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Sunscreen Cream Formulation of Noni Leaf Extract (*Morinda citrifolia* L.) with Emulsifier Combination of Tween 80 and Lecithin

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Abstract
Background*: Noni leaf (Morinda citrifolia L.) extract is a natural product that can be used as a sunscreen. The extract contains flavonoids which function act as an antioxidant. In this work, sunscreen cream formulated with noni leaf extract was prepared using a combination of tween 80 and lecithin.* ***Objective:*** *The purpose of this study is to evaluate how the combination of tween 80 and lecithin affects the physical qualities of the cream, such as organoleptic, homogeneity, emulsion type, spreadability, adhesion, pH, and stability over 28 days of storage at room temperature, and to find the best formula.* ***Methods:*** *This study used 10% of noni leaf extract in the cream formulation. The Simplex Lattice Design (SLD) method was used to determine the effect of different concentrations of the two emulsifiers on the cream's spreadability, adhesion, and pH. Furthermore, the SLD was used to find the best formula.* ***Results:*** *The results showed that different concentrations of the emulsifier, which are the tween 80 and lecithin combination, affected the physical properties and storage stability of cream preparations. The interaction of tween 80 and lecithin is having a significant impact on the cream's adhesion and spreadability; however, the effect of the interaction on the pH value was not significant.* ***Conclusion:*** *The formula containing 2.5 % tween 80 and 2.5 percent lecithin was found to be the most effective in fulfilling the cream physical properties while remaining stable during storage.*

Keywords*: noni leaf extract (Morinda citrifolia L.), sunscreen, cream, tween 80, lecithin*

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INTRODUCTION

Ultraviolet (UV) rays are one type of radiation emitted by sunlight. UV rays are classified as UV-A (320 - 400 nm), UV-B (290-320 nm), and UV-C (200-290 nm) (Morita, 2018). UV-A and UV-B radiation are important factors in skin ageing (Park *et al*., 2017). Long-term sun exposure can have negative effects on the skin, such as causing degenerative changes in skin cells that lead to premature ageing, sunburn, and skin cancer (Rohmah *et al.*, 2020). Sweating, melanin formation, and other natural mechanisms protect the skin from the harmful effects of sunlight (Putri *et al*., 2019). However, skin tissue can be damaged if the body's defense system is insufficient to protect it from such radiation.

Sunscreen can protect the skin against the harmful effect of UV radiation from the sun. The sunscreen's component(s) can absorb, reflect or scatter the sunlight (Goswami *et al*., 2013). The effectiveness of sunscreen protection against UV rays can be determined by the Sun Protection Factor (SPF) of the range 0 - 100, at which a value of more than 15 is categorized as adequate protection (Mulyani *et al.*, 2015; Suhaenah *et al*., 2019).

The molecular structure of flavonoids contains more than one phenol group (-OH and aromatic groups) and conjugated double bonds to protect against free radicals (Kamilatussaniah *et al*., 2015). The leaf of the noni tree (*Morinda citrifolia* L.) contains more flavonoids than the fruit. According to Rubens *et al*., (2018), the noni leaf has 89.1063 mg/L of rutin flavonoid. Besides flavonoids, other phytochemical compounds are present in the noni leaf extract. Phytochemical screening of noni leaf extract by Ly *et al*. (2020) resulted from maceration on 70% ethanol demonstrates the existence of alkaloids, tannins, triterpenoids, saponins, coumarins, anthraquinones, carotenoids, organic acids, and reducing agents.

In this study, the oil-in-water (O/W) cream was chosen as a sunscreen dosage form because it has advantages such as being comfortable to use, easy to apply, non-sticky, and easy to wash with water compared to ointment or paste preparations (Sharon et al., 2013). In cream preparations, an emulsifier or surfactant is required to stabilize the emulsion. Surfactant is also chemical enhancer to accelerate the absorption of active substances (Ramadon *et al*., 2021). Tween 80 is one of the most commonly used emulsifiers. Tween 80 is used because it is relatively stable to electrolytes, does not irritate the skin, is non-toxic, and can produce stable emulsions (Syamsuddin *et al*., 2016). However, due to its hydrophilic nature, tween 80 molecules can be desorbed from the oil droplet to the aqueous phase, leaving an uncovered region of the oil droplet at the interface and can cause flocculation or coalescence (Athas *et al*., 2014).

