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Physicochemical Characteristics of Lotion Formulated with Moringa (*Moringa oleifera* L.) Seed Oil and Sunflower (*Helianthus annuus* L.) Seed Oil

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ABSTRACT

Background: Skin damage caused by ultraviolet light and free radicals is a growing health problem in tropical countries such as Indonesia. The demand for natural skin care products with high antioxidant and moisturizing effects has driven the development of vegetable oil-based formulations.
Objective: This study aimed to analyze the effects of varying concentrations of moringa seed oil on the physical characteristics and stability of lotions formulated with a combination of moringa seed and sunflower seed oils.
Methods: This study used a completely randomized laboratory experimental design (CRD). Four formula variations were created with varying moringa seed oil concentrations: 0%, 6%, 9%, and 12%, with a fixed sunflower seed oil concentration of 5%. Physical quality evaluation included organoleptic tests, homogeneity, pH, spreadability, and stability testing for 28 days at temperatures of 25-30°C. Data were analyzed using a one-way ANOVA at a significance level of 0.05.
Results: All formulas produced a homogeneous lotion preparation with a pH ranging from 5.2–5.6 and a spreadability diameter between 5.8–6.8 cm, which are within the standard range for topical preparations. Statistical analysis showed that increasing the concentration of moringa seed oil significantly affected the pH and spreadability of the lotion ($p < 0.05$), but did not affect homogeneity. Over 28 days of storage, no significant changes were observed in the physical parameters, indicating good stability of the preparation. Theoretically, this study strengthens the oil-water phase equilibrium model in the emulsion structure. At the same time, practically, the results contribute to the development of natural cosmetic products based on local ingredients that are safe, effective, and highly competitive in the cosmetic industry market.
Conclusion: The results of this study indicate that moringa seed oil has the potential to be used as a natural active ingredient in cosmetic lotion formulations based on local natural ingredients. A limitation of this study lies in the short storage time. Further research is recommended to include long-term stability tests and quantitative analysis of antioxidant activity to strengthen empirical evidence of the formulation's effectiveness.

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1. Introduction

Indonesia experiences high levels of sun exposure due to its location on the equator, resulting in a tropical climate. High levels of sun exposure can cause skin damage due to ultraviolet (UV) radiation (Sulistiyowati, 2022). UV exposure can cause various skin conditions, including acne, dullness, uneven skin tone, oiliness, premature aging, dark spots, and even skin cancer. Therefore, skin protection is crucial, even though the body has a natural defense system against UV rays and pollution (Adzhani *et al.,* 2022).

One form of additional skin protection is the use of cosmetic products such as lotions containing antioxidants (Herlina *et al.,* 2024). Lotions function as moisturizers and protect the skin from pollution. They also play an important role in protecting the skin from sun exposure. The most popular type of lotion is oil-in-water (O/W) due to its light texture, easy absorption, non-stickiness, and practicality (Pramushita & Hardani, 2021). Antioxidants are compounds that protect the body from cell damage caused by free radicals by donating electrons to produce oxidants (Nurkhasanah *et al.,* 2023). The natural bioactive ingredients used are considered safer than synthetic ingredients, such as the potentially carcinogenic antioxidants BHA and BHT. Natural antioxidants from plant extracts are highly sought after in cosmetics because they can neutralize ROS (Reactive Oxygen Species), maintain skin homeostasis, and prevent premature aging, erythema, and UV damage. In addition to increasing photoprotective activity, antioxidants help prevent the negative effects of sunlight, such as sunburn, irritation, redness, and hyperpigmentation (Nurkhasanah *et al.,* 2023).

