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Development and Evaluation of Herbal Anti-Acne Gel Containing Neem and Aloe Vera with QA & QC Parameters

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Abstract:
The present research work focused on the development and evaluation of a herbal anti-acne gel containing Neem (Azadirachta indica) and Aloe vera (Aloe barbadensis Miller) using various Quality Assurance (QA) and Quality Control (QC) parameters. Acne vulgaris is one of the most common chronic inflammatory skin disorders caused by excessive sebum secretion, bacterial infection, inflammation, and blockage of sebaceous follicles. Conventional anti-acne preparations often produce adverse effects such as skin irritation, dryness, redness, and microbial resistance during prolonged use. Therefore, herbal formulations are increasingly preferred because of their safety, effectiveness, affordability, and minimal side effects. Neem possesses significant antibacterial, anti-inflammatory, antifungal, antioxidant, and antiseptic properties due to the presence of bioactive constituents such as nimbidin, azadirachtin, flavonoids, and tannins. Aloe vera provides moisturizing, soothing, wound-healing, and skin-regenerating effects that improve skin hydration and reduce irritation associated with acne lesions. In the present study, three formulations of herbal anti-acne gel (F1, F2, and F3) were prepared using different concentrations of Neem extract and Aloe vera gel with Carbopol 940 as the gelling agent. The prepared formulations were evaluated for various physicochemical and quality control parameters including colour, appearance, pH, viscosity, spreadability, extrudability, washability, antimicrobial activity, phytochemical screening, microbial limit test, and stability studies. The pH of all formulations was found within the acceptable skin-compatible range of 5.5–7.0. Phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, and saponins responsible for therapeutic activity. Among all formulations, batch F2 exhibited the most desirable characteristics with optimum viscosity, excellent spreadability, superior extrudability, enhanced antimicrobial activity, suitable pH, highly stable nature, and better patient acceptability. Stability studies revealed no significant changes in colour, consistency, pH, or homogeneity during storage. The antimicrobial evaluation demonstrated effective inhibition of acne-causing microorganisms. The synergistic combination of Neem and Aloe vera provided antibacterial, anti-inflammatory, antioxidant, moisturizing, and healing effects, making the formulation effective for topical acne management. Based on the overall findings, it can be concluded that the formulated herbal anti-acne gel is safe, stable, effective, economical, and suitable for topical application. Formulation F2 was selected as the optimized batch due to its superior physicochemical properties, stability, and therapeutic effectiveness. The study suggests that the herbal anti-acne gel containing Neem and Aloe vera may serve as a promising natural alternative to synthetic anti-acne preparations with reduced side effects and improved patient compliance.

Keywords: Herbal, Quality Assurance, Quality Cntrol, Antimicrobial, Patient compliance

Introduction

Herbal formulations containing medicinal plant extracts are widely accepted in pharmaceutical and cosmetic industries due to the presence of phytoconstituents such as flavonoids, alkaloids, tannins, saponins, and phenolic compounds that possess antimicrobial, antioxidant, anti-inflammatory, and wound-healing activities. The use of herbal ingredients in topical gel formulations offers several advantages including non-greasy texture, better patient compliance, prolonged contact time, easy application, and improved drug release at the affected site. Neem (Azadirachta indica) is one of the most important medicinal plants used in traditional systems of medicine such as Ayurveda. It is well known for its broad-spectrum antibacterial, antifungal, anti-inflammatory, and antiseptic properties. Active constituents such as nimbidin, azadirachtin, and flavonoids present in Neem help inhibit acne-causing microorganisms and reduce skin inflammation. Aloe vera (Aloe barbadensis Miller) is another valuable medicinal plant extensively used in dermatological preparations due to its soothing, moisturizing, antioxidant, and wound-healing properties. Aloe vera helps maintain skin hydration, promotes tissue regeneration, and reduces irritation associated with acne lesions. [1,2]

