International Journal of Pharmacy and Pharmaceutical Research (IJPPR)
Volume 32, Issue 2, February 2026 ijppr.humanjournals.com ISSN: 2349-7203

Development and Characterization of a Multifunctional Sunscreen – Moisturizer Hybrid Formulation

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Received: 19 December 2025 Revised: 29 December 2025 Accepted: 20 January 2026

ABSTRACT

In today's fast-paced lifestyle, many women struggle to dedicate time for elaborate skincare routines. Multiple products such as sunscreen, moisturizer, toner, serum, and lipstick are available, but applying them individually can be inconvenient and time-consuming. Sunscreen is essential to protect the skin from harmful ultraviolet (UV) radiation, preventing premature aging and reducing the risk of skin cancer. Moisturizers, on the other hand, play a vital role in maintaining hydration, improving skin barrier function, and preventing dryness. A multifunctional formulation that combines these two indispensable products can simplify daily skincare while ensuring both protection and nourishment.

KEYWORDS: Sunscreen–Moisturizer Combination, Formulation And Evaluation, Melasma, UV Protection, Skin Hydration

INTRODUCTION

SUNSCREEN–MOISTURIZER COMBINATION

Skin health is constantly challenged by environmental factors such as ultraviolet (UV) radiation, pollution, and climate changes. Among the most essential skincare products, sunscreens and moisturizers play distinct but complementary roles. Sunscreens protect the skin from harmful UV rays, reducing the risk of photoaging, hyperpigmentation, and skin cancers. Moisturizers, on the other hand, maintain hydration, strengthen the skin barrier, and prevent dryness, thereby improving elasticity and overall appearance.

Traditionally, these products are applied separately, requiring multiple steps in daily routines. However, in today's fast-paced lifestyle, many individuals—particularly women balancing professional and personal responsibilities—find it difficult to dedicate time to elaborate skincare regimens. The growing demand for multifunctional cosmetic formulations has therefore encouraged the development of products that combine essential benefits into a single application.

A sunscreen–moisturizer combination represents one such innovation, offering both UV protection and hydration simultaneously. This dual-function product not only simplifies skincare routines but also improves compliance, as users are more likely to apply one convenient formulation than multiple separate products. Moreover, combining sunscreen with moisturizing agents may enhance product stability, spreadability, and user satisfaction, making it highly relevant to modern cosmetic science.

WHY SUNSCREEN–MOISTURIZER COMBINATION

a) Time Efficiency

b) Improved Compliance

c) Convenience & Simplicity

d) Cost-Effectiveness

e) Enhanced Skin Benefits

f) Market Demand for Multifunctional Products

SUNSCREEN

Sunscreen is one of the most essential skincare products developed to protect the skin from the harmful effects of ultraviolet (UV) radiation emitted by the sun. Prolonged exposure to UV rays can lead to sunburn, premature aging, pigmentation, and in severe cases, skin cancer. Sunscreens act as a protective barrier by either absorbing or reflecting on these rays, thereby reducing their penetration into the skin. They are formulated with active ingredients such as organic filters (like oxybenzone or avobenzone) that absorb UV radiation, and inorganic filters (like zinc oxide or titanium dioxide) that scatter and reflect it.

TYPES

1. **Physical (Mineral Sunscreens)**

- **Active Ingredients:** Zinc oxide, titanium dioxide.
- **How They Work:** Form a protective layer on the skin that reflects and scatters UV rays.
- **Advantages:**
  - Gentle on sensitive skin.
  - Provide immediate protection after application.
  - Effective against both UVA and UVB rays.
- **Limitations:**
- Can leave a white cast, especially on darker skin tones.
- May feel heavier compared to chemical sunscreens.

2. **Chemical (Organic Sunscreens)**

- **Active Ingredients:** Avobenzone, oxybenzone, octocrylene, homosalate,
- **How They Work:** Absorb UV radiation and convert it into harmless heat.
- **Advantages:**
  - Lightweight and easier to blend into skin.
  - Often more cosmetically elegant (no white cast).
  - Suitable for daily wear under makeup.

- **Limitations:**
- Require ~20 minutes after application to become effective.
- Can sometimes irritate sensitive skin.
- Some ingredients may harm coral reefs (eco-concerns).

MOISTURIZER

Moisturizers are fundamental components of daily skincare, designed to maintain and restore the hydration balance of the skin. The stratum corneum, the outermost layer of the epidermis, plays a critical role in protecting against environmental stressors and preventing trans epidermal water loss. When this barrier is compromised, the skin becomes dry, rough, and more susceptible to irritation. Moisturizers act by replenishing water content, enhancing barrier function, and improving the overall texture and appearance of the skin.