Moringa (*Moringa oleifera* Lam) is known as a multifunctional plant due to its economic value and medicinal properties. Almost all parts of the tree have been utilized for nutrition and medicine. Moringa has high antioxidant potential due to its content of carotene, vitamin C, and vitamin E (Seifu & Teketay, 2020; Yulyuswarni & Mulatasih, 2023). The seeds contain 35–40% oil with qualities similar to olive oil and are an edible oil with antioxidant, anti-aging, moisturizing, and skin-lightening properties. Moringa seed oil also has high oxidation stability and a phenolic content of 4.58–4.95 mg/100g seeds, as well as active flavonoids such as catechin, epicatechin, quercetin, and kaempferol (Ayu *et al.,* 2024). The highest antioxidant activity was observed at 8% seed moisture content, with an IC_{50} of 67.4 ppm, which is considered strong. Moringa seed oil has been successfully formulated into a lotion at a concentration of 12% (Yulyuswarni, 2021) and a cream at 25% (Athikomkulchai *et al.,* 2021). Moringa seed oil is more resistant to oxidation than other oils, such as olive oil. Moringa seed oil has protective characteristics from UV rays and is recommended for maintaining natural epidermal pigmentation (Fue *et al.,* 2021; Shahbaz *et al.,* 2024).

In addition to moringa seed oil, sunflower seed oil (*Helianthus annuus* L.) is also rich in antioxidants, containing omega-6, omega-9, vitamin E, tocopherol, lecithin, carotenoids, and β-sitosterol, which play a role in maintaining healthy skin, accelerating wound healing, and protecting against free radicals (Pramushita & Hardani, 2021). Its antioxidant activity is quite strong, with an IC_{50} of 88.372 µg/mL and a vitamin E content of 58.7 (Susanti *et al.,* 2020). Research by Zenny (2022) shows that a sunflower seed oil-based lotion at a concentration of 5–10% can increase SPF.

Several studies have reported the success of lotion formulations that use moringa seed oil as the primary active ingredient. For example, research conducted by Yulyuswarni (2021) showed that the use of moringa seed oil in lotion formulations can produce stable preparations with physical characteristics that meet cosmetic quality standards. However, most of this research still focuses on using moringa seed oil alone. Studies examining the combination of moringa seed oil with other vegetable oils as an emulsion system in lotion formulations are relatively limited. Furthermore, studies quantitatively analyzing the effect of varying moringa seed oil concentrations on the physical characteristics of lotions combined with sunflower seed oil are also rare. However, the combination of these two oils has the potential to provide a synergistic effect in improving emulsion stability while enriching the bioactive content in cosmetic preparations.

Based on this background, this study aims to analyze the effect of varying moringa seed oil concentrations on the physical characteristics and stability of lotions formulated with a combination of moringa seed oil (*Moringa oleifera* L.) and sunflower seed oil (*Helianthus annuus* L.). *The novelty of this study lies in the formulation and physicochemical evaluation of a lotion combining moringa seed oil and sunflower seed oil, with systematic variation of moringa seed oil concentration to determine its effect on lotion characteristics and stability.*The results of this study are expected to provide scientific contributions in the development of natural ingredient-based cosmetic formulations that are stable, safe, and have the potential to be developed as local resource-based skin care products.

2. Methods

2.1 Research design

This study was a laboratory experiment with a completely randomized design (CRD). Four lotion formulas were created with varying concentrations of moringa seed oil (0%, 6%, 9%, and 12%) combined with 5% sunflower seed oil as the active ingredient. Test parameters included homogeneity (visual inspection), pH (using a digital pH meter), and spreadability (gradual loading method). Data were analyzed using a one-way ANOVA test with a significance level of 0.05 to determine the effect of each formula on physical parameters.

The equipment used included beakers, a hand blender, a spatula, a dropper, an analytical balance, a hot plate, a watch glass, a 10x10 glass, a digital pH meter, weights, a lotion tube, a vernier caliper, and a glass slide. The materials used were moringa seed oil, sunflower seed oil, stearic acid, cetyl alcohol, liquid paraffin, glycerin, phenoxyethanol, xanthan gum, triethanolamine (TEA), vitamin E (tocopherol), strawberry fragrance, and distilled water.