Skin is the largest protective organ of the human body and is continuously exposed to environmental pollutants, microorganisms, ultraviolet radiation, and dust particles that may lead to various dermatological disorders. Among these disorders, acne vulgaris is one of the most prevalent chronic inflammatory skin conditions affecting millions of individuals worldwide, particularly adolescents and young adults. Acne not only affects physical appearance but may also produce psychological stress, low self-esteem, anxiety, and social discomfort. The condition commonly develops due to excessive sebum secretion, bacterial colonization, hormonal imbalance, inflammation, and blockage of hair follicles.In recent years, the demand for herbal cosmetics and herbal medicinal preparations has increased significantly because of their natural origin, biocompatibility, safety, and minimal adverse effects compared to synthetic drugs. Conventional anti-acne therapies such as antibiotics, retinoids, and benzoyl peroxide are often associated with side effects including skin irritation, dryness, peeling, redness, allergic reactions, and microbial resistance after prolonged use. These limitations have encouraged researchers to explore herbal alternatives for safer and more effective acne treatment. The combination of Neem and Aloe vera in a topical gel formulation may provide synergistic therapeutic benefits by combining antimicrobial action with skin-healing and moisturizing effects. Therefore, the present research work was undertaken to formulate and evaluate a herbal anti-acne gel containing Neem and Aloe vera using different Quality Assurance (QA) and Quality Control (QC) parameters. The study aims to develop a safe, stable, effective, and patient-friendly herbal topical preparation for acne management. Acne vulgaris is one of the most common skin disorders affecting adolescents and adults. Herbal formulations are gaining popularity due to their safety, affordability, and reduced side effects compared to synthetic preparations. [2-5]

The present research study focuses on the formulation and evaluation of a herbal anti-acne gel containing Neem (Azadirachta indica) and Aloe vera. Neem possesses potent antibacterial, anti-inflammatory, and antifungal activities, while Aloe vera provides soothing, moisturizing, and wound-healing effects. The gel was prepared using Carbopol 940 as a gelling agent and evaluated for physical appearance, pH, viscosity, spreadability, microbial limit test, stability studies, and phytochemical screening. The formulated gel exhibited acceptable physicochemical characteristics, good stability, and antimicrobial potential, indicating its suitability for topical anti-acne therapy. Acne vulgaris is a chronic inflammatory disorder of the sebaceous glands and hair follicles characterized by pimples, blackheads, whiteheads, papules, and pustules. It commonly occurs due to excessive sebum production, bacterial infection, hormonal imbalance, and blockage of skin pores. Conventional anti-acne products often contain synthetic antibiotics and chemicals that may cause skin irritation, dryness, redness, and antibiotic resistance. Therefore, herbal formulations are increasingly preferred because they are safer, economical, biocompatible, and possess fewer side effects. Herbal medicines have been used since ancient times for the treatment of skin diseases. Among various medicinal plants, Neem and Aloe vera are widely recognized for their therapeutic properties. [4-7]

Aim & Objective

To develop and evaluate a herbal anti-acne gel containing Neem and Aloe vera using Quality Assurance (QA) and Quality Control (QC) parameters.

To formulate a stable herbal anti-acne gel using Neem and Aloe vera.

To evaluate the physicochemical properties of the prepared gel.

To perform QA and QC tests for safety and effectiveness.

To study the stability of the formulation at different temperatures.
To confirm the presence of phytoconstituents through phytochemical screening.

Plan of Work

The present research work was systematically planned to develop and evaluate a herbal anti-acne gel containing Neem and Aloe vera using appropriate pharmaceutical and analytical techniques. Initially, an extensive literature survey was carried out using research articles, pharmacognosy textbooks, WHO guidelines, and Indian Pharmacopoeia to collect information regarding acne vulgaris, herbal anti-acne agents, topical gel formulations, and evaluation methods. Based on the literature review, Neem and Aloe vera were selected as the active herbal ingredients due to their well-known antibacterial, anti-inflammatory, antioxidant, moisturizing, and wound-healing properties.

After selection of the herbal ingredients, all required materials including Carbopol 940, glycerin, triethanolamine, methyl paraben, and distilled water were procured from reliable sources and evaluated for purity and suitability. Different batches of herbal anti-acne gel formulations (F1, F2, and F3) were then prepared using varying concentrations of Neem extract and Aloe vera gel to obtain an optimized formulation with improved therapeutic effectiveness and physicochemical properties.

The prepared gel formulations were subjected to various Quality Assurance (QA) and Quality Control (QC) evaluation parameters including colour, appearance, pH, viscosity, spreadability, extrudability, washability, antimicrobial activity, and stability studies. Phytochemical screening was also performed to identify the presence of important bioactive constituents such as alkaloids, flavonoids, tannins, and saponins responsible for the therapeutic activity of the formulation.

