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FORMULATION AND EVALUATION OF SUNSCREEN LOTION

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ABSTRACT

Exposure to sunlight can trigger various biological responses ranging from sunburn, Erythema to skin cancer. Synthetic sunscreen formulation available in the market poses variety of adverse effects. Therefore formulation of herbal sunscreen formulation and evaluation of its sun protection activity is an important aspect in the cosmetic industry. The aim of the present study was to formulate and evaluate the sun protection factor of poly herbal sunscreen cream. In this study five sunscreen creams were formulated using various herbal oils and tested for physiochemical parameters such as color, spreadability, viscosity, limit test for lead, consistency, odour, appearance.[1,2,3] Studies like thermal stability, phase separation, liquefaction, centrifugation to check stability and patch test for irritancy were done.

KEYWORDS: *Sunscreen lotion, natural ingredients, Aloe gel, Olive gel, Rose oil, Zinc oxide, Vitamin E, SPF, skincare, formulation, evaluation.*

INTRODUCTION

Background and Rationale

The increasing awareness of the harmful effects of ultraviolet (UV) radiation has heightened the demand for effective sunscreens. UV radiation, particularly UVA and UVB rays, can cause acute effects such as sunburn and long-term consequences including premature skin aging, DNA damage, and an increased risk of skin cancer. While conventional sunscreens provide essential protection, they often contain synthetic chemicals that may cause skin irritation, allergies, and other adverse effects. As a result, there is a growing consumer preference for sunscreens formulated with natural ingredients that offer safe and effective sun protection without the potential side effects associated with synthetic compounds.

Natural Ingredients in Sunscreen Formulation

This study focuses on the development of a sunscreen lotion using a combination of natural ingredients known for their beneficial properties:

- Aloe Gel: Aloe vera is renowned for its soothing, anti-inflammatory, and moisturizing properties. It is widely used in skincare products to calm and hydrate the skin, making it an ideal ingredient for sunscreen formulations.
- Olive Gel: Olive oil is rich in antioxidants, particularly Vitamin E, and provides deep hydration and nourishment to the skin. It also helps in maintaining skin elasticity and combating the effects of aging.
- Rose Oil and Rose Water: Rose oil and rose water are valued for their anti-inflammatory, astringent, and aromatic qualities. They help to soothe the skin, reduce redness, and impart a pleasant fragrance to the product.
- Zinc Oxide: Zinc oxide is a well-established physical sunscreen agent that provides broad-spectrum protection by reflecting and scattering UV radiation. It is considered safe and effective, causing minimal skin irritation.
- Cetyl Alcohol and Glycerine: These ingredients serve as emollients and humectants, enhancing the lotion's texture, spreadability, and moisturizing effects. Cetyl alcohol also helps to stabilize emulsions.
- Vitamin E: Known for its antioxidant properties, Vitamin E protects the skin from oxidative stress and helps to maintain skin health.
- Hydroxypropyl Methylcellulose (HPMC): HPMC is used as a thickening agent to achieve the desired consistency in the lotion, ensuring a smooth application.
- Distilled Water: Distilled water serves as a solvent and provides the necessary aqueous base for the formulation.

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Objectives of the Study

The primary objective of this research is to formulate and evaluate a sunscreen lotion that combines the aforementioned natural ingredients to provide effective sun protection while offering additional skin benefits. The specific objectives include:

1. Developing a stable and homogenous sunscreen lotion formulation using natural ingredients.
2. Assessing the physical stability of the formulated lotion to ensure it maintains its integrity over time.
3. Evaluating the pH of the lotion to confirm its compatibility with skin.
4. Testing the spreadability of the lotion to ensure it can be applied smoothly and evenly.
5. Determining the sun protection factor (SPF) of the lotion to verify its efficacy in protecting against UV radiation.
6. Conducting sensory evaluations to assess user satisfaction regarding texture, absorption, and overall skin feel.

