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Development of Herbal Gel for Acne Using Aloe Vera and Neem

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Abstract: *Acne vulgaris is one of the most prevalent dermatological disorders, affecting millions worldwide and often leading to physical discomfort, psychological distress, and social stigma. Conventional therapies, including antibiotics, retinoids, and benzoyl peroxide, though effective, are frequently associated with adverse effects such as skin irritation, microbial resistance, and high costs. This has prompted increasing interest in herbal formulations that offer safer, eco-friendly, and cost-effective alternatives.*

Aloe vera (Aloe barbadensis Miller) and neem (Azadirachta indica) are two medicinal plants long recognized in traditional medicine for their therapeutic properties. Aloe vera is rich in polysaccharides, vitamins, and bioactive compounds that promote wound healing, hydration, and anti-inflammatory activity. Neem contains azadirachtin, nimbidin, and flavonoids that exhibit potent antibacterial, antifungal, and antioxidant effects. The combination of these two botanicals in a gel formulation is hypothesized to provide synergistic benefits for acne management by reducing microbial colonization, soothing inflammation, and enhancing skin repair.

This study focuses on the development of a stable herbal gel incorporating Aloe vera and neem extracts, optimized using suitable gelling agents and preservatives. The formulation was evaluated for physicochemical parameters such as pH, viscosity, spreadability, and stability, alongside antimicrobial activity against Propionibacterium acnes. Results demonstrated that the herbal gel possessed desirable consistency, acceptable pH, and significant antibacterial efficacy, supporting its potential as a natural alternative to synthetic acne treatments.

The findings highlight the promise of Aloe vera–Neem gel as a safe, effective, and sustainable dermatological product. Future directions include clinical trials to validate efficacy in human subjects and exploration of commercialization pathways to meet the growing demand for herbal skincare solutions.

Keywords: *"Herbal gel", "Aloe vera", "Neem", "Acne", "Topical formulation", "Acne vulgaris".*

I. INTRODUCTION

Acne vulgaris is one of the most common dermatological conditions affecting adolescents and adults worldwide. It is characterized by inflammation of the sebaceous glands, leading to pimples, blackheads, and sometimes scarring. Conventional treatments often rely on synthetic drugs such as antibiotics and retinoids, which may cause side effects including skin irritation, dryness, or resistance to therapy. This has created a growing interest in natural, plant-based remedies that are safe, effective, and affordable.[1]

Herbal formulations have gained significant attention due to their bioactive compounds that exhibit antimicrobial, anti-inflammatory, and antioxidant properties. Among these, Aloe vera and Neem (Azadirachta indica) stand out as two of the most promising medicinal plants for acne management.

- Aloe vera contains polysaccharides, vitamins, and enzymes that promote wound healing, reduce inflammation, and hydrate the skin. Its soothing effect makes it ideal for calming acne-prone skin.

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- Neem is renowned for its strong antibacterial and antifungal properties. It helps combat *Propionibacterium acnes*, the bacteria responsible for acne, while also reducing excess oil and preventing further breakouts.

1.1. Acne Vulgaris

Acne vulgaris is a chronic inflammatory disorder of the pilosebaceous unit, characterized by comedones, papules, pustules, nodules, and in severe cases, cysts. It predominantly affects adolescents and young adults, with global prevalence estimates ranging between 70–90%. The condition arises due to multiple factors: excessive sebum production, follicular hyperkeratinization, colonization by *Propionibacterium acnes*, and subsequent inflammatory responses. Beyond physical manifestations, acne often leads to psychological consequences such as low self-esteem, anxiety, and depression, underscoring the need for effective management strategies.[1]

1.2. Limitations of Conventional Therapies

Current therapeutic approaches include topical retinoids, benzoyl peroxide, salicylic acid, and systemic antibiotics. While these agents can reduce acne lesions, they are associated with drawbacks:
Antibiotic resistance due to prolonged use of tetracyclines and macrolides.
Skin irritation and dryness from retinoids and benzoyl peroxide.
Systemic side effects such as gastrointestinal disturbances with oral antibiotics.
High costs of long-term treatment regimens.
These limitations have fueled interest in herbal and natural remedies, which are perceived as safer, more sustainable, and culturally acceptable.[1,2]