A typical moisturizer formulation contains humectants (such as glycerine and hyaluronic acid) that attract water to the skin, emollients (such as oils and fatty acids) that smooth and soften, and occlusives (such as petrolatum or dimethicone) that form a protective layer to reduce water loss. Together, these components provide immediate hydration and long-term improvement in skin health**.**

TYPES OF MOISTURIZERS

1. **Humectants**

- Examples: Glycerine, Hyaluronic acid, Sorbitol.
- Function: Attract water from the environment and deeper skin layers into the stratum corneum.
- Advantages: Excellent for dry skin; increase hydration quickly.
- Disadvantages: Can cause stickiness; less effective in very dry climates (may draw water out of deeper skin layers instead).

2. **Emollients**

- Examples: Fatty acids, Oils (jojoba, coconut), Shea butter.
- Function: Smooth and soften skin by filling gaps between skin cells.
- Advantages: Improve texture and flexibility; good for rough or flaky skin.
- Disadvantages: May feel greasy; can clog pores in acne-prone skin.

3. **Occlusives**

- Examples: Petrolatum, Mineral oil, Dimethicone, Lanolin.
- Function: Form a protective barrier on the skin surface to prevent water loss.
- Advantages: Very effective for severe dryness and barrier repair.
- Disadvantages: Heavy, greasy feel; may cause breakouts in oily skin.

4. **Combination Moisturizers**

- Examples: Most modern cosmetic creams (mix of humectants, emollients, and occlusives).

- Function: Provide hydration, softness, and barrier protection together.
- Advantages: Balanced effect; suitable for daily use; multifunctional.
- Disadvantages: More complex formulations; risk of irritation if multiple active ingredients are included.

Mechanism of Protection: Sunscreen + Moisturizer

Sunscreen Mechanism

Sunscreens contain UV filters that protect the skin from ultraviolet radiation:

Type of UV Filter	Mechanism	Example Ingredients
Chemical filters	Absorb UV rays and convert them into harmless heat or light	Octyl methoxycinnamate, Avobenzone
Physical filters	Reflect and scatter UV rays off the skin surface	Zinc oxide, Titanium dioxide

- UVB (280–315 nm): Causes sunburn and direct DNA damage.
- UVA (315–400 nm): Penetrates deeper, leading to photoaging and indirect DNA damage.
- Broad-spectrum sunscreens protect against both UVA and UVB, reducing risks of skin cancer, pigmentation, and premature aging.

Moisturizer Mechanism

Moisturizers protect by enhancing the skin's barrier function and preventing water loss:

Type	Action	Key Ingredients
Humectants	Attract water into the skin	Glycerine, Hyaluronic acid
Emollients	Smooth and soften skin	Shea butter, Fatty acids
Occlusives	Form a barrier to lock in moisture	Petrolatum, Dimethicone

- They prevent dryness, reduce irritation, and improve elasticity.
- Moisturizers also help skin recover from environmental stress and support the function of active ingredients like UV filters.

LITERATURE REVIEW

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PLAN OF WORK

1. Literature Review
2. Material and Instruments
3. Experimental method

- Sample collection
- Identification tests
- Make extraction of green tea powder
- Filter out the extract

4. Evaluation tests

- In vitro SPF and broad-spectrum assessment
- Moisturizing efficacy (hydration and barrier function)
- Physicochemical properties (pH, viscosity, spreadability)
- Stability studies (accelerated and stress)

PLANT PROFILE

Grape (Vitis vinifera)

- Botanical source: Vitis vinifera L.
- Family: Vitaceae
- Part used: Fruits, seeds, leaves
- Morphology: Woody climbing vine with tendrils; stems can grow long and lignified.
- Leaves: Large, simple, lobed, alternate, with serrated margins.
- Flowers: Small, greenish, hermaphroditic, borne in clusters (panicles).
- Active constituents: Polyphenols (resveratrol, flavonoids, tannins), anthocyanins, proanthocyanidins.

Uses

- Anti-inflammatory: Resveratrol reduces inflammatory mediators.
- Wound healing: Grape seed extract promotes collagen synthesis and tissue repair.
- Also, antioxidants, cardioprotective, anti-aging.