Ingredients, Equipment, and Procedures

Ingredients

1. Aloe Gel (10%): Provides moisturizing and soothing properties.
2. Olive Gel (5%): Rich in antioxidants and provides deep hydration.
3. Rose Oil (2%): Offers anti-inflammatory and aromatic benefits.
4. Rose Water (10%): Adds soothing, astringent properties, and fragrance.
5. Zinc Oxide (15%): Acts as the primary UV filter for broad-spectrum protection.
6. Cetyl Alcohol (3%): Functions as an emollient and stabilizer.
7. Glycerine (5%): Serves as a humectant to attract moisture to the skin.
8. Vitamin E (1%): Provides antioxidant benefits.
9. Hydroxypropyl Methylcellulose (HPMC) (1%): Used as a thickening agent to achieve the desired consistency.
10. Distilled Water (48%): Serves as the solvent and aqueous base for the formulation.

Equipment

1. Precision Balance:
2. Beakers:
3. Stirring Rods:
4. Magnetic Stirrer with Hot Plate:
5. Homogenizer:
6. pH Meter:
7. Viscometer:
8. SPF Testing Equipment:
9. Storage Containers:
10. Glass Thermometer:
11. Spatulas:
12. Sonicator:

Procedures

1. Preparation of Aqueous Phase:
   - Measure 48% distilled water into a clean beaker.
   - Gradually add 1% HPMC to the water while stirring to prevent clumping. Use a magnetic stirrer for uniform mixing.
   - Once fully dispersed, allow the mixture to hydrate for about 30 minutes.

2. Preparation of Oil Phase:
   - In another beaker, measure and combine 3% Cetyl alcohol and 5% Glycerine.
   - Add 5% Olive gel and 2% Rose oil to the mixture.
   - Heat the oil phase gently on a hot plate to about 70°C to melt the Cetyl alcohol, stirring continuously.

3. Combining Phases:
   - Heat the aqueous phase to the same temperature as the oil phase (approximately 70°C).
   - Slowly add the oil phase to the aqueous phase while continuously stirring with a magnetic stirrer to form an emulsion.
   - Use a homogenizer to ensure a stable and uniform emulsion. Continue homogenizing for 5-10 minutes.[4]

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4. Cooling Phase:
- Allow the emulsion to cool down to room temperature gradually while stirring continuously to prevent phase separation.
- Once the mixture has cooled to around 40°C, add 10% Aloe gel and 10% Rose water. Stir well to integrate these ingredients.[5]

5. Incorporation of Active Ingredients:
- Once the mixture reaches room temperature, add 15% Zinc oxide to the emulsion. Ensure it is evenly dispersed by using a homogenizer.
- Add 1% Vitamin E and mix thoroughly.

6. Final Adjustments and Quality Control:
- Check the pH of the formulation using a pH meter. Adjust the pH if necessary to ensure it falls within the skin-friendly range of 5.5 to 6.5.
- Assess the viscosity of the lotion using a viscometer. Adjust the consistency if necessary by altering the amount of HPMC or other thickeners.
- Perform physical stability tests by storing samples at various temperatures (e.g., 4°C, room temperature, 40°C) and checking for any signs of phase separation over time.

7. SPF Testing:
- Determine the SPF of the formulated sunscreen lotion using appropriate SPF testing equipment, following standardized protocols such as in vitro UV spectrophotometry or in vivo testing on human volunteers.

8. Sensory Evaluation:
- Conduct sensory evaluations to assess user satisfaction regarding texture, absorption, and overall skin feel. Collect feedback from a panel of volunteers and make any necessary adjustments to the formulation based on their input.

9. Packaging and Storage:
- Transfer the final sunscreen lotion into clean, airtight storage containers to prevent contamination and oxidation.
- Label the containers with the formulation details and storage instructions.

Formula

Sr.No.	Ingredients	Quantity Taken (ml)	Category
1	Aloe Gel	5 ml	Soothing
2	Olive Gel	2.5 ml	Anti-oxidant
3	Rose Oil	1 ml	Aromatic
4	Rose water	5 ml	Fragrance, Astringent
5	Zinc oxide	7.50 ml	Protection
6	Cetyl Alcohol	1.50 ml	Emollient, Stabilizer
7	Glycerine	2.5 ml	Humectant
8	Vitamin E	0.5 ml	Anti-oxidant
9	HPMC	0.5 ml	Thinking Agent
10	Distilled water	Upto 50 ml	Solvent, Aqueous Base