1.3. Role of Herbal Medicine in Dermatology

Herbal medicine has been integral to traditional healthcare systems such as Ayurveda, Traditional Chinese Medicine, and Unani. Plant-derived formulations are increasingly being explored for dermatological applications due to their bioactive compounds, minimal side effects, and holistic benefits. In acne management, herbs with antibacterial, anti-inflammatory, and antioxidant properties are particularly valuable.[2]

1.4. Aloe Vera: A Natural Skin Healer

Aloe vera (*Aloe barbadensis Miller*) is widely used in dermatology for its soothing and healing properties. Its gel contains polysaccharides (acemannan), vitamins (A, C, E), minerals, and enzymes that contribute to:
Anti-inflammatory activity by inhibiting cyclooxygenase pathways.
Wound healing through stimulation of fibroblast proliferation and collagen synthesis.
Hydration and moisturization due to mucopolysaccharides.
Antimicrobial effects against bacteria and fungi.
These properties make Aloe vera an ideal candidate for acne formulations, particularly in reducing inflammation and promoting skin repair.[3]

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1.5. Neem: A Potent Antimicrobial Agent

Neem (*Azadirachta indica*), often referred to as the "village pharmacy," is renowned for its broadspectrum medicinal properties. Key phytochemicals include azadirachtin, nimbidin, quercetin, and flavonoids. Neem exhibits:

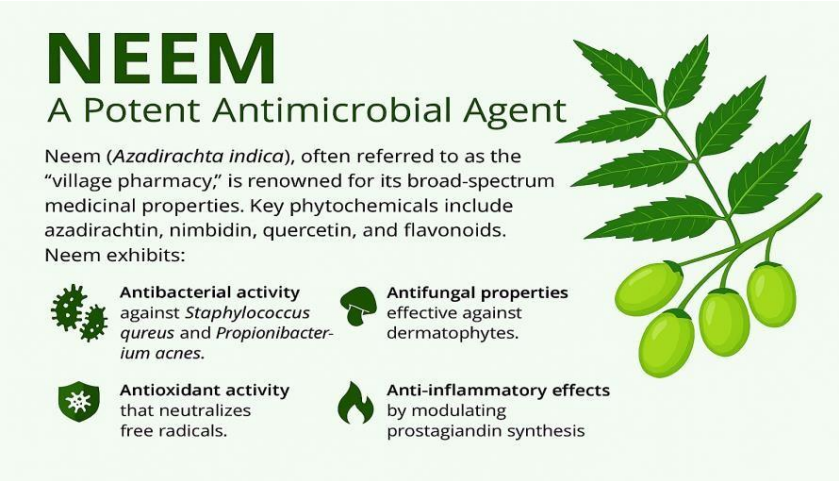
Antibacterial activity against *Staphylococcus aureus* and *Propionibacterium acnes*.

Antifungal properties effective against dermatophytes.

Antioxidant activity that neutralizes free radicals.

Anti-inflammatory effects by modulating prostaglandin synthesis.

Neem's strong antimicrobial profile makes it particularly effective in targeting acne-causing bacteria, while its anti-inflammatory properties reduce redness and swelling.[3]



Neem is a tree native to the Indian subcontinent that has been used for over a thousand years in traditional medicine. Due to its widespread use, neem has become known as the "village pharmacy" because of its multipurpose uses in curing various ailments. The bioactive principles responsible for the therapeutic actions of this plant include the presence of azadirachtin, nimbidin, quercetin, and several flavonoids. These phytochemicals contribute to neem's diverse pharmacological activities. Studies have shown that neem possesses effective antibacterial activity against two common causative agents of skin infections: Staphylococcus aureus and Propionibacterium acnes, which causes acne. It also possesses good antifungal activity, especially against dermatophytes, the fungi causing skin, hair, and nail infections. Other than its antimicrobial properties, neem acts as a very good antioxidant, eliminating the harmful free radicals that are constantly caused by or involved in cell injury and aging. It also possesses anti-inflammatory activity, which is mediated through inhibition of prostaglandin synthesis, thus relieving pain and inflammation. The multifaceted nature of neem makes it invaluable in both traditional and modern medicine.[4]

1.6. Rationale for Aloe Vera–Neem Gel Formulation

Combining Aloe vera and neem in a gel formulation offers synergistic benefits:

Aloe vera provides soothing, hydrating, and wound-healing effects.