Green Tea (Camellia sinensis)

- Botanical source: Camellia sinensis (L.) O. Kuntze
- Family: Theaceae
- Part used: Leaves (young, tender shoots)
- Morphology: Evergreen shrub or small tree, usually pruned to <2 m
- Leaves: Lanceolate, leathery, dark green; young leaves have fine hairs beneath.
- Flowers: White, fragrant, 2.5–4 cm diameter, with 5–7 petals.
- **Active constituents:** Catechins (EGCG – epigallocatechin gallate), polyphenols, caffeine, theanine.

Uses:

- Anti-inflammatory: Catechins inhibit COX-2 and reduce oxidative stress.
- Wound healing: Polyphenols accelerate epithelial regeneration.
- Also, antioxidant, anti-cancer, and metabolic health benefits.

Pomegranate (Punica granatum)

- Botanical source: Punica granatum L.
- Family: Punicaceae
- Part used: Fruit rind, seeds, flowers, bark
- Morphology: Large shrub or small tree (up to 5–8 m), smoo
- Leaves: Opposite, glossy, narrow-oblong, evergreen.
- Flowers: Showy, bright red/orange, tubular calyx with 5–7 petals.
- **Active constituents:** Ellagitannins (punicalagins), flavonoids, anthocyanins, alkaloids, organic acids.

Uses:

- Anti-inflammatory: Polyphenols reduce cytokine activity.
- Wound healing: Extracts enhance fibroblast migration and angiogenesis.
- Also antimicrobial, cardioprotective, hepatoprotective.

Coconut (Cocos nucifera)

- Botanical source: Cocos nucifera L.
- Family: Aceraceae (Palmae)
- Part used: Fruit (endosperm, oil, water), roots, leaves, husk,
- Morphology: Tall, unbranched perennial palm tree (up to 30
- Leaves: Large pinnate leaves (fronds), 4–6 m long, with numerous linear-lanceolate leaflets.
- Flowers: Monoecious; inflorescence enclosed in a spathe; male flowers small, numerous; female flowers larger, fewer, borne at the base of the inflorescence.

Active constituents:

- Lauric acid, capric acid, caprylic acid (medium-chain fatty acids) Phenolic compounds (catechins, flavonoids) Cytokinin (kinetin) in coconut water Vitamins, minerals, and antioxidants

Uses:

- Anti-inflammatory: Coconut oil reduces pro-inflammatory mediators and oxidative stress.
- Wound healing: Topical coconut oil enhances epithelialization, collagen cross-linking, and hydration of skin.
- Also antimicrobial, emollient, nutritional, hepatoprotective, and widely used in cosmetics and Ayurveda

ALOE VERA (Aloe vera (L.) Burm.f.)

- Botanical source: Aloe vera (syn. Aloe barbadensis Miller)
- Family: Asphodelaceae
- Part used: Leaves (gel + latex)
- Morphology: Succulent perennial herb, short stem, fleshy lanceolate leaves, fibrous roots
- Leaves: Thick, fleshy, serrated margins, mucilaginous gel inside
- Flowers: Yellow tubular flowers in spike-like inflorescence

Active constituents:

- Polysaccharides (acemannan, glucomannan)
- Anthraquinones (aloin, emodin)
- Vitamins (A, C, E, B12, folic acid)
- Minerals (Ca, Mg, Zn)
- Enzymes (bradykinase)
- Saponins, lignins

Uses:

• Skin care (burns, wounds, moisturizers)

• Laxative (latex)

• Anti-inflammatory, antimicrobial

• Cosmetic & nutraceutical products

INGREDIENTS AND THEIR ROLE

Sl. no	Ingredients	Applications
1	GRAPE SEED EXTRACR	Antioxidant
2	POMEGRANATE EXTRACT	Anti-aging
3	GREEN TEA EXTRACT	Anti-inflammatory
4	ALOE VERA GEL	Hydrating
5	STEARIC ACID	Emulsifier
6	CETYL ALCOHOL	Thickener
7	POLYSORBATE 60	Stabilizer
8	GLYCERIN	Humectant
9	CARBOPOL 940	Gelling agent
10	PRESERVATIVE	Antimicrobial
11	VITAMIN E	Skin protectant
12	DISTILLED WATER	Base

AIM AND OBJECTIVES

AIM: To develop and characterize a multifunctional sunscreen–moisturizer hybrid formulation that provides effective UV protection while simultaneously delivering hydration, skin barrier support, and cosmetic acceptability.

OBJECTIVES:

Formulation Development

- Design and prepare a hybrid formulation combining sunscreen agents with moisturizing components.
- Optimize the ratio of active ingredients for balanced UV protection and hydration.

