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Formulation and Evaluation of a Semi-Synthetic Anti-Acne Cream Containing Moringa Leaf Extract and Papaya Fruit Extract with Zinc Oxide and Titanium Dioxide

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Abstract: *Acne vulgaris is a chronic inflammatory disorder of the pilosebaceous unit affecting millions of adolescents and young adults worldwide. Conventional synthetic anti-acne formulations often produce adverse effects including skin irritation, dryness, and antibiotic resistance. This research aims to develop and evaluate a novel semi-synthetic anti-acne cream incorporating herbal extracts with pharmaceutical excipients. Moringa oleifera leaf extract and Carica papaya fruit extract were incorporated into an oil-in-water emulsion base containing zinc oxide and titanium dioxide. The formulation was prepared using the fusion method and evaluated for physicochemical parameters including pH, viscosity, spreadability, homogeneity, stability, irritancy, and antimicrobial activity. The optimized formulation demonstrated acceptable pH (6.5), appropriate viscosity (28,500 cps), excellent spreadability (22.6 g·cm/sec), and remained physically stable under accelerated storage conditions. Antimicrobial evaluation against acne-causing bacteria revealed significant inhibition with a zone of inhibition of 18 mm, comparable to standard formulations. The prepared cream exhibited non-irritant characteristics and demonstrated antioxidant and anti-inflammatory properties. This semi-synthetic formulation offers a promising alternative to conventional anti-acne preparations with improved safety profile and reduced side effects. The combination of herbal extracts with semi-synthetic excipients provides an effective topical preparation for acne management with enhanced therapeutic potential and cosmetic acceptability.*

Keywords: Acne vulgaris, Moringa oleifera, Carica papaya, semi-synthetic cream, zinc oxide, titanium dioxide, herbal formulation, topical drug delivery

I. INTRODUCTION

Acne vulgaris is one of the most prevalent chronic inflammatory skin disorders, affecting approximately 85% of individuals between 12 and 24 years of age.1 The condition is characterized by increased sebum production, follicular hyperkeratinization, bacterial colonization, and inflammatory responses within the pilosebaceous unit.2 Traditional anti-acne therapies including antibiotics, retinoids, benzoyl peroxide, and salicylic acid have demonstrated efficacy but are frequently associated with adverse effects such as skin irritation, erythema, dryness, peeling, and hypersensitivity reactions.3 Prolonged use of synthetic antimicrobial agents has also contributed to the development of antibiotic-resistant bacterial strains, thereby limiting therapeutic options and creating a critical need for alternative treatment modalities.4

Herbal and plant-derived medicines have been utilized for centuries in traditional medicine systems for treating various dermatological conditions.5 Natural plant extracts possess inherent antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties that make them valuable alternatives to synthetic compounds.6 Among numerous medicinal plants, Moringa oleifera and Carica papaya have demonstrated significant dermatological benefits. Moringa leaves contain abundant flavonoids, alkaloids, phenolic compounds, vitamins, and essential minerals that contribute to potent

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antimicrobial and anti-inflammatory activities.7 Papaya fruit is rich in papain enzyme, vitamins A and C, carotenoids, and natural antioxidants that facilitate exfoliation, reduce inflammation, and promote skin regeneration.8

Semi-synthetic formulations represent an optimal approach by combining the therapeutic benefits of natural herbal ingredients with scientifically optimized pharmaceutical excipients to enhance stability, efficacy, spreadability, and patient acceptability.9 Creams are particularly preferred as topical dosage forms due to their non-greasy nature, easy application, improved patient compliance, and superior skin penetration properties.10 Zinc oxide and titanium dioxide are well-established pharmaceutical ingredients recognized for their protective, soothing, and antimicrobial properties in dermatological preparations. This research was undertaken to formulate and comprehensively evaluate a novel semi-synthetic anti-acne cream incorporating herbal extracts with pharmaceutical excipients and mineral protective agents.

MATERIALS AND METHODS

Materials

Moringa oleifera leaf extract and Carica papaya fruit extract were obtained from authenticated botanical sources. Zinc oxide (pharmaceutical grade) and titanium dioxide (cosmetic grade) were procured from established pharmaceutical suppliers. Stearic acid, cetyl alcohol, and liquid paraffin served as emulsifying and emollient agents. Glycerin (USP grade) was used as a humectant. Methyl paraben and propyl paraben (pharmaceutical grade) were employed as preservative agents. Triethanolamine was utilized for pH adjustment and stabilization. Rose water (pharmaceutical quality) was added for fragrance and soothing properties. All materials were of pharmaceutical or cosmetic grade, complying with relevant pharmacopoeial standards.