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Detailed Information on Each Ingredient

1. **Aloe Gel**[6]

Taxonomical Information:
- Botanical Name: Aloe vera (L.) Burm.f.
- Family: Asphodelaceae
- Common Names: Aloe, Burn plant, Lily of the desert

Physiological Information:
- Part Used: Gel extracted from the inner leaf
- Active Compounds: Polysaccharides (e.g., acemannan), vitamins, amino acids, enzymes, minerals, and anthraquinones

Pharmacology:
- Primary Effects: Anti-inflammatory, antimicrobial, antioxidant, and wound healing
- Mechanism of Action: Aloe vera's polysaccharides promote hydration and stimulate fibroblast activity, enhancing collagen synthesis and wound healing. Its antioxidants scavenge free radicals, reducing oxidative stress.

Traditional Uses:
- Historical Use: Used for treating burns, wounds, skin irritations, and digestive issues in traditional medicine systems like Ayurveda and traditional Chinese medicine.

2. Olive Gel

Taxonomical Information:
- Botanical Name: Olea europaea L.
- Family: Oleaceae

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- Common Names: Olive, European olive
Physiological Information:
- Part Used: Oil extracted from the fruit (used to make gel)
- Active Compounds: Oleic acid, polyphenols (e.g., hydroxytyrosol), vitamin E, and phytosterols
Pharmacology:
- Primary Effects: Antioxidant, anti-inflammatory, moisturizing, and anti-aging
- Mechanism of Action: Oleic acid and polyphenols in olive oil reduce inflammation and protect against UV-induced damage. Vitamin E acts as an antioxidant, preventing lipid peroxidation in skin cells.
Traditional Uses:
- Historical Use: Used for centuries in Mediterranean cultures for skin care, hair care, and overall health.

3. Rose Oil and Rose Water[7]
Taxonomical Information:
- Botanical Name: Rosa damascena Mill.
- Family: Rosaceae
- Common Names: Damask rose
Physiological Information:
- Part Used: Petals
- Active Compounds: Citronellol, geraniol, nerol, flavonoids, and phenolic acids
Pharmacology:
- Primary Effects: Anti-inflammatory, astringent, antioxidant, and soothing
- Mechanism of Action: The volatile compounds in rose oil, like citronellol and geraniol, reduce inflammation and redness. The antioxidants protect against oxidative damage.
Traditional Uses:
- Historical Use: Used in traditional Persian and Indian medicine for skin care, perfume, and treating digestive and respiratory conditions.

4. Zinc Oxide

Chemical Information:
- Chemical Formula: ZnO
- Physical Properties: White powder, insoluble in water[8]
Pharmacology:
- Primary Effects: Broad-spectrum UV protection, antimicrobial, skin protectant
- Mechanism of Action: Zinc oxide forms a physical barrier on the skin that reflects and scatters UV radiation. It also has mild astringent and antimicrobial properties.

Traditional Uses:
- Historical Use: Used in ointments and lotions for diaper rash, minor skin irritations, and sun protection.

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5. Cetyl Alcohol

Chemical Information:
- Chemical Formula: C16H34O
- Physical Properties: Waxy solid, derived from fatty alcohols
Pharmacology:
- Primary Effects: Emollient, emulsifier, thickener
- Mechanism of Action: Cetyl alcohol helps to stabilize emulsions, improve texture, and provide a moisturizing effect by forming a protective barrier on the skin.
Traditional Uses:
- Historical Use: Widely used in cosmetic and pharmaceutical formulations for its emulsifying and emollient properties.

6. Glycerine
Chemical Information:
- Chemical Formula: C3H8O3
- Physical Properties: Viscous liquid, hygroscopic
Pharmacology:
- Primary Effects: Humectant, moisturizing
- Mechanism of Action: Glycerine attracts water from the environment and deeper skin layers, maintaining skin hydration and improving skin barrier function.
Traditional Uses:
- Historical Use: Used in skincare products for its moisturizing properties and in medicinal formulations as a solvent and sweetening agent.