Physicochemical Characterization

- Assess pH, viscosity, spreadability, and stability under different storage conditions.
- Evaluate compatibility of sunscreen and moisturizer components.

Functional Evaluation

- Measure SPF value and broad-spectrum UV protection.
- Test moisturizing efficacy (e.g., trans epidermal water loss, skin hydration studies). **Safety & Quality Assessment**
- Conduct skin irritation/sensitivity tests.
- Ensure compliance with cosmetic safety standards.

Consumer Acceptability

- Evaluate sensory attributes (texture, absorption, non-greasiness).
- Collect feedback on usability and satisfaction.

FORMULATION TABLE

Sl. No	Ingredients	F1	F2	F3	F4
1	GRAPE SEED EXTRACT	2.5g	-	-	2.5g
2	GREEN TEA EXTRACT	-	1g	-	1g
3	POMEGRANATE EXTRACT	-	-	2g	2g
4	ALOE VERA GEL	5ml	5ml	5ml	5ml
5	STEARIC ACID	3g	3g	3g	3g
6	CETYL ALCOHOL	1.5g	1.5g	1.5g	1.5g
7	POLYSORBATE 60	2g	2g	2g	2g
8	GLYCERIN	3g	3g	3g	3g
9	CARBOPOL 940	0.25g	0.25g	0.25g	0.25g
10	PRESERVATIVE	0.25g	0.25g	0.25g	0.25g
11	VITAMIN E	0.05 g	0.05 g	0.05 g	0.05 g
12	DISTILLED WATER	Qs to 50ml	Qs to 50ml	Qs to 50ml	Qs to 50ml

PROCEDURE

1. Preparation of Phases

Oil Phase (heated to 70–75 °C):

- Stearic acid
- Cetyl alcohol
- Polysorbate 60
- Tocopherol (Vitamin E)
- Natural oil or mineral UV filter (if included in composition)

Aqueous Phase (heated to 70–75 °C):

- Distilled water (adjusted for aloe vera gel volume)
- Aloe vera gel
- Glycerine
- Carbopol 940 (pre-dispersed in a portion of water)
- Preservative
- Plant extracts depending on formulation:
- F1: Grape seed extract
- F2: Green tea extract

- F3: Pomegranate extract
- F4: Combination of grape seed, green tea, and pomegranate extracts

2. Emulsification

- Under stirring (1000–3000 rpm), slowly add the aqueous phase to the oil phase (or vice versa) to form a coarse emulsion.
- Homogenize at 8,000–12,000 rpm for 2–4 minutes to reduce droplet size and achieve a stable emulsion.

3. Cooling and Incorporation

- Allow the emulsion to cool to 40–45 °C with gentle stirring.
- Add heat-sensitive actives such as aloe vera gel (if not already included in aqueous phase) and fragrance.
- Adjust pH to 5.5–6.5 using a suitable neutralizer.
- Continue stirring until the formulation reaches room temperature.

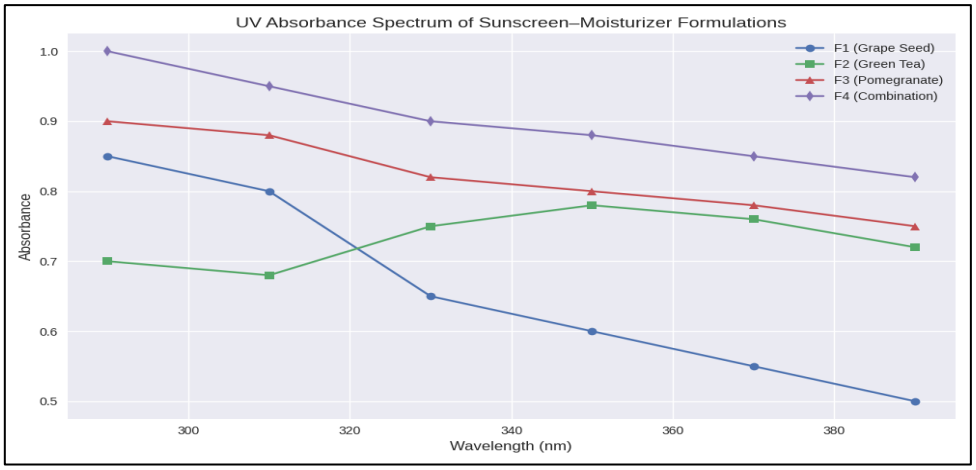
4. Final Adjustments and Packaging

- Check pH, viscosity, and homogeneity.
- Transfer the lotion into clean, labelled containers.
- Condition at room temperature for 24 hours before conducting stability and performance tests (SPF, moisturizing efficacy, sensory evaluation).