The use of a combination of emulsifiers, one more hydrophobic and one more hydrophilic, can improve emulsion stability (Yamashita *et al*., 2017). Tween 80, a hydrophilic emulsifier, can be combined with a more hydrophobic emulsifier, such as lecithin, to improve emulsion stability. With an HLB value of 4, lecithin is less toxic and more biocompatible than polymer surfactants (Chuacharoen *et al*., 2019; Estiasih *et al*., 2015). Lecithin is an emulsifier with two hydrophobic tails, one of which has unsaturated cis bonds, while tween 80 (HLB 15) has 1 oleyl tail with one unsaturated cis bond. The presence of unsaturated cis bonds in the tail of the emulsifier causes the tail to remain flexible and liquid at room temperature. By combining the unsaturated with the saturated bond in lecithin and Tween 80; the tails of the saturated bond tend to stiffen at room temperature; this combination renders flexibility in the molecular organization in the cream formulation. The flexible lecithin and tween 80 tails will help pack the molecules close together. The interactions between the hydrocarbon tails of tween 80 and lecithin include van der Waals forces, whose interactions become more vital when the molecules are close together (Athas *et al*., 2014). The aim of this study was to understand the effect of the combination of emulsifier tween 80 and lecithin on the cream physical properties and to obtain the optimum formulation of the cream containing noni leaf extract.

MATERIALS AND METHODS

Materials

A dry powder of the noni leaf ethanol extract was obtained from PT. Bina Agro Mandiri, Tirtonirmolo, Kasihan, Bantul, Yogyakarta. Ethanol pro analysis were obtained from Merck (Darmstadt, Germany). Liquid paraffin, distilled water, and glycerin were purchased from CV. Sentra Teknosains Indonesia. Stearic acid, cetyl alcohol, methylparaben, and tween 80 were obtained from PT. Brataco, Indonesia. Lecithin was purchased from Tokyo Chemical Industry (TCI) (Japan).

Method

Total flavonoid content

The total flavonoid content was determined using rutin as the standard compound. The measurement was carried out at Gadjah Mada University's Integrated

Research and Testing Institute (LPPT) using a UV-Vis spectrophotometer instrument.

Determination of noni leaf extract SPF value

The noni leaf extract samples were prepared in ethanol at 5%, 10%, and 20% concentrations. The UV absorption of the samples was measured using a UV-Vis spectrophotometer at the wavelength of 290 - 320 nm with 5 nm intervals (Mugitasari & Rahmawati, 2020; Mulyani *et al*., 2015). The Mansur formula in equation (1) (Mansur *et al*., 1986), which was updated by a later researcher (Yulianti *et al*., 2015) was used to determine the Sun Protection Factor (SPF) value. The SPF formula involves the value of the constant of Effectiveness of Erythema due to light (EE x I). The value of EE x I were according to Table 1.

Calculation of SPF value

The SPF value of noni leaf extract was calculated using the Mansur formula:

$$\text{SPF} = CF \times \sum_{290}^{320} EE\ (\lambda) \times I\ (\lambda) \times Abs(\lambda) \quad (1)$$

Information:

EE : The effectiveness of erythema due to UV light at a wavelength of nm

I : Intensity of UV light at wavelength nm

Abs : Extract absorbance

CF : Correction factor (10) (Yulianti *et al*., 2015).

Table 1. EE X I value in calculation of SPF value

No	Wavelength (λ nm)	EE x I
1	290	0.015
2	295	0.0817
3	300	0.2874
4	305	0.3278
5	310	0.1864
6	315	0.0839
7	320	0.018
	Total	1

The EE X I value in calculation of SPF value can be seen in Table 1.