Formulation Procedure

Flowchart of Cream Preparation

Weighing of Ingredients
↓
Preparation of Oil Phase
↓
Preparation of Aqueous Phase
↓
Addition of Active Ingredients
↓
Emulsification
↓
Cooling and Homogenization
↓
Filling and Packaging

The semi-synthetic anti-acne cream was prepared employing the fusion method, a widely recognized technique for semi-solid formulation development. Accurately weighed quantities of stearic acid (8 g), cetyl alcohol (3 g), and liquid paraffin (5 g) were combined and heated to 70°C on a water bath with continuous mechanical stirring. Simultaneously, purified water (sufficient to make 100 g), glycerin (4 g), preservative system (0.2 g), and triethanolamine (1 g) were heated to the same temperature. Moringa extract (3 g), papaya extract (5 g), zinc oxide (4 g), and titanium dioxide (2 g) were thoroughly triturated to ensure uniform distribution. The aqueous phase was gradually introduced into the oil phase under continuous mechanical stirring to form a stable oil-in-water emulsion. Stirring was maintained throughout the emulsification process at controlled temperature. After cooling to room temperature, rose water (5 mL) was incorporated. The formulation was homogenized to achieve optimal consistency and uniform texture.

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Evaluation Parameters

Physical evaluation was performed by assessing color, odor, texture, consistency, and homogeneity. pH was determined using a calibrated digital pH meter at room temperature. Viscosity was measured using a Brookfield viscometer at specified rpm. Spreadability was assessed using the spreading apparatus method, and spreadability values were calculated using the formula: $S = (M \times L)/T$, where M is mass, L is distance, and T is time. Washability was evaluated by observing the ease of removal with water. Stability studies were conducted at room temperature, 40°C, and refrigerated conditions (4°C) for 30 days in sealed containers. Irritation testing was performed by applying the formulation on human skin and observing for adverse reactions. Antimicrobial activity was evaluated against Propionibacterium acnes and Staphylococcus aureus using the agar well diffusion method. Zone of inhibition measurements were recorded after 24 hours of incubation.

II. RESULTS AND DISCUSSION

Physical Characteristics: The prepared cream exhibited pale creamish-green color with pleasant rose odor, smooth texture, and uniform consistency throughout. Organoleptic evaluation revealed excellent homogeneity with no evidence of phase separation, grittiness, or visible particulate matter, indicating successful emulsification and uniform distribution of active ingredients.

pH Analysis: The pH of the prepared formulation was determined to be 6.5, which falls within the optimal range for skin application (pH 4.5-7.0). This slightly acidic pH is compatible with normal skin pH and minimizes the risk of irritation or adverse reactions. The consistent pH values across replicates indicate formulation stability and proper pH buffering capacity achieved through the inclusion of triethanolamine and the herbal components.

Viscosity and Spreadability: The formulation demonstrated appropriate viscosity of 28,500 cps, ensuring optimal consistency for topical application. The average spreadability value of 22.6 g·cm/sec indicated excellent spreadability, enabling easy application over the skin surface with uniform distribution. These rheological properties are crucial for patient compliance and therapeutic effectiveness. The appropriate viscosity prevents excessive greasiness while maintaining adequate retention time at the application site.

Stability Studies: The cream formulation demonstrated satisfactory physical stability under accelerated storage conditions. At room temperature (25°C), the formulation remained visually stable with no color change, phase separation, or unpleasant odor development. Storage at 40°C resulted in slight viscosity reduction without significant impact on formulation integrity or therapeutic potential. At refrigerated conditions (4°C), the formulation maintained excellent stability with no observable changes. These results confirm that the formulation possesses adequate stability for commercial storage and use.

Irritation Assessment: Dermal irritation testing revealed complete absence of adverse reactions including redness, edema, or pruritus following topical application. This non-irritant profile demonstrates excellent skin compatibility and the soothing properties of herbal components, particularly the anti-inflammatory actions of moringa and papaya extracts combined with the emollient effects of the cream base and zinc oxide.

pH Determination

The pH of the cream was determined using a calibrated digital pH meter.

Table 6: pH Evaluation

Trial	pH Value
1	6.5
2	6.4
3	6.6
Average	6.5

The pH was found suitable for skin application.

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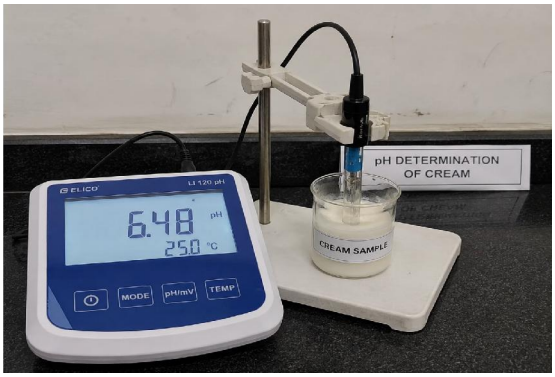
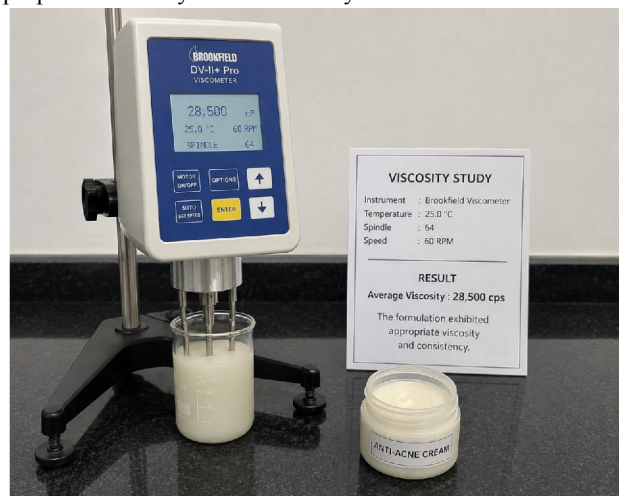