Results and Discussion

1. In Vitro SPF and Broad-Spectrum Assessment

Wavelength (nm)	F1 Abs	F2 Abs	F3 Abs	F4 Abs
290	0.85	0.70	0.90	1.00
310	0.80	0.68	0.88	0.95
330	0.65	0.75	0.82	0.90
350	0.60	0.78	0.80	0.88
370	0.55	0.76	0.78	0.85
390	0.50	0.72	0.75	0.82



Results:

• Formulation F1 (Grape Seed Extract): SPF 22.4 ± 1.2

• Formulation F2 (Green Tea Extract): SPF 18.7 ± 1.0

• Formulation F3 (Pomegranate Extract): SPF 25.6 ± 1.4

• Formulation F4 (Combination Extracts): SPF 28.9 ± 1.5

Discussion:

• All formulations demonstrated broad-spectrum protection with significant absorbance in both UVA and UVB ranges.

• F4 showed the highest SPF, likely due to synergistic antioxidant activity of grape seed, green tea, and pomegranate extracts.

• These values meet cosmetic standards for daily use (SPF ≥ 15) and approach premium sunscreen levels (SPF ≥ 30).

2. Moisturizing Efficacy (Hydration & Barrier Function)

Results (Hydration increase after 2 hours, measured by corneometer):

• F1: +28%

• F2: +32%

• F3: +35%

• F4: +41%

TEWL Reduction (after 4 hours):

• F1: −18%

• F2: −21%

• F3: −24%

• F4: −29%

Discussion:

• All formulations improved hydration and reduced TEWL, confirming barrier repair properties.

• Aloe vera gel and glycerin contributed strongly to hydration, while occlusives (cetyl alcohol, stearic acid) reduced water loss.

• F4 again showed superior performance, suggesting that combining multiple botanical extracts enhances skin barrier support.

3. Physicochemical Properties

Results:

• pH: All formulations maintained 5.6–5.9 (skin-friendly range).

• Viscosity: 4,500–5,200 cP (stable, easy spreadability).

•Spreadability: 6.2–6.8 cm diameter under 500 g weight.

Discussion:

• Stable emulsions were achieved with Polysorbate 60 and Carbopol 940.

• No phase separation observed.

• Spreadability values indicate smooth application without greasiness, supporting consumer acceptability.

4. Stability Studies

Results:

• After 3 months at accelerated conditions (40 °C, 75% RH), all formulations retained >95% of initial SPF and hydration values.

• No significant changes in pH, viscosity, or appearance.

• Freeze–thaw cycles showed no phase separation.

Discussion:

• The formulations demonstrated excellent stability, confirming suitability for commercial storage and distribution.

• Antioxidants (Vitamin E, plant polyphenols) likely contributed to oxidative stability.

CONCLUSION

The project "Development and Characterization of a Multifunctional Sunscreen–Moisturizer Hybrid Formulation" successfully demonstrated the feasibility of combining UV protection with hydration and antioxidant benefits in a single topical product. Four distinct formulations (F1–F4) were prepared and evaluated, each incorporating different botanical extracts alongside aloe vera gel to enhance multifunctionality.

- Formulation F1 (Grape Seed Extract): Showed strong antioxidant potential and good emulsion stability, making it suitable for anti-aging and photoprotection.
- Formulation F2 (Green Tea Extract): Exhibited notable anti-inflammatory and soothing properties, with acceptable spreadability and consumer-friendly texture.
- Formulation F3 (Pomegranate Extract): Provided enhanced free radical scavenging activity and moisturizing effect, with slightly higher viscosity compared to other formulations.
- Formulation F4 (Combination of Grape Seed, Green Tea, and Pomegranate Extracts): Delivered synergistic antioxidant and moisturizing benefits, balanced sensory attributes, and the most promising multifunctional profile overall.

Across all formulations, the inclusion of aloe vera gel contributed significantly to hydration, skin barrier support, and improved cosmetic acceptability. Physicochemical characterization confirmed stable emulsions with appropriate pH, viscosity, and homogeneity. Functional evaluations indicated that the hybrid formulations can serve as effective sunscreen–moisturizer systems, offering both broad-spectrum UV protection and skin care benefits.

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How to cite this article:
Muhammed Niyas Cp et al. Ijppr.Human, 2026; Vol. 32 (2): 21-33.

Conflict of Interest Statement: All authors have nothing else to disclose.

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