Sunscreen cream formulation

The formula refers to Mugitasari & Rahmawati (2020) research on the formulation of noni leaf extract sunscreen cream using various extract concentrations (Table 2).

The ingredients that will be used in making the cream are weighed first. The oil phase in the (stearic acid, cetyl alcohol, liquid paraffin, and lecithin) was melted in a water bath at a temperature of 70 - 80ºC. The aqueous phase (glycerin, propylene glycol, and tween 80) was dissolved in distilled water heated at a temperature of 70 - 80ºC in a beaker glass. The oil phase is added to the water phase gradually in the stainless bowl and stirred using a mixer at 5800 rpm until a cream is formed. Noni leaf extract powder that has been weighed is put into a mortar and ground until smooth. Half of the distilled water used in the formula was added gradually into the mortar containing the extract and ground until the extract was dissolved. Noni leaf extract, which had been dissolved, was added to the base at 45ºC. The cream is stirred again and put into a closed container (Mugitasari & Rahmawati, 2020; Safitri *et al.*, 2014).

Physical properties test

Emulsion type. The dilution method conducted the test by dissolving the oil-in-water (O/W) cream in water. If the cream is soluble in water, then the cream is O/W type (Elcistia & Zulkarnain, 2018). *Spreadability test*. A total of 0.5 grams of cream was weighed, placed in a round glass, then covered with another glass, and left for 1 minute. The diameter of the spread cream was measured by taking the average diameter from several sides. Then the load is added every 1 minute, 50 grams to 250 grams, and the diameter of the spread is measured (Elcistia & Zulkarnain, 2018).

Table 2. Noni leaf extract cream formula modified from Mugitasari & Rahmawati, (2020)

Ingredients	**Concentration (%*w/v*)**				
	F1	**F2**	**F3**	**F4**	**F5**
Noni leaf extract	10	10	10	10	10
Stearic acid	4	4	4	4	4
Liquid paraffin	10	10	10	10	10
Cetyl alcohol	3	3	3	3	3
Glycerine	10	10	10	10	10
Methyl paraben	0.1	0.1	0.1	0.1	0.1
Tween 80	**5**	**3.75**	**2.5**	**1.25**	**0**
Lecithin	**0**	**1.25**	**2.5**	**3.75**	**5**
Distilled Water	ad 100 mL	ad 100 mL	ad 100 mL	ad 100 mL	ad 100 mL

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The spreadability test requirements for topical preparations are 5 - 7 cm (Mugitasari & Rahmawati, 2020). *Adhesion test*. A total of 0.1 grams of cream was weighed and placed on two glass objects whose area had been determined. Then press with a load of 1 Kg for 5 minutes. The glass object is mounted on the test equipment, and a 20-gram load is dropped. The time was recorded until the two glass objects were released (Elcistia & Zulkarnain, 2018). The adhesion test requirement for topical preparations is 4 seconds (Mugitasari & Rahmawati, 2020). *pH measurement*. A total of 1 gram of cream was weighed and then diluted with 10 mL of distilled water. The pH of the preparation was measured using a pH meter. The pH requirement for good topical preparation is 4.5 - 6.5 (Lumentut *et al*., 2020).

Storage stability test

The stability test of the cream was carried out by storing the cream in a tightly-closed container for 28 days at 75% Relative Humidity and 30°C temperature (Phetmung & Sawatdee, 2019). Changes in the cream physical properties such as organoleptic (color, shape, odor), spreadability, adhesion, and pH were observed. If there is no significant change during the storage period, its characterization remains within acceptable limits, and there is no phase separation, the cream preparation is stable (Dewi *et al*., 2014; Mailana *et al*., 2016).

Data analysis

The Design-Expert programme version 13.0 Trial was used to analyse quantitative data on the physical properties of sunscreen cream, such as spreadability, adhesion, and pH. The stability test results of sunscreen cream, including spreadability, adhesion, and pH after 28 days of storage, were analysed with a 95% confidence level using paired samples T-Test on IBM SPSS Statistic version 25 Trial programme. The data was analysed on the first and 28th days. There is no significant difference during storage if the p-value is greater than 0.05.