Table 1. Lotion formula combining moringa seed oil and sunflower oil.

Ingredient	Formula (%)			
	F0	F1	F2	F3
Phase A				
Moringa seed oil	0	6	9	12
Sunflower oil	5	5	5	5
Stearic acid	3	3	3	3
Liquid paraffin	7	7	7	7
Cetyl alcohol	2.5	2.5	2.5	2.5
Phase B				
Glycerin	3	3	3	3
Phenoxyethanol	1	1	1	1
Xanthan gum	1	1	1	1
Aquadest	Ad 100	Ad 100	Ad 100	Ad 100
Phase C				
Tocopherol	1	1	1	1
Strawberry Fragrance	3 drops	3 drops	3 drops	3 drops
TEA	qs	qs	qs	qs

2.2 Lotion Manufacturing Procedure

The lotion making process is carried out by melting phase A (oil phase), consisting of moringa seed oil, sunflower seed oil, stearic acid, liquid paraffin, and cetyl alcohol, heated at a temperature of 70-75 °C until all components melt. Disperse xanthan gum with glycerin until homogeneous, put it in a beaker glass containing distilled water and phenoxyethanol. Heat phase B (water phase) until both phases are at the same temperature (70-75 °C), add phase B into phase A, stir with a hand blender until a homogeneous emulsion is formed. Stir continuously until the temperature drops to around 40 °C, then add tocopherol (Vitamin E) and strawberry fragrance. Check the pH, adjust the pH with TEA so that the pH is obtained according to the physiological pH of the skin (4.5-6.5). Each formula is made with 3 repetitions. The preparations obtained are then evaluated for quality testing. including:

1. Organoleptic Test

Organoleptic tests are conducted to visually describe the lotion preparation for color, aroma, and texture.

2. Homogeneity Test

The homogeneity test is conducted to assess the uniformity of the lotion preparation particles and ensure that all ingredients are evenly dispersed. The homogeneity test is performed by applying 0.5 grams of the preparation to a glass slide, then covering it with another glass slide, and observing the homogeneity of the preparation. The preparation is considered homogeneous if there are no coarse or clumpy particles and the color is evenly dispersed.

3. pH Test

The pH test aims to determine the acidity and base level of the preparation. Cosmetic preparations should be within the physiological pH range of 4.5-6.5 for the skin. The pH test is performed by dissolving 1 gram of the preparation in 9 ml of distilled water, then dipping a calibrated digital pH meter into the preparation. Wait until the reading on the instrument stabilizes and stops moving; the reading indicates the pH value of the preparation.

4. Spreadability Test

The spreadability test aims to determine the spreadability of the lotion when applied to the skin. A 1 gram of lotion is placed between two 10x10 cm glass slides and a 125 gram load is applied for 1 minute. The spread diameter is measured.

5. Stability Test

The stability test is conducted to assess the physical stability of the preparation during storage at room temperature (25-30°C) for 28 days. Observations are made on days 0, 7, 14, 21, and 28. Observations include organoleptic, pH, and spreadability.

3. Result and Discussion

3.1 Organoleptic, homogeneity and pH test results

The results of organoleptic observations, homogeneity, and pH of the lotion preparation combination of moringa seed oil (*Moringa oleifera* L.) and sunflower seed oil (*Helianthus annuus* L.) are presented in Table 2. Based on Table 2, the organoleptic properties show that F0, the formula without moringa seed oil and 5% sunflower oil, produces a white color, while formulas F1 and F2 are ivory yellow, and F3 is light yellow. The color difference occurs as the concentration of moringa seed oil in the formula increases. All formulas provide a strong strawberry aroma and an easy-to-pour texture, similar to the texture of lotion. This yellowish color is thought to originate from the natural pigments in moringa seed oil, such as carotenoids and phenolic compounds that naturally give a distinctive color to vegetable oil-based cosmetic preparations (Seifu & Teketay, 2020).