Further, stability studies were carried out under different storage conditions to observe any changes in colour, consistency, pH, homogeneity, and phase separation during storage. Comparative evaluation of all formulations was performed to identify the optimized batch showing the best overall performance in terms of stability, spreadability, antimicrobial activity, viscosity, and patient acceptability. Finally, all obtained results were analyzed systematically, interpreted scientifically, and used to draw conclusions regarding the safety, stability, and effectiveness of the formulated herbal anti-acne gel for topical acne management.

Advantages of Herbal Anti-Acne Gel

Safe and natural herbal formulation
Reduced chances of skin irritation and side effects
Possesses antibacterial activity against acne-causing microorganisms
Provides anti-inflammatory effect and reduces redness and swelling
Aloe vera offers soothing and moisturizing action
Promotes wound healing and skin regeneration
Non-greasy and easy to apply on skin
Excellent spreadability and washability
Good patient compliance and acceptability
Economical and cost-effective preparation
Simple formulation method and easy manufacturing process
Suitable for prolonged and regular use
Reduced risk of microbial resistance compared to synthetic antibiotics
Contains antioxidant phytoconstituents beneficial for skin health

Stable formulation with good physicochemical properties

Herbal ingredients used in Herbal Anti-acne Gel

1) Neem

Biological Source : Neem consists of dried leaves and bark of Azadirachta indica.

Family : Meliaceae

Chemical Constituents : Nimbin, Nimbidin, Azadirachtin , Tannins, Flavonoids.

Pharmacological Actions :

- Antibacterial
- Anti-inflammatory
- Antifungal
- Antioxidant

Uses :

- Treatment of acne
- Skin infections
- Wound healing
- Antiseptic applications [8]

2) Aloe vera

Biological Source : Aloe vera gel is obtained from the leaves of Aloe barbadensis Miller.

Family : Liliaceae

Chemical Constituents :

- Aloin

- Polysaccharides
- Vitamins
- Amino acids
- Enzymes

Pharmacological Actions :

- Moisturizing
- Healing
- Anti-inflammatory
- Cooling effect

Uses :

- Skin hydration
- Treatment of burns
- Acne management
- Cosmetic formulations [9]

Methodology

Materials Required

Ingredients	Category	Function
Neem extract	Active ingredient	Antibacterial agent
Aloe vera gel	Active ingredient	Moisturizer & healing
Carbopol 940	Polymer	Gelling agent
Glycerin	Humectant	Moisturizing agent
Triethanolamine	Neutralizer	pH adjustment
Methyl paraben	Preservative	Prevents microbial growth
Distilled water	Vehicle	Solvent

Formulation Table

Ingredients	Quantity for F1	Quantity for F2	Quantity for F3
Neem extract	2%	4%	6%
Aloevera gel	5%	10%	15%
Carbopol 940	1 %	1%	1 %
Glycerin	5 %	5%	5%
Methyl paraben	0.2 %	0.2 %	0.2 %
Triethanolamine	q.s	q.s	q.s
Distilled Water	Up to 100%	Up to 100%	Up to 100%

Method of Preparation

Step 1: Preparation of Gel Base

Carbopol 940 was dispersed slowly in distilled water with continuous stirring to avoid lump formation. The mixture was allowed to swell for 24 hours.

Step 2: Addition of Humectant

Glycerin was added to the swollen Carbopol solution and mixed thoroughly.

Step 3: Incorporation of Herbal Extracts

Measured quantities of Neem extract and Aloe vera gel were added slowly with continuous stirring to obtain a homogeneous mixture.

Step 4: pH Adjustment

Triethanolamine was added dropwise until a transparent gel with suitable consistency was formed.

Step 5: Addition of Preservative

Methyl paraben was dissolved and incorporated into the formulation.