Using Design-Expert version 13.0 Trial, the optimum emulsifier composition was determined by inserting the criteria for spreadability, adhesion, and pH that met the requirements for a good cream preparation, and then selecting the formula that approached the highest desirability.

RESULTS AND DISCUSSION

Noni leaf extract total flavonoid content test

This test aimed to determine the total flavonoid content of noni leaf extract powder. According to the results of the tests, a 70% ethanol extract of noni leaves had a total flavonoid content of 4768.18 µg/g, standardized as rutin.

Determination of extract concentration

The concentration of noni leaf extract is being determined in order to determine the concentration of the extract to be used in the preparation of sunscreen cream. According to the results, extracts with concentrations of 5%, 10%, and 20% (equal to 0.024, 0.048, 0.095% flavonoid) in ethanol solvent had SPF values of 39.46, 39.59, and 39.68, respectively. All extract concentrations are ultra-protective, with SPF values greater than 15 (Damogalad *et al*., 2013).

When large quantities of plant-based derivatives are employed to increase the product's effectiveness, the research on the interactions between the active ingredients and the vehicle components should always be considered. Finding the ideal balance between rheological characteristics, such as the usability and stability of the emulsion, and the efficacy of the product, such as the concentration of its active ingredients, is the most difficult task for cosmetic formulators Numerous literature reports discuss how plant extracts' activity decreases when they are combined with topical bases and when stored, which emphasizes the significance of thorough formulation development and optimization process (Almeida *et al*., 2014). In this study, we examined the strength of the tween 80 emulsifier and lecithin in sustaining and supporting the stability of the cream product, so we chose 10% extract rather than 5% extract for our formulation in the tween 80-lecithin emulsion system. Therefore, through this study, we convey that the carrying capacity of the tween 80-lecithin system can still produce stable emulsions at 10% extract, so we predict that this system can be used at lower concentrations.

Initially, the cream was made with extract concentrations of 10% and 20% (Table 3). The sunscreen cream with 10% extract had a smooth texture with no coarse grains. Meanwhile, grains of noni leaf extract powder feel rough on the skin when sunscreen cream with 20% extract is applied. The presence of powder granules in sunscreen cream containing 20% extract is due to the extract powders not being completely dispersed in the emulsion with the emulsifier used. Based on the preliminary results, a concentration of 10% extract was used in subsequent experiments, resulting in an SPF value of 39.57.

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Table 3. Sunscreen cream formula using noni leaf extract 10% and 20%

Ingredients	Concentration (%*w/v*)	
	10% Extract Cream	**20% Extract Cream**
Noni leaf extract	**2**	**4**
Stearic acid	0.8	0.8
Liquid paraffin	2	2
Cetyl alcohol	0.6	0.6
Glycerin	2	2
Methyl paraben	0.02	0.02
Tween 80	0.5	0.5
Lecithin	0.5	0.5
Distilled Water	ad 20 mL	ad 20 mL

Table 4. Organoleptic test results of F1, F2, F3, F4, F5

Organoleptic	F1	F2	F3	F4	F5
Shape	Slightly liquid	Semisolid	Semisolid	Semisolid	Semisolid
Colour	Light green	Light green	Yellowish green	Yellowish green	Yellowish green
Odour	Typical noni leaves	Typical noni leaves	Typical noni leaves	Typical noni leaves	Typical noni leaves
Texture	Smooth	Smooth	Smooth	Smooth	Smooth

Table 5. Spreadability test results of F1, F2, F3, F4, F5

Spreadability	F1 (cm)	F2 (cm)	F3 (cm)	F4 (cm)	F5 (cm)
$\bar{x}$ ± SD	7.45 ± 0.05	6.66 ± 0.15	6.3 ± 0.2	5.61 ± 0.12	4.47 ± 0.13

Organoleptic test

The organoleptic test aims to determine the characteristics of the cream preparations that have been made. The organoleptic test was performed visually by observing the cream preparation's shape, color, smell, and texture (Table 4).