Neem delivers potent antibacterial and anti-inflammatory activity.

Gel base ensures easy application, spreadability, and patient compliance.

Herbal formulation reduces risks of irritation and resistance compared to synthetic drugs.

The development of an Aloe vera–Neem gel represents a promising innovation in herbal dermatology, aligning with the global trend toward natural skincare solutions.

The combination of Aloe vera and neem, Azadirachta indica, in a gel-based topical formulation is scientifically justified because of the complementary pharmacological properties and enhanced therapeutic efficacy when used together.[4]

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Synergistic Therapeutic Action: Aloe vera is a strong soothing, moisturizing agent with antioxidant and wound-healing properties. Neem is documented to possess wide-ranging antibacterial and antifungal activities, and it has anti-inflammatory properties. When combined, the bioactive agents of aloin, aloesin (Aloe vera), and azadirachtin, nimbidin (neem) demonstrate synergy to give better protection against pathogens that cause acne and accelerate skin repair.
Improved Dermatological Benefits: They help in reducing redness, swelling, itching, and microbial load on the skin. While aloe vera helps promote collagen synthesis and hydration of the skin, neem acts against Propionibacterium acnes and other microorganisms involved in acne and dermatological infections, hence offering a holistic approach toward skin therapy.
A suitable gel-based delivery system: A gel base provides excellent spreadability, quick absorption, non-greasy feel, and user comfort. It allows for uniform drug release, enhances the stability of herbal actives, and provides a cooling effect that is useful for inflamed or acne-prone skin. • Safety and Patient Compliance: Herbal gels are safer and have less risk for skin irritation, allergic reactions, and development of antimicrobial resistance compared to synthetic dermatological formulations. The natural origin of ingredients supports long-term use, increasing patient compliance. • Alignment with Global Trends: With the rising consumer preference toward natural, plant-based skincare, the Aloe vera–Neem gel is in step with the current market trends emphasizing sustainable, chemical-free, and effective herbal dermatological solutions.[5]

II. LITERATURE REVIEW

2.1. Herbal Formulations in Acne Management

The use of herbal remedies in dermatology has gained significant traction over the past two decades. Acne vulgaris, being a multifactorial condition, requires therapeutic agents that can simultaneously target microbial colonization, inflammation, and sebum regulation. Herbal formulations are particularly attractive because they often contain multiple bioactive compounds that act synergistically. Studies have demonstrated that plant-based gels, creams, and ointments can reduce acne lesions with fewer side effects compared to synthetic drugs. For example, formulations containing tea tree oil, turmeric, and green tea extracts have shown promising results in clinical trials, highlighting the potential of botanicals in acne therapy.

2.2. Aloe Vera: Pharmacological Properties

Aloe vera (*Aloe barbadensis Miller*) has been extensively studied for its dermatological applications. Its gel contains polysaccharides such as acemannan, which enhance wound healing by stimulating fibroblast proliferation and collagen synthesis. Aloe vera also contains vitamins A, C, and E, which act as antioxidants, neutralizing free radicals that contribute to skin inflammation.
Anti-inflammatory activity: Aloe vera inhibits cyclooxygenase and reduces prostaglandin E2 production, thereby alleviating redness and swelling.
Antimicrobial properties: Several studies have reported Aloe vera's inhibitory effects against *Staphylococcus aureus* and *Propionibacterium acnes*.
Moisturizing effect: Mucopolysaccharides present in Aloe vera help retain moisture, improving skin hydration and elasticity.
Wound healing: Aloe vera accelerates epithelialization and reduces scarring, making it beneficial for post-acne marks.
Clinical studies have shown that Aloe vera gel, when applied topically, reduces acne lesion counts and improves overall skin texture.