Step 6: Final Mixing

The gel was mixed uniformly until a smooth and bubble-free preparation was obtained and then packed in suitable containers. [10-14]

Mechanism of Action

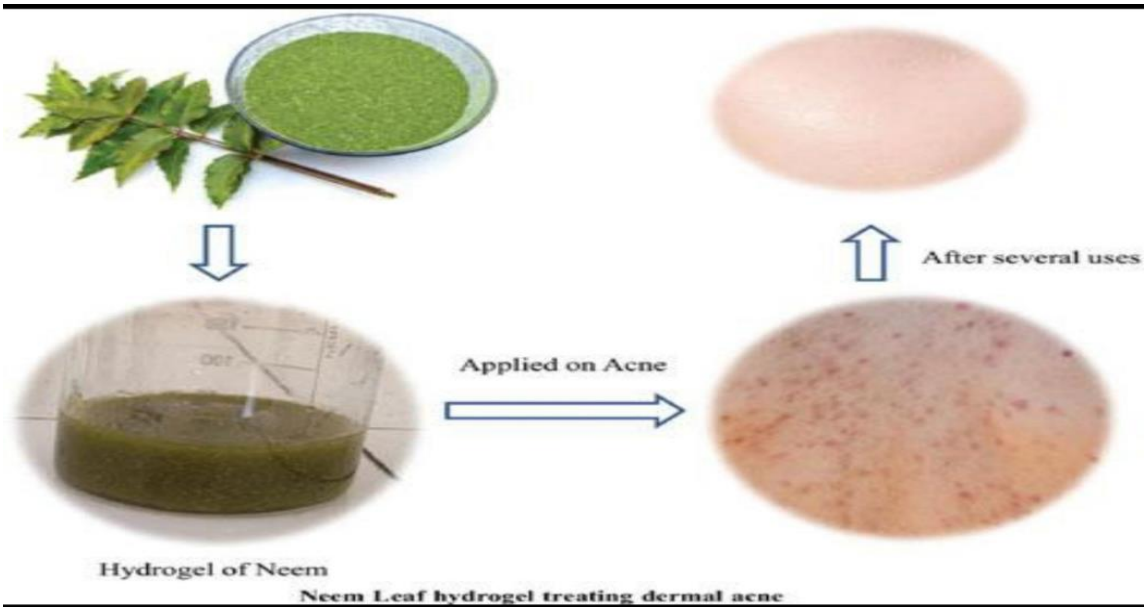
The formulated herbal anti-acne gel exerts its therapeutic activity through a combination of antibacterial, anti-inflammatory, antioxidant, moisturizing, and wound-healing mechanisms provided by Neem extract and Aloe vera gel. Acne vulgaris mainly develops due to excessive sebum production, blockage of sebaceous follicles, bacterial colonization, and inflammation of the skin. The herbal formulation targets these pathogenic factors simultaneously and helps in reducing acne lesions effectively.

Neem (Azadirachta indica) acts as the major antibacterial component of the formulation. It contains several biologically active phytoconstituents such as nimbidin, azadirachtin, quercetin, flavonoids, tannins, and phenolic compounds that possess strong antimicrobial activity against acne-causing microorganisms including Propionibacterium acnes and Staphylococcus aureus. These bioactive compounds inhibit microbial growth by damaging bacterial cell walls, interfering with protein synthesis, and suppressing microbial multiplication. Reduction in bacterial population helps prevent infection, pus formation, and further progression of acne lesions.

Neem also exhibits significant anti-inflammatory activity. The flavonoids and limonoids present in Neem inhibit the release of inflammatory mediators such as prostaglandins, histamine, and cytokines responsible for redness, swelling, irritation, and pain associated with acne. By controlling inflammation, the formulation helps reduce erythema and skin irritation while promoting faster recovery of inflamed acne lesions.

In addition, Neem possesses antioxidant properties due to the presence of polyphenolic compounds that neutralize free radicals generated during inflammatory skin conditions. This antioxidant activity helps protect skin cells from oxidative stress and tissue damage, thereby improving overall skin health and preventing scar formation.

Aloe vera (Aloe barbadensis Miller) contributes primarily through its soothing, moisturizing, healing, and regenerative properties. It contains polysaccharides, glycoproteins, vitamins, amino acids, enzymes, and minerals that help maintain skin hydration and elasticity. Aloe vera forms a protective moisturizing layer over the skin surface, preventing dryness and irritation commonly associated with acne treatments.
The polysaccharides present in Aloe vera stimulate fibroblast activity and collagen synthesis, thereby accelerating wound healing and tissue repair. This action helps in faster healing of acne lesions, reduction of acne marks, and regeneration of damaged skin cells. Aloe vera also exhibits mild antimicrobial and anti-inflammatory properties that further support acne treatment by reducing swelling and calming irritated skin.