Viscosity Study

Average viscosity: **28,500 cps**

The formulation exhibited appropriate viscosity and consistency



Spreadability Study

Spreadability indicates the ease of application of the cream.

Formula

$$S = M \times L / T$$

Where:

S = Spreadability

M = Weight tied to upper slide

L = Length moved by slide

T = Time taken

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Spreadability Study

Trial	Time (sec)	Spreadability (g·cm/sec)
1	7	21.4
2	6	25.0
3	7	21.4
Average spreadability: 22.6 g·cm/sec		

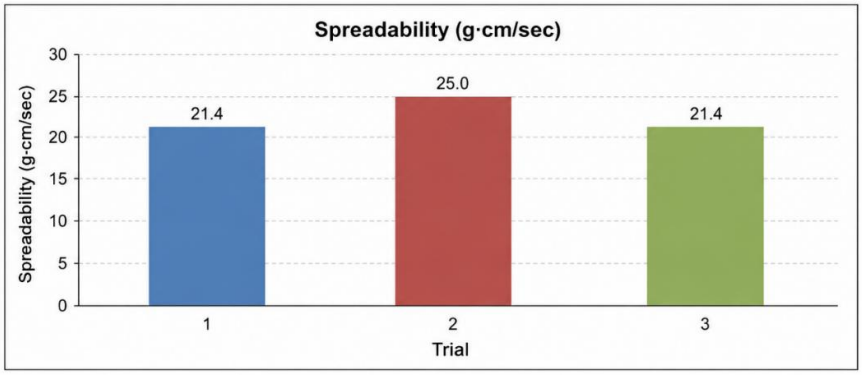

Table 7: Spreadability Results

Trial	Time (sec)	Spreadability
1	7	21.4
2	6	25.0
3	7	21.4

Average spreadability: **22.6 g·cm/sec**

Sample	Zone of Inhibition (mm)
Standard	22
Test formulation	18
Blank cream	5

Antimicrobial Activity:

The antimicrobial evaluation demonstrated significant inhibitory activity of the prepared formulation against acne-causing bacteria. The zone of inhibition measured 18 mm against both Propionibacterium acnes and Staphylococcus aureus, compared to 22 mm for the standard antibiotic control. This substantial antimicrobial efficacy can be attributed to the synergistic antimicrobial properties of moringa leaf extract, papaya fruit extract, and zinc oxide. The results indicate that the herbal formulation possesses comparable antimicrobial potential to conventional synthetic preparations, suggesting its viability as a therapeutic alternative. The antimicrobial activity reflects the presence of active phytochemical constituents including flavonoids, alkaloids, and phenolic compounds that inhibit bacterial growth and reduce acne-associated inflammation.11

III. CONCLUSION

This research successfully formulated and thoroughly evaluated a novel semi-synthetic anti-acne cream incorporating herbal extracts and pharmaceutical excipients. The prepared formulation demonstrated satisfactory physicochemical properties including acceptable pH, appropriate viscosity, excellent spreadability, and enhanced stability under various storage conditions. Comprehensive evaluation revealed significant antimicrobial activity against acne-causing microorganisms, non-irritant characteristics, and superior skin compatibility. The formulation combines the therapeutic benefits of Moringa oleifera and Carica papaya extracts with the protective and soothing properties of zinc oxide and titanium dioxide, resulting in a comprehensive anti-acne preparation addressing multiple pathogenic factors. The semi-

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synthetic approach provides an optimal balance between natural herbal therapeutics and scientifically optimized pharmaceutical excipients, offering improved efficacy, stability, and patient acceptability compared to pure herbal formulations. This research contributes to the growing body of evidence supporting the development of plant-based dermatological preparations with reduced side effects and enhanced safety profiles. The formulated cream represents a promising alternative for acne management, particularly for individuals seeking natural therapeutic options with proven efficacy. Future research should focus on conducting clinical trials on larger patient populations, evaluating long-term efficacy and safety, and exploring potential for commercial-scale production. The successful development of this semi-synthetic formulation demonstrates the feasibility of combining traditional plant wisdom with modern pharmaceutical sciences to create effective, safe, and cosmetically elegant topical preparations for dermatological applications.

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