Table 2. Organoleptic, homogeneity and pH of the lotion preparation combining moringa seed oil and sunflower oil

Formula	Organoleptic			Homogeneity	pH (Mean ±SD)	Criteria
	Color	Odor	Texture			
F0	White	Strong characteristic strawberry aroma	Thick, easy to pour	Homogeneous	5.20 ±0.02	MS
F1	Ivory yellow	Strong characteristic strawberry aroma	Thick, easy to pour	Homogeneous	5.30±0.01	MS
F2	Ivory yellow	Strong characteristic strawberry aroma	Thick, easy to pour	Homogeneous	5.50±0.01	MS
F3	Light yellow	Strong characteristic strawberry aroma	Thick, easy to pour	Homogeneous	5.6±0.02	MS

Note: pH requirement: 4.5-6.5, MS= meet the standards
F0 = Lotion formula without moringa seed oil and 5% sunflower oil
F1 = Lotion formula with 5% sunflower oil and 6% moringa seed oil
F2 = Lotion formula with 5% sunflower oil and 9% moringa seed oil
F3 = Lotion formula with 5% sunflower oil and 12% moringa seed oil

All formulas exhibited a distinctive strawberry aroma and a thick texture but easy to pour, which aligns with the characteristics of oil-in-water (O/W) emulsion lotions. This type of lotion is widely used in cosmetic formulations due to its light texture, easy absorption, and non-sticky feel (Pramushita & Hardani, 2021).

Homogeneity test results showed that all formulas produced a homogeneous preparation without any coarse particles or phase separation. This indicates that the emulsion system formed was able to disperse all components evenly within the preparation. This homogeneity stability indicates that the combination of emulsifying agents such as stearic acid and triethanolamine was able to form a stable emulsion system between the oil and water phases (Tranggono & Fatimah, 2007).

The pH values of the lotions in all formulas ranged from 5.20 ± 0.02 to 5.60 ± 0.02, which is still within the physiological skin pH range of 4.5–6.5. A pH value appropriate to skin conditions is crucial for maintaining the skin's protective barrier and preventing irritation (Nurkhasanah *et al.,* 2023). Statistical analysis using One-Way ANOVA showed significant differences in pH values between formulas ($p < 0.01$; $\eta^2 = 0.82$).

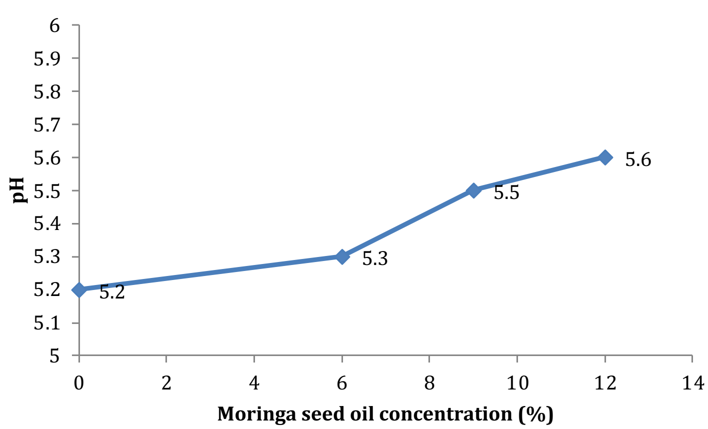

Figure 1. Relationship between moringa seed oil concentration and lotion pH.

Based on the graph in Figure 1, the pH value appears to increase with increasing concentration of moringa seed oil. This is thought to be related to the oil's chemical composition, which contains bioactive compounds such as fatty acids and phenolic compounds that can influence the chemical characteristics of the emulsion system (Fu *et al.,* 2021). This finding is in line with research by Yulyuswarni (2021), which reported that increasing the concentration of moringa seed oil in lotion formulations can affect the physical characteristics of the preparation, including pH, but that the resulting values remain within the safe range for topical application.