According to observations, all sunscreen creams have a typical noni leaf aroma, a green colour, and a smooth texture. F1 has a slightly liquid consistency. Meanwhile, F2, F3, F4, and F5 have semisolid forms, and the consistency becomes denser as the concentration of lecithin increases. This is due to a lecithin emulsifier in F2, F3, F4, and F5, but not in F1. The presence of lecithin in the oil phase reduces the size of the oil droplets and narrows the particle size distribution, allowing for increased viscosity. Some lecithin molecules can migrate to the aqueous phase and form vesicles, increasing the volume fraction of the dispersion phase in the system and the emulsion's viscosity (Luo *et al*., 2017).

There is a slight colour difference between the formulas due to differences in the composition of the lecithin concentration. Because it lacks lecithin, F1 cream is typically light green. While F5 has the highest concentration of lecithin, the cream is yellowish-green. Lecithin is a brownish-yellow coloured emulsifier (Agu *et al*., 2021). The higher the concentration of lecithin used, the more yellow the cream.

Physical appearance

Physical appearance was used to monitor whether the cream product was smooth, and free of coarse particles or lumps. According to the observations, all formulas were free of coarse particles and lumps.

Emulsion type test

The dilution test of water determines the type of emulsion used in the sunscreen cream. Based on the observations, it was determined that all formulas were soluble in water, implying that all formulas were of the O/W type.

Spreadability test

The spreadability test determines how easily the cream can be used or applied (Lumentut *et al*., 2020). The spreadability test for topical preparations is 5-7 cm (Mugitasari & Rahmawati, 2020). Table 5 shows the results of the spreadability test.

According to the spreadability test results, F2, F3, and F4 have diameters in the range of 5 - 7 cm and thus meet the requirements for good cream spreadability (Mugitasari & Rahmawati, 2020). Meanwhile, F1 does not meet the requirements for good cream spreadability because it has an average of more than 7 cm whereas F5 has an average spread of less than 5 cm. The analysis results using the Simplex Lattice Design method are given in equation (2).

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Table 6. Adhesion test results of F1, F2, F3, F4, F5

Adhesion	F1 (seconds)	F2 (seconds)	F3 (seconds)	F4 (seconds)	F5 (seconds)
$\bar{x}$ ± SD	2.00 ± 0.00	5.00 ± 0.00	5.67 ± 0.58	6.67 ± 0.58	8.33 ± 0.58

$Y = 7.46A + 4.49B + 1.07AB$ (2)

Information:

Y : spreadability (cm)

A : concentration tween 80

B : lecithin concentration

AB : interaction between tween 80 and lecithin

In equation (2), it is discovered that tween 80 has a higher coefficient than lecithin. As a result, tween 80 has a greater effect than lecithin in increasing spreadability.

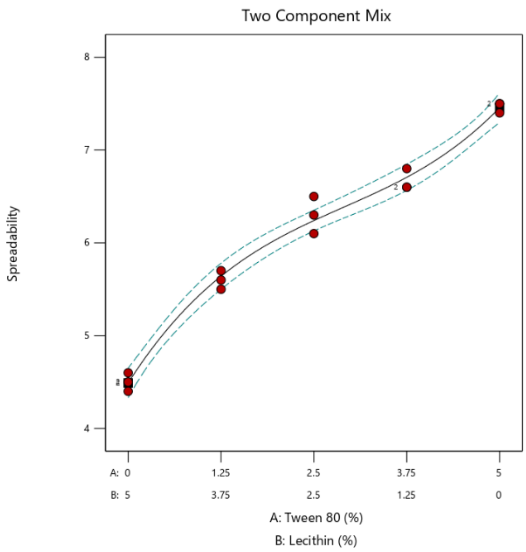

Figure 1. Spreadability test results contour plot graph of F1, F2, F3, F4, F5

According to the contour plot graph in Figure 1, the higher the spreadability value, the higher the concentration of tween 80 and the lower the concentration of lecithin. The spreadability value is inversely proportional to the viscosity; the greater the viscosity, the lower the spreadability value (Yusuf et al., 2017). Lecithin can increase cream viscosity due to the formation of phospholipid vesicles in the aqueous phase (Arancibia *et al.*, 2017). As a result, the higher the concentration of lecithin, the higher the viscosity and the lower the spreadability value.