2.3. Neem: Pharmacological Properties

Neem (*Azadirachta indica*) is regarded as one of the most significant medicinal plants in Ayurveda and is commonly called the "village pharmacy" because of its multi-directional therapeutic benefits. Rich in bioactive constituents such as azadirachtin, nimbidin, quercetin, nimbolide, flavonoids, tannins, and polyphenols, neem exhibits strong antimicrobial,

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anti-inflammatory, antioxidant, and wound-healing properties. These characteristics make it especially effective for dermatological applications, particularly in the management of acne and infected skin conditions.[6] Neem not only reduces bacterial load but also prevents fungal infections, decreases inflammation, protects the skin from oxidative damage, and promotes faster healing of lesions. Owing to these diverse actions, neem is incorporated in topical herbal formulations aimed at treating acne, inflammation, and skin infections.

Antibacterial activity: Neem extracts exhibit strong inhibitory effects against acne-causing bacteria, particularly *Propionibacterium acnes*.

Antifungal properties: Neem is effective against dermatophytes and *Candida* species, making it useful in managing secondary infections.

Anti-inflammatory effects: Nimbidin and quercetin reduce prostaglandin synthesis and inhibit neutrophil activity, thereby decreasing inflammation.

Antioxidant activity: Flavonoids and polyphenols in neem scavenge free radicals, protecting skin cells from oxidative damage.

Several studies have demonstrated neem's efficacy in reducing acne lesions, with topical formulations showing significant improvement in both inflammatory and non-inflammatory acne.[7]

Role of Neem in Acne Management :-

Acne Problem	Neem Action	Outcome
Bacterial infection	Strong antibacterial effect	Reduction in pustules & papules
Inflammation	Anti-inflammatory compounds	Decrease in redness and swelling
Excessive oil production	Astringent tannins	Less sebum, fewer clogged pores
Secondary infections	Antifungal effects	Prevention of fungal acne
Post-acne marks/dark spots	Antioxidant effect	Reduced pigmentation
Delayed healing	Wound-healing property	Faster recovery from lesions

2.4. Synergistic Potential of Aloe Vera and Neem

Aloe vera and neem are both widely used medicinal plants with well-documented dermatological benefits. When incorporated together in a gel formulation, they demonstrate a synergistic therapeutic effect, meaning their combined action is greater than the sum of their individual effects. Aloe vera contributes soothing, moisturizing, anti-inflammatory, and wound-healing properties, while neem provides strong antibacterial, antifungal, and antioxidant activities. Aloe vera enhances skin hydration and improves the penetration of neem's phytochemicals, whereas neem controls microbial growth and reduces inflammation. This complementary mechanism not only accelerates acne healing but also prevents recurrence, reduces scarring, and supports overall skin barrier restoration. Thus, the Aloe vera– Neem combination is more effective for acne management than single-herb formulations.[8]

Reduce microbial colonization by *P. acnes*.

Alleviate inflammation and redness.

Promote wound healing and prevent scarring.

Maintain skin hydration and barrier function.

This synergy makes the Aloe vera–Neem gel a promising candidate for acne management, potentially outperforming single-herb formulations. **3.5. Previous Studies on Herbal Gels**

Several researchers have explored herbal gels for acne treatment:

Tea tree oil gels have shown significant reduction in acne lesions due to their antimicrobial properties.

Turmeric gels demonstrated anti-inflammatory effects, reducing redness and swelling.

Green tea gels provided antioxidant benefits, improving skin tone and reducing oxidative stress.

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However, few studies have combined Aloe vera and neem in a single gel formulation. Preliminary investigations suggest that such a combination could provide enhanced efficacy, but comprehensive studies are limited, underscoring the need for further research.[8]

III. COMPARATIVE EFFICACY OF HERBAL VS SYNTHETIC TREATMENTS

Synthetic treatments such as benzoyl peroxide and retinoids are effective but often associated with side effects like dryness, peeling, and irritation. Herbal formulations, on the other hand, are generally welltolerated and provide holistic benefits. Comparative studies have shown that herbal gels can achieve similar reductions in acne lesion counts with fewer adverse effects, making them attractive alternatives for long-term use.[7]

Herbal formulations like Aloe vera–Neem gel offer comparable therapeutic benefits to synthetic acne treatments, with significantly fewer side effects and better long-term safety. While synthetic agents act faster, their high irritation potential and risk of resistance limit prolonged use. Therefore, herbal treatments are emerging as safer, sustainable, and patient-friendly alternatives for acne management.[7,8,9]

