a wavelength of 262 nm (the UV-C region), so it lacks the intrinsic ability to absorb UVB radiation (290–320 nm), which serves as the indicator for the SPF value (Pantea et al., 2023). However, niacinamide can indirectly optimize the SPF efficacy of the formulation through chemical interactions, specifically hydrogen bonding and stacking interactions between the amide groups on its pyridine ring and the aromatic hydroxyl groups of the flavonoids from moringa leaf extract (quercetin and kaempferol). These intermolecular interactions, along with the hydrotropic properties of niacinamide, significantly enhance solubility, prevent the aggregation of phenolic compounds within the emulsion matrix, and form a homogeneous dispersion of active ingredients, thereby protecting moringa flavonoids from premature photodegradation when exposed to UV radiation.

The average obtained based on the data obtained from the SPF tests F1, F2, F3, and F4 is F1 with an average value of 2.197; F2 with an average of 3.178; F3 with an average of 2.209; Control with an average of 2.434 (Table 12). The strength classification of the four moringa leaf cream formulations above falls into the minimum SPF classification, which is between 2-11 (Suhaenah et al., 2019).

Table 12. SPF test results

Cream	Wavelength							SPF value
	290,0	295,0	300,0	305,0	310,0	315,0	320,0	
F1	2.220	2.266	2.209	2.190	2.168	2.160	2.166	2.197 ± 0.056
F2	2.836	3.163	3.250	3.170	3.120	3.165	3.095	3.178 ± 0.029
F3	2.318	2.284	2.232	2.201	2.173	2.157	2.161	2.209 ± 0.060
Control	2.397	2.468	2.459	2.429	2.408	2.402	2.402	2.434 ± 0.017

All four formulas have a minimum cream grade (Figure 2). The SPF value in formula 2 is slightly higher than in formulas 1 and 3, at 3.178 with a 4% niacinamide concentration. This may be due to several factors, such as the F2 formulation with a 4% niacinamide concentration being the optimum point, where the active ingredient is evenly distributed on the skin surface. In formulation F3, the 5% niacinamide concentration results in poor homogeneity or phase separation, preventing the active ingredient from working optimally (Danila et al., 2024). The results of the Sun Protection Factor (SPF) study show that the moringa leaf extract creams in formulations F1, F2, F3, and Control cannot be used as creams because according to SNI 16-4399-1996, the minimum protection factor for creams is 4. This requires the addition of moringa leaf extract to increase effective UV protection. A sunscreen with a pH of 6.78 is considered neutral and safe. This formulation is ideal for maintaining the stability of the active ingredients in the sunscreen, while also being safe for use on the skin without the risk of causing irritation or a burning sensation.

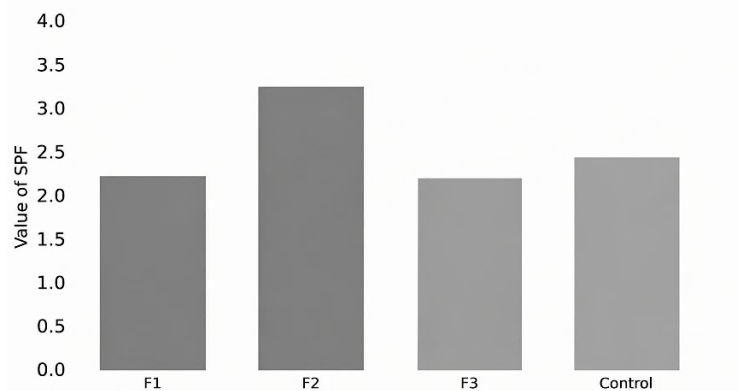


Figure 2. Bar Chart of SPF Test Results

4. CONCLUSION

This study successfully demonstrated that ethanol extract of moringa leaves (*Moringa oleifera*) contains active antioxidant compounds (flavonoids, tannins, and polyphenols), and that all cream formulations combining moringa leaf extract and niacinamide meet the physical quality standards for topical preparations that are stable and safe for the skin. Among all the formulations tested, Formula 2 (F2) with a 4% niacinamide concentration was the most optimal as a sunscreen base because it produced the highest Sun Protection Factor (SPF) value. The optimality of this formula is supported by synergistic interactions, specifically hydrogen bonding and stacking interactions, between the amide groups of niacinamide and the hydroxyl groups of moringa leaf flavonoids, which effectively enhance solubility, prevent the aggregation of active ingredients, and protect phenolic compounds from photodegradation caused by UV exposure. However, since the overall SPF efficacy is still relatively low, it is recommended to increase the concentration of moringa leaf extract in future formula developments to maximize protection against ultraviolet radiation.

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6. CONFLICT OF INTEREST

The author declares that there is no conflict of interest in the conduct of this research.

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