Adhesion test

The adhesion test aims to determine the cream's ability to adhere to the skin (Mailana *et al.*, 2016). The adhesion test time for good topical preparations must be at least 4 seconds (Mugitasari & Rahmawati, 2020). The results of the adhesion test can be seen in Table 6.

As shown in Table 6, F2, F3, F4, and F5 have met the requirements for good cream adhesion, which are greater than 4 seconds. Meanwhile, F1 does not meet the adhesive power requirements because the stickiness is less than 4 seconds. This has to do with the spreadability of each cream formulation formula. The adhesion value is inversely proportional to the spreadability value—the greater the spreadability, the lower the adhesion value (Lumentut *et al.*, 2020). The analysis results using the Simplex Lattice Design method are given in equation (3).

$Y = 2.03A + 8.37B + 2.67AB$ (3)

The tween 80 coefficient and lecithin have a positive value according to equation (3). As a result, the two emulsifiers affect the adhesion of sunscreen cream preparations. Because lecithin has a higher coefficient than tween 80, it can be said that lecithin has a more significant effect on cream adhesion than tween 80.

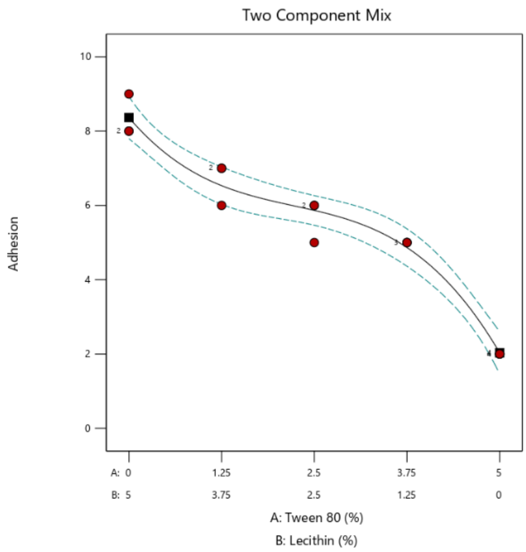

Figure 2. Adhesion test results contour plot graph of F1, F2, F3, F4, F5

The contour plot of the adhesion test results in Figure 2 shows that the higher the concentration of tween 80 and the lower the concentration of lecithin, the lower the adhesion value. The adhesion contour plot has an inversely proportional to the spreadability contour plot. This follows the statement that the greater the spreadability, the lower the adhesive power (Lumentut *et al.*, 2020).

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Table 7. pH value of F1, F2, F3, F4, F5

pH	F1	F2	F3	F4	F5
$\bar{x}$ ± SD	5.07 ± 0.06	5.03 ± 0.06	5.03 ± 0.06	5.1 ± 0.00	5.13 ± 0.06

pH measurement

The pH measurement aims to determine the preparation's pH value in order to meet the pH requirements of topical preparations. A good topical preparation must have a pH between 4.5 and 6.5 (Lumentut *et al*., 2020). A very low pH or acidic preparation can irritate the skin, whereas a high pH or alkaline preparation can make the skin scaly (Iskandar *et al*., 2021). According to Table 7, all formulas met the requirements for the pH of the cream preparation, which ranged from 4.5 to 6.5, and there was no statistically significant difference between each formula.