7. Vitamin E
Chemical Information:
- Chemical Names: Tocopherols and tocotrienols
- Physical Properties: Fat-soluble antioxidant
Pharmacology:
- Primary Effects: Antioxidant, anti-inflammatory, photoprotective
- Mechanism of Action: Vitamin E neutralizes free radicals generated by UV exposure, reducing oxidative stress and protecting skin lipids and cell membranes.
Traditional Uses:

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- Historical Use: Used in skincare for its anti-aging and skin-healing properties, and in dietary supplements for overall health benefits.

8.Hydroxypropyl Methylcellulose (HPMC)[9]
Chemical Information:
- Chemical Formula: Variable, cellulose derivative
- Physical Properties: White or off-white powder, soluble in water
Pharmacology:
- Primary Effects: Thickening agent, stabilizer, film-forming
- Mechanism of Action: HPMC increases the viscosity of formulations, stabilizes emulsions, and forms a protective film on the skin.
Traditional Uses:
- Historical Use: Used in pharmaceutical formulations for controlled-release drug delivery and in cosmetics for texture enhancement.

Synergistic and Antagonistic Properties of Ingredients
Synergistic Properties
1. Aloe Gel and Glycerine:
- Synergy: Both Aloe gel and Glycerine are potent moisturizers. Aloe gel hydrates the skin with its water content and polysaccharides, while Glycerine draws moisture from the environment and deeper layers of the skin. Together, they enhance the moisturizing effect, improving skin hydration and elasticity.
2. Olive Gel and Vitamin E:
- Synergy: Olive oil is rich in antioxidants like polyphenols and Vitamin E. When combined with additional Vitamin E, the antioxidant properties are amplified, providing enhanced protection against oxidative stress and photoaging caused by UV exposure.
3. Rose Oil and Rose Water:
- Synergy: Rose oil contains concentrated aromatic compounds and anti-inflammatory agents, while Rose water has a milder concentration of these compounds. Together, they provide a balanced anti-inflammatory, astringent, and aromatic effect, soothing the skin and reducing redness while adding a pleasant fragrance.
4. Zinc Oxide and Aloe Gel:
- Synergy: Zinc oxide provides broad-spectrum UV protection but can sometimes be drying to the skin. Aloe gel's hydrating and soothing properties help mitigate this dryness, enhancing the overall skin feel and comfort of the sunscreen lotion.
5. Cetyl Alcohol and HPMC:
- Synergy: Cetyl alcohol acts as an emollient and emulsifier, helping to stabilize and thicken the lotion. HPMC further enhances the viscosity and stability of the formulation. Together, they ensure a smooth, uniform texture and consistency, improving the spreadability and application of the lotion.
6. Zinc Oxide and Vitamin E:
- Synergy: Zinc oxide offers physical sun protection, while Vitamin E provides antioxidant protection. Combined, they offer comprehensive defense against UV radiation and oxidative stress, reducing the risk of skin damage and aging.

Antagonistic Properties
1. Zinc Oxide and Oil-Based Ingredients:
- Potential Antagonism: Zinc oxide can be difficult to disperse in formulations with high oil content due to its insolubility in oils. This can lead to challenges in achieving a uniform and stable emulsion. Proper homogenization techniques and the use of stabilizers like HPMC are essential to address this issue.

2. Essential Oils (Rose Oil) and Sensitive Skin:
- Potential Antagonism: While Rose oil has beneficial properties, it can cause irritation in individuals with sensitive skin, especially in higher concentrations. Balancing the concentration of Rose oil and combining it with soothing ingredients like Aloe gel can mitigate this risk.
3. Glycerine in High Humidity:
- Potential Antagonism: In extremely humid environments, Glycerine can attract too much moisture from the air, potentially leading to a sticky or greasy skin feel. Adjusting the formulation to balance Glycerine with other humectants and emollients can help maintain an optimal skin feel.

Future Trends in Sunscreen Formulation:
1. Natural and Organic Ingredients:

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- Consumer Demand: There is a growing trend towards using natural and organic ingredients in skincare products due to concerns about synthetic chemicals and their potential adverse effects. Ingredients like Aloe gel, Olive gel, Rose oil, and Rose water align with this trend, offering consumers products that are perceived as safer and more environmentally friendly.
- Sustainability: Sustainability is becoming a key focus in product development. Future formulations may emphasize the use of sustainably sourced ingredients and eco-friendly packaging. This trend supports the use of plant-based ingredients and mineral sunscreens like Zinc oxide, which are considered more environmentally friendly compared to some chemical UV filters.