Neem Leaf hydrogel treating dermal acne

The gel base prepared using Carbopol 940 plays an important role in enhancing the therapeutic efficacy of the formulation. The gel provides uniform distribution of active ingredients over the skin surface and ensures prolonged contact time at the site of application. This increases penetration and absorption of herbal constituents into the affected skin layers, resulting in sustained therapeutic action. The non-greasy and easily spreadable nature of the gel also improves patient compliance and comfort during application.
Thus, the combined action of Neem and Aloe vera provides a synergistic effect by controlling microbial infection, reducing inflammation, promoting wound healing, maintaining skin hydration, and regenerating damaged tissues. These combined mechanisms make the herbal anti-acne gel an effective, safe, and natural topical preparation for the management of acne vulgaris. [15-19]

Evaluation Parameters (QA & QC)

Physical Evaluation

The prepared gel was visually examined for:
Color , Odor, Appearance, Homogeneity, Consistency
Observation :
Color: Light green
Odor: Characteristic herbal odor
Appearance: Smooth homogeneous gel [20,21]

pH Determination

The pH of the gel was measured using a calibrated digital pH meter.

Procedure

1 g of gel was dissolved in 100 mL distilled water and measured at room temperature.

Ideal Range : 5.5 to 7

Result

Observed pH: 6.2

The pH was compatible with skin and suitable for topical application.

Viscosity Test

Viscosity determines the consistency and spreadability of the gel.

Instrument Used

Brookfield Viscometer

Observation

The gel showed optimum viscosity and good consistency suitable for topical application.

Spreadability Test

Spreadability indicates ease of application on the skin. [22-24]

Formula

$S = M \times L / T$

Where:

S = Spreadability

M = Weight tied to upper slide

L = Length moved by glass slide

T = Time taken

Observation

The gel spread uniformly without grittiness.

Extrudability Test

Extrudability measures the ease with which gel is removed from the tube. [25]

Observation

The gel extruded smoothly with slight pressure.

Washability Test

The gel was applied on skin and washed with tap water.[26]

Observation

The formulation was easily washable and non-sticky.

Microbial Limit Test

The microbial test ensures absence of contamination.

Procedure

The gel sample was inoculated on nutrient agar plates and incubated.

Observation

Microbial count was within acceptable pharmacopeial limits.

Stability Studies

The prepared gel was stored at:

Room temperature

40°C ± 2°C

for a period of one month. [27-28]
Parameters Observed
Color, pH, Viscosity, Homogeneity
Observation
No significant changes were observed during storage.

Phytochemical Screening

Phytochemical tests were carried out to identify active constituents.

Test	Observation	Result
Alkaloids	Precipitate formed	Present
Flavonoids	Yellow coloration	Present
Tannins	Greenish black color	Present
Saponins	Foam formation	Present

The presence of phytochemicals confirms therapeutic potential. [29,30]

Results & Discussion

Parameters	F1	F2	F3
Colour	Light green	Green	Dark green
PH	6.0	6.2	6.5
Viscosity	Moderate	Good	Very high
Spreadability	Good	Excellent	Moderate
Stability	Stable	Highly stable	Slight separation
Antimicrobial activity	Moderate	Excellent	Good
Extrudability	Good	Excellent	Moderate
Washability	Easy	Highly easy	Easy

The formulated herbal anti-acne gels F1, F2, and F3 were evaluated for various physicochemical and quality control parameters including colour, pH, viscosity, spreadability, stability, antimicrobial activity, extrudability, and washability. All formulations showed acceptable characteristics suitable for topical application; however, noticeable differences were observed among the batches due to variation in the concentration of Neem extract and Aloe vera gel. Formulation F1 showed a light green colour with a pH of 6.0, moderate viscosity, good spreadability, stable nature, moderate antimicrobial activity, good extrudability, and easy washability. Although F1 demonstrated satisfactory properties, its lower concentration of herbal ingredients may have contributed to comparatively reduced therapeutic activity.