Storage stability test

The appearance of F4 and F5 changes after 28 days of storage. On day 14, both formulas began to release oil on the surface of the cream preparation. This indicates that the resulting cream is unstable. Because F4 contains more lecithin than tween 80 and F5 only contains lecithin as an emulsifier, oil may be released onto the cream's surface. Excess lecithin concentration cannot be adsorbed at the oil droplet interface, resulting in a less stable emulsion. As a result, when the lecithin concentration is too high, the oil droplets are completely covered, and excess lecithin can cause droplet interactions or coalescence, resulting in the formation of an oil layer on the cream preparation's surface (Dammak & Sobral, 2017). During storage, F1, F2, and F3 have consistent physical appearances. The odour and colour of each formula did not change significantly during storage.

There were significant changes in F1 and F4 marked with a significance value of 0.05 based on the analysis of the spreadability test data on the first and 28th day. Spreadability in F1 is decreasing while spreadability in F4 is increasing. F2, F3, and F5 have significance values greater than 0.05, indicating that there is no significant change in the spreadability of the cream after 28 days of storage. F1 to F4 still had a spreadability value within the required limits of 5 - 7 cm on the 28th day, indicating that they were stable during storage, whereas F5 had a spreadability value of less than 5 cm, indicating that they did not meet the requirements for the cream spreadability value.

There was no significant difference of each formula based on the analysis of the adhesion test data on the first and 28^{th} days. The significance value of each formula indicates this is greater than 0.05. The adhesion test results of each formula still met the requirements for good cream adhesion on the 28^{th} day because it can stick for more than 4 seconds.

There was no significant change in each formula based on the analysis of the pH test data from the first to the 28th day. The pH of all formulas is within the required range of 4.5 - 6.5. As a result, the pH of each formula remained stable after 28 days of storage.

Interaction between lecithin and tween 80

Tween 80 and lecithin may bind strongly at the O/W cream preparation's interface and stabilize the cream. The interaction between the tail and head of each emulsifier results in this tight packaging. Both emulsifiers have hydrocarbon tails; tween 80 has one oleyl tail, and lecithin has two C16 - C18 tails. There is a van der Waals or dispersion force interaction between the hydrocarbon tails, which becomes much more potent when the tails are close. Because of the presence of unsaturated cis bonds in the emulsifier's tail, it remains flexible and liquid at room temperature. On the other hand, Saturated tails tend to stiffen or "freeze" at room temperature. The flexible lecithin and tween 80 tails will aid in packing the molecules (Figure 3a) (Athas *et al*., 2014).

Because of its low HLB, lecithin is hydrophobic and oil-soluble. As a result, when lecithin reaches the O/W cream interface, it has a low tendency to desorb into the aqueous phase and remains on the oil droplets (Figure 3b). The lecithin will cover the oil droplets, preventing the cream preparation from coalescing. Tween 80, on the other hand, provides steric repulsion on oil droplets (Figure 3c). This is due to tween 80's highly water soluble oxyethylene side chain, which prefers to be surrounded by solvent rather than interpenetrated when droplets collide (Athas *et al*., 2014).

If the O/W cream only contains lecithin, there will be only a weak barrier to prevent oil droplet coalescence. If only tween 80 is present, a steric barrier will be present initially, but desorption of tween 80 into the aqueous phase will leave the droplet uncovered, and coalescence may occur (Athas *et al*., 2014). This helps to explain why an emulsifier combination of lecithin and tween 80 is required in the emulsion to ensure the stability of the O/W cream.