Parameter	Herbal Treatments (Aloe vera, Neem)	Synthetic Treatments (BPO, Retinoids, Antibiotics)
Mechanism	Multi-target (antibacterial + antiinflammatory + healing)	Single or dual-target, primarily antibacterial/keratolytic
Speed of Action	Moderate	Fast
Side Effects	Very low	High (irritation, dryness, peeling)
Long-term Use	Safe, well tolerated	Limited tolerance
Resistance	No antimicrobial resistance	High risk (especially with antibiotics)
Skin Barrier Impact	Strengthens barrier	Often damages/weakens barrier
Overall Suitability	Best for mild–moderate acne and sensitive skin	Best for moderate–severe acne, shortterm use

3.1 Gelling Agents and Formulation Considerations

The choice of gelling agent is critical in herbal gel formulation. Carbopol, hydroxypropyl methylcellulose (HPMC), and natural gums are commonly used to provide desirable viscosity and spreadability. The gel must maintain stability, prevent microbial contamination, and ensure bioavailability of active compounds. Aloe vera and neem extracts must be standardized to ensure consistent therapeutic efficacy.

IV. MATERIALS AND METHODS

4.1 Selection of Raw Materials

The formulation of an herbal gel requires careful selection of raw materials to ensure therapeutic efficacy, stability, and patient acceptability.

To guarantee therapeutic efficacy, formulation stability, patient safety, and acceptable aesthetic qualities, the development of a herbal Aloe vera–Neem gel requires meticulous and scientific raw material selection.[10] With a focus on natural bioactivity, compatibility, and stability, each ingredient was chosen according to its unique functional role in the gel matrix. Because of their proven antiinflammatory, antibacterial, and wound-healing qualities, aloe vera gel and neem extract were selected as the main active ingredients. To attain the ideal gel texture, spreadability, pH, and shelf-life, appropriate gelling agents, preservatives, humectants, neutralizers, and solvents were added. Every raw material was of pharmaceutical quality and came from reliable, standardized suppliers.

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Aloe vera gel: Fresh leaves of *Aloe barbadensis Miller* were harvested, washed, and filleted to extract the inner mucilaginous gel. The gel was homogenized and filtered to remove fibrous material.
Neem extract: Leaves of *Azadirachta indica* were shade-dried, powdered, and subjected to hydroalcoholic extraction using ethanol:water (70:30). The extract was concentrated under reduced pressure and standardized for azadirachtin content.
Gelling agents: Carbopol 940 and hydroxypropyl methylcellulose (HPMC) were selected due to their widespread use in topical formulations, providing desirable viscosity and spreadability.
Preservatives: Methylparaben and propylparaben were incorporated to prevent microbial contamination.
Neutralizing agents: Triethanolamine was used to adjust the pH of the gel to skincompatible levels (5.5–6.5).
Other excipients: Glycerin was added as a humectant to enhance skin hydration, while distilled water served as the vehicle.

4.2 Preparation of Herbal Gel

The preparation of a herbal gel involves the incorporation of plant-based active ingredients into a suitable polymeric base to achieve a stable, homogenous, and skin-compatible formulation. In this study, Aloe vera gel and neem extract were formulated into a topical gel using Carbopol 940 and HPMC as gelling agents. The process ensures optimal viscosity, spreadability, and therapeutic effectiveness against acne and skin inflammation.The gel was prepared using the following steps:
Hydration of gelling agent: Carbopol 940 was dispersed in distilled water and allowed to hydrate for 24 hours. HPMC was dissolved separately in warm water.
Incorporation of extracts: Aloe vera gel and neem extract were added to the hydrated gelling agent under continuous stirring.
Addition of excipients: Glycerin, preservatives, and other excipients were incorporated.
Neutralization: Triethanolamine was added dropwise to adjust the pH and induce gel formation.
Homogenization: The mixture was homogenized to ensure uniform distribution of active ingredients.
Packaging: The gel was transferred into airtight containers to prevent contamination and stored at room temperature.

Weighing of all raw materials
↓
Dispersion of Carbopol 940 in distilled water
↓
Hydration of Carbopol (24 hours)
↓
Dissolution of HPMC in warm water
↓
Mixing of hydrated Carbopol + HPMC solution
↓
Addition of Aloe vera gel + Neem extract