3.2 Spreadability evaluation

The results of the spreadability test of the combination lotion preparation of moringa seed oil and sunflower seed oil are presented in Table 2.

Table 2. Spreadability test of the combination lotion preparation of moringa seed oil and sunflower oil

Formula	Moringa seed oil concentration	Spreadability diameter (cm) ± SD	Requirement (cm)	Criteria
F0	0	6.8±0.05	5-7	MS
F1	6	6.5±0.07		MS
F2	9	6.2±0.06		MS
F3	12	5.8±0.08		MS

Note: Requirement: 5-7, MS= meet the standards

The spread diameter of the lotion ranged from 5.8 ± 0.08 cm to 6.8 ± 0.05 cm, still within the standard spread range for topical lotion preparations (5–7 cm). This indicates that all formulas have good spreadability when applied to the skin surface.

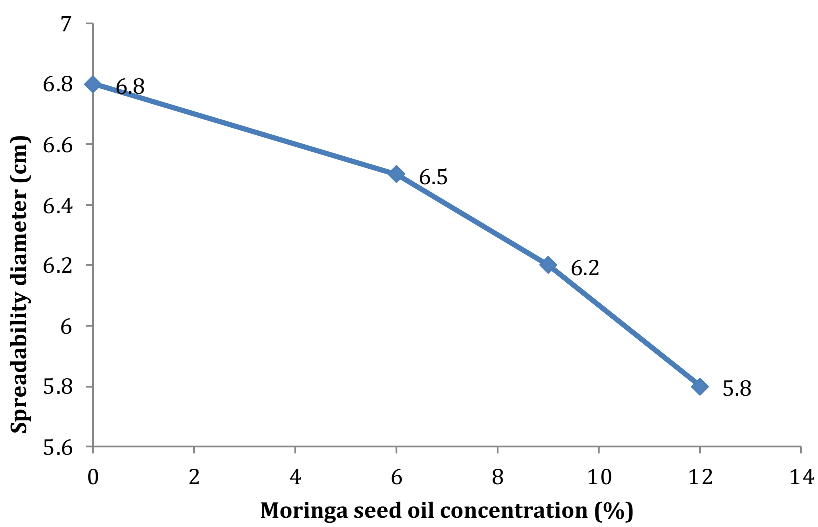

Figure 2. Relationship between moringa seed oil concentration and lotion spreadability.

The highest spreadability was found in the control formula F0, at 6.8 cm, while the lowest spreadability was found in formula F3, with a 12% moringa seed oil concentration, at 5.8 cm. These results indicate that increasing the concentration of moringa seed oil in the formulation decreases the lotion's spreadability.

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Statistical analysis using one-way ANOVA showed a significant difference between the formulas ($p < 0.05$; $\eta^2 = 0.78$). The Pearson correlation test showed a strong negative relationship between moringa seed oil concentration and lotion spreadability ($r = -0.93$; $p < 0.01$). This indicates that the higher the concentration of moringa seed oil in the formulation, the lower the lotion's spreadability.

This decrease in spreadability is thought to be related to the increased viscosity of the emulsion system due to the addition of the oil phase in the formulation. The higher the oil concentration in the emulsion system, the greater the viscosity of the preparation, thereby limiting molecular mobility and decreasing the preparation's spreadability (Ulandari & Sugihartini, 2020). This phenomenon is also in line with the emulsion system theory, which states that increasing the oil phase ratio in an oil-in-water emulsion can increase the viscosity of the system and reduce the spreadability of the preparation (Tian *et al.,* 2022). Thus, the balance between the oil and water phases is an important factor in determining the physical characteristics of lotion preparations.