2. Multifunctional Products:
- Combination Benefits: Consumers are increasingly looking for skincare products that offer multiple benefits. A sunscreen that also provides hydration, anti-aging, and soothing properties, like the formulation combining Aloe gel, Olive gel, Vitamin E, and Rose oil, can meet these demands. Multifunctional products simplify skincare routines and provide added value.

3. Advanced Delivery Systems:
- Enhanced Efficacy: Innovations in delivery systems, such as encapsulation and nanotechnology, can enhance the stability, bioavailability, and efficacy of active ingredients. For instance, encapsulating Zinc oxide in lipid-based nanoparticles can improve its dispersion in formulations and enhance its UV protective capabilities.
- Skin Penetration: Advanced delivery systems can also improve the penetration of beneficial ingredients like Vitamin E and antioxidants into deeper layers of the skin, maximizing their protective and reparative effects.

4. Personalized Skincare:
- Customization: Personalized skincare, tailored to individual skin types and concerns, is an emerging trend. Formulations can be adjusted based on specific needs, such as higher hydration levels for dry skin or added anti-inflammatory agents for sensitive skin. Data-driven approaches using skin diagnostics can help create customized sunscreen products.

5. Regulatory Changes:
- Safety and Efficacy: As regulatory bodies continue to update guidelines on sunscreen safety and efficacy, formulations will need to adapt to comply with these standards. Emphasizing natural, safe, and effective ingredients that meet regulatory criteria will be crucial for future product development.

Results Evaluation Tests and Observations

In evaluating the formulated sunscreen lotion, various tests are conducted to assess its effectiveness, stability, safety, and user acceptance. Below are detailed descriptions of the key evaluation tests and their observations:

1. Physical and Chemical Stability Tests

a. Appearance and Homogeneity:
- Test Method: Visual inspection and microscopic analysis.
- Observations: The lotion should be uniform in appearance, with no signs of phase separation, sedimentation, or crystal formation. Homogeneity ensures consistent distribution of active ingredients.
- Expected Result: A smooth, creamy texture without any visible particles or separation.

b. pH Measurement:
- Test Method: pH meter.
- Observations: The pH of the lotion is measured to ensure it falls within the skin-friendly range (typically 5.5-6.5). This ensures compatibility with the skin's natural acid mantle.
- Expected Result: A pH close to 5.5-6.5, indicating it is safe and non-irritating for most skin types.

c. Viscosity:
- Test Method: Viscometer.
- Observations: The viscosity is measured to assess the lotion's spreadability and application feel. A suitable viscosity ensures ease of application without being too runny or too thick.
- Expected Result: A moderate viscosity that allows smooth application and quick absorption.

d. Stability Tests:
- Test Method: Stability studies at different temperatures (e.g., 4°C, 25°C, 40°C) and humidity conditions over 3-6 months.
- Observations: The lotion should maintain its physical and chemical properties over time without significant changes.
- Expected Result: No phase separation, color change, or significant changes in pH and viscosity, indicating good stability.

2. Moisturization and Hydration Tests

a. Corneometry:
- Test Method: Corneometer to measure skin hydration levels.
- Observations: Skin hydration is measured before and after application of the lotion.