Formulation F2 exhibited a green colour with a pH of 6.2, which was found to be highly compatible with normal skin physiology and less likely to cause irritation. The formulation showed optimum viscosity, excellent spreadability, highly stable characteristics, excellent antimicrobial activity, superior extrudability, and highly easy washability. The balanced concentration of Neem and Aloe vera in F2 contributed to better consistency and enhanced therapeutic effectiveness. Neem extract provided

significant antibacterial and anti-inflammatory activity against acne-causing microorganisms, while Aloe vera improved moisturizing, soothing, and healing properties. The excellent spreadability and smooth consistency ensured uniform application over the skin surface, thereby improving patient compliance and acceptability. Formulation F3 showed a dark green colour and a pH of 6.5, which also remained within the acceptable skin pH range. However, the formulation exhibited very high viscosity and moderate spreadability due to the higher concentration of herbal extracts. Slight phase separation was observed during stability studies, indicating reduced physical stability compared to F1 and F2. Although F3 demonstrated good antimicrobial activity, the excessive thickness affected its ease of application and extrudability. The increased viscosity may reduce patient convenience and uniform spreading on the skin surface.

Comparative evaluation of all three batches indicated that F2 possessed the most desirable

physicochemical and therapeutic properties among all formulations. Stability studies revealed that F2 remained stable without significant changes in colour, pH, consistency, or appearance under different storage conditions. The antimicrobial activity of F2 was found to be superior, suggesting effective inhibition of acne-causing microorganisms. The phytochemical screening confirmed the presence of active constituents such as alkaloids, flavonoids, tannins, and saponins, which are responsible for the antibacterial, antioxidant, and anti-inflammatory effects of the herbal formulation. Based on the overall evaluation results, formulation F2 was selected as the optimized batch because it demonstrated optimum viscosity, excellent spreadability, suitable skin-compatible pH, superior stability, enhanced antimicrobial activity, and better patient acceptability compared to F1 and F3. Therefore, the study concludes that the formulated herbal anti-acne gel containing Neem and Aloe vera can serve as a safe, stable, and effective topical preparation for acne management.

Summary and Conclusion

The present research work was carried out to formulate and evaluate a herbal anti-acne gel containing Neem (Azadirachta indica) and Aloe vera (Aloe barbadensis Miller). Acne vulgaris is one of the most common skin disorders caused by bacterial infection, inflammation, excessive sebum secretion, and blockage of hair follicles. Herbal formulations are widely accepted due to their safety, effectiveness, affordability, and minimal side effects compared to synthetic anti-acne preparations. Neem possesses significant antibacterial, anti-inflammatory, antioxidant, and antiseptic properties, while Aloe vera provides soothing, moisturizing, wound-healing, and skin-regenerating effects. The combination of these herbal ingredients was selected to prepare an effective and patient-friendly topical anti-acne gel. Three formulations, namely F1, F2, and F3, were prepared using different concentrations of herbal extracts and evaluated using various Quality Assurance (QA) and Quality Control (QC) parameters such as colour, appearance, pH, viscosity, spreadability, extrudability, washability, antimicrobial activity, and stability studies. Phytochemical screening confirmed the presence of important bioactive constituents including alkaloids, flavonoids, tannins, and saponins responsible for therapeutic activity. The evaluation results indicated that all formulations possessed satisfactory physicochemical characteristics suitable for topical application. However, formulation F2 exhibited the best overall performance among all batches. F2 showed optimum viscosity, excellent spreadability, suitable skin-compatible pH, superior stability without phase separation, enhanced antimicrobial activity, excellent extrudability, and better washability. The balanced concentration of Neem and Aloe vera in F2 provided improved consistency, better patient acceptability, and enhanced therapeutic effectiveness. Neem extract effectively inhibited acne-causing microorganisms and reduced inflammation, whereas Aloe vera promoted moisturizing, soothing, healing, and regeneration of damaged skin tissues. Stability studies revealed that the formulations remained physically stable under different storage conditions, although slight separation was observed in F3 due to higher extract concentration. The antimicrobial studies confirmed that the herbal gel possessed significant activity against acne-causing microorganisms. The gel base ensured uniform distribution and prolonged contact of active ingredients with the skin, thereby improving therapeutic efficacy. Based on the overall findings, it can be concluded that the formulated herbal anti-acne gel is safe, stable, effective, economical, and suitable for topical use in acne management. Among all prepared batches, formulation F2 was selected as the optimized formulation due to its superior physicochemical properties, stability, antimicrobial activity, and patient compliance. The study suggests that the herbal anti-acne gel containing Neem and Aloe vera may serve as a promising natural alternative to synthetic anti-acne formulations with reduced side effects and improved therapeutic benefits.

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