3.3 Stability evaluation results

Results of stability evaluation of the combination lotion preparation of moringa seed oil and sunflower oil at room temperature for 4 weeks (Table 3). The results of stability tests during 4 weeks of storage at room temperature (25-30°C) showed no changes in organoleptic parameters, pH, or spreadability throughout the formula. The pH value was stable with a variation of less than 2%, and the spreadability did not show significant differences during the storage period. This pH stability indicates that there was no degradation of the active components or significant chemical changes in the emulsion system during the storage period.

Increasing the concentration of moringa oil causes the viscosity of the system to increase, so that the mobility of water molecules decreases and the ability of the lotion to spread decreases (Ulandari & Sugihartini, 2020). This supports the oil-water phase emulsion equilibrium model, where a higher oil phase ratio increases viscosity and decreases the ability of the emulsion to spread (Tian *et al.,* 2022). This finding is also in line with the emulsion theory according to Harborne, (1998) in (Tranggono & Fatimah, 2007) which emphasizes the balance between the oil and water phases as a determining factor in the stability of the preparation. According to Yulyuswarni, (2021) and Susanti *et al.* (2020) vegetable oil has the ability to maintain moisture and stability of topical preparations. However, the results differ from (Ayu *et al.,* 2024) who reported an increase in antioxidant activity without a decrease in spreadability. This difference is likely influenced by variations in the composition of the emulsifier and manufacturing conditions. The results of this study are in line with the study of Yulyuswarni (2021) who reported that lotion formulations with A 12% concentration of moringa seed oil produces optimal emulsion stability and pH. Similarly, research by Zenny (2021) shows that a combination of sunflower seed oil at 5–10% concentrations increases the SPF value without compromising the physical stability of the lotion.

Parameter	Formula	Weeks			
		1	2	3	4
Color	F0	White	White	White	White
	F1	Ivory yellow	Ivory yellow	Ivory yellow	Ivory yellow
	F2	Ivory yellow	Ivory yellow	Ivory yellow	Ivory yellow
	F3	Light yellow	Light yellow	Light yellow	Light yellow
Aroma/ Odor	F0	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma
	F1	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma
	F2	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma
	F3	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma	Strong characteristic strawberry aroma
Texture	F0	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour
	F1	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour
	F2	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour
	F3	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour	Thick, easy to pour
Homogeneity	F0	Homogeneous	Homogeneous	Homogeneous	Homogeneous
	F1	Homogeneous	Homogeneous	Homogeneous	Homogeneous
	F2	Homogeneous	Homogeneous	Homogeneous	Homogeneous
	F3	Homogeneous	Homogeneous	Homogeneous	Homogeneous
pH	F0	5.2	5.2	5.2	5.2
	F1	5.3	5.3	5.3	5.3
	F2	5.5	5.5	5.5	5.5
	F3	5.6	5.6	5.6	5.6
Spreadability (cm)	F0	6.8	6.8	6.8	6.9
	F1	6.5	6.6	6.8	6.8
	F2	6.2	6.2	6.5	6.6
	F3	5.8	5.8	6.0	6.2

Based on the research data above, it shows that variations in the concentration of moringa seed oil have a significant effect on pH and spreadability, but do not affect the homogeneity and physical stability of the preparation when stored at room temperature (25-30 °C) for 4 weeks. All formulas (F0-F4) meet the requirements for lotion preparations. The combination of moringa seed oil and sunflower seed oil in lotion formulations has the potential to be an effective alternative natural active ingredient in the development of natural-based cosmetic products.

4. Conclusion

Based on the research results, it can be concluded that all formulas meet the requirements for lotion preparations. Increasing the concentration of moringa seed oil significantly affected pH and spreadability, but did not affect homogeneity. The combination of the two oils produced a stable, easy-to-apply lotion preparation. The results of this study indicate that moringa seed oil has the potential to be used as a natural active ingredient in cosmetic lotion formulations based on local natural ingredients. A limitation of this study lies in the short storage time. Further research is recommended to include long-term stability tests and quantitative analysis of antioxidant activity to strengthen empirical evidence of the formulation's effectiveness.

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