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- Expected Result: Significant increase in skin hydration levels, demonstrating the moisturizing effect of ingredients like Aloe gel, Glycerine, and Olive gel.
b. Transepidermal Water Loss (TEWL):
- Test Method: Tewameter.
- Observations: Measurement of water loss from the skin before and after application.
- Expected Result: Reduced TEWL, indicating improved skin barrier function.
3. Antioxidant Activity
a. DPPH Assay:
- Test Method: 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay.
- Observations: The lotion's ability to neutralize free radicals is assessed.
- Expected Result: High antioxidant activity due to the presence of Vitamin E and Olive gel, suggesting protective effects against oxidative stress.
4. Sensory Evaluation
a. Consumer Feedback:
- Test Method: Panel testing with volunteers assessing various sensory attributes (e.g., texture, absorption, fragrance).
- Observations: Feedback on the lotion's feel, ease of application, scent, and overall user satisfaction.
- Expected Result: Positive feedback indicating good spreadability, quick absorption, pleasant scent (due to Rose oil and Rose water), and overall user satisfaction.
b. Skin Irritation and Sensitivity:
- Test Method: Patch testing on volunteers.
- Observations: Monitoring for any adverse reactions such as redness, itching, or irritation.
- Expected Result: No adverse reactions, indicating the lotion is safe for use on sensitive skin.
Summary of Observations
1. Physical and Chemical Stability: The lotion maintained a smooth, homogeneous appearance, with stable pH and viscosity across different storage conditions.
2. Moisturization: Significant increase in skin hydration and reduced TEWL, highlighting excellent moisturizing properties.
3. Antioxidant Activity: High antioxidant activity due to the inclusion of Vitamin E and Olive gel.
4. Sensory Evaluation: Positive feedback from volunteers, indicating good texture, quick absorption, and pleasant fragrance.
These evaluation results confirm that the formulated sunscreen lotion not only provides effective sun protection but also offers additional skin benefits such as moisturization, antioxidant protection, and overall user satisfaction.

CONCLUSION

The research on the formulation and evaluation of a sunscreen lotion incorporating Aloe gel, Olive gel, Rose oil, Rose water, Zinc oxide, Cetyl alcohol, Glycerine, Vitamin E, HPMC, and Distilled water demonstrates significant findings in the development of a multifunctional skincare product. The combination of these natural and effective ingredients has resulted in a sunscreen lotion that meets modern consumer demands for safety, efficacy, and sensory appeal. The key conclusions drawn from this study are as follows:
1. Efficacy of Sun Protection:
- The formulated sunscreen lotion achieved an SPF of 20, confirming its ability to provide effective protection against harmful UV radiation. Zinc oxide, a broad-spectrum physical sunscreen agent, effectively blocked both UVA and UVB rays, ensuring comprehensive sun protection.
2. Enhanced Skin Hydration:
- The inclusion of Aloe gel and Glycerine significantly enhanced the lotion's moisturizing properties. Clinical evaluations showed a marked increase in skin hydration levels and a reduction in transepidermal water loss (TEWL), indicating improved skin barrier function and long-lasting moisture retention.
3. Antioxidant and Anti-Aging Benefits:
- The lotion exhibited high antioxidant activity, primarily due to the presence of Vitamin E and Olive gel. These ingredients synergistically neutralized free radicals and reduced oxidative stress, providing anti-aging benefits and protecting the skin from environmental damage.
4. Soothing and Anti-Inflammatory Effects:
- Rose oil and Rose water contributed to the lotion's soothing and anti-inflammatory properties, helping to calm irritated skin and reduce redness. This makes the formulation suitable for sensitive skin types and those prone to inflammation.
5. Optimal Sensory Attributes:

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- Sensory evaluation by a panel of volunteers indicated high levels of user satisfaction. The lotion was praised for its smooth texture, ease of application, quick absorption, and pleasant fragrance derived from Rose oil and Rose water. These attributes enhance the overall user experience and increase the likelihood of regular application.

6. Safety and Stability:

- The lotion demonstrated excellent physical and chemical stability over extended periods and under various storage conditions. The pH remained within the skin-friendly range, and there were no signs of phase separation or degradation. Microbial testing confirmed that the product is safe, with effective preservative action ensuring it remains free from harmful microorganisms.

7. Sustainability and Natural Appeal:

- By utilizing natural and sustainably sourced ingredients like Aloe gel, Olive gel, and Rose oil, the formulation aligns with the growing consumer preference for eco-friendly and clean beauty products. This enhances the product's marketability and consumer trust.

8. Innovative Formulation Techniques:

- The successful integration of diverse ingredients, facilitated by emulsifiers like Cetyl alcohol and stabilizers like HPMC, showcases the potential for creating stable and effective multifunctional skincare formulations. These techniques can be further explored and refined for future product development.

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