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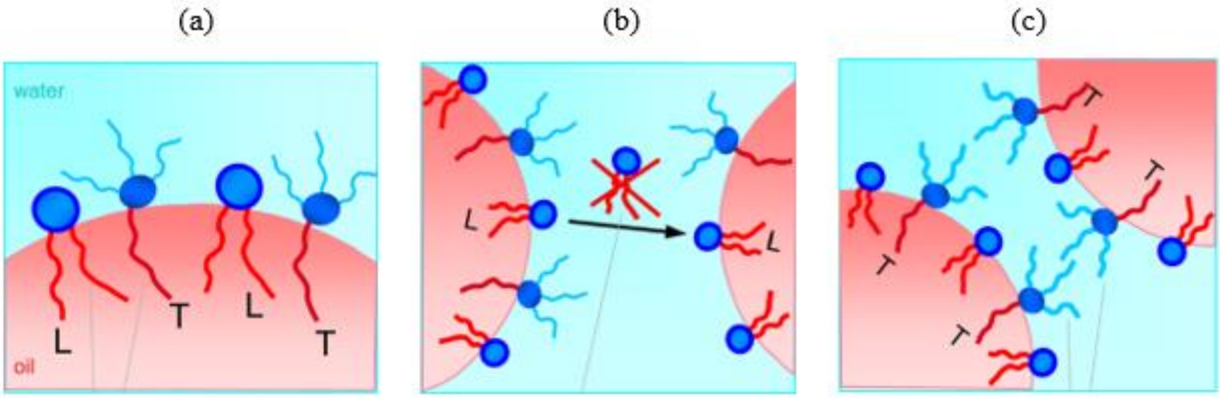

Figure 3. (a) The unsaturated cis tail of tween 80 and lecithin provide a tight packing in the oil droplet. (b) Lecithin does not desorb to the water phase because its low HLB. (c) Tween 80 prevent the droplets from coalescence by steric repulsion (Athas *et al*., 2014)

Determination of optimum composition

The highest desirability value was discovered to be between F3 and F4 based on data analysis using the Design Expert version 13.0 Trial. F3 and F4 are the best formulas based on the desirability value (Figure 4). However, according to the stability test, the oil began to leak from the F4's surface on the 14th day. This indicates that the cream preparation is unstable due to the presence of coalescence, which occurs in the O/W cream preparation, and thus F4 was not chosen as the optimum formula. F3 was selected as the best formula because it has a desirability value close to one and meets the criteria for organoleptic tests, homogeneity, emulsion type, and storage stability.

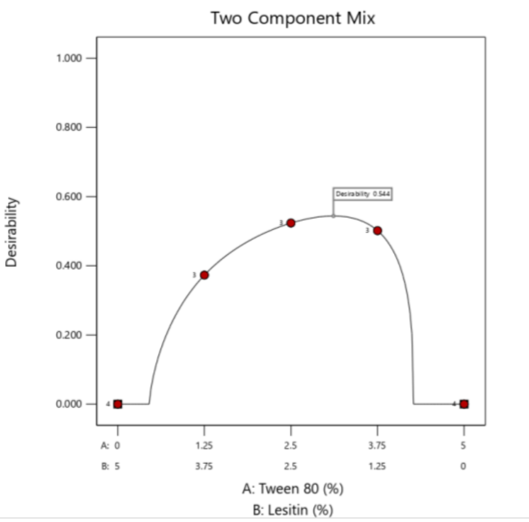

Figure 4. Desirability value of F1, F2, F3, F4, F5

CONCLUSION

Based on the findings, it can be concluded that 10% noni leaf extract is the best extract concentration, with an SPF value of 39.59. The tween 80/lecithin emulsifier combination affects the physical properties and physical stability of the noni leaf extract sunscreen cream, including spreadability and adhesion, but does not affect pH value. F3 with 2.5 % tween 80 and 2.5 % lecithin is a sunscreen cream with an optimal formula that has met the requirements for good cream preparation and good physical stability of the cream based on data analysis and storage stability for 28 days.

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AUTHOR CONTRIBUTIONS

Conceptualization, D. S., B. L.T.; Methodology, D. S.; Software, B. L. T.; Validation, D. S., A. B. S. L.; Formal Analysis, D. S., B. L. T., A. B. S. L.; Investigation, B. L. T.; Resources, D. S., R. D.; Data Curation, B. L. T.; Writing - Original Draft, D. S., B. L. T., A. B. S. L., R. D.; Writing - Review & Editing, D. S.; Visualization, B. L. T.; Supervision, D. S.; Project Administration, D. S.; Funding acquisition, D. S., B. L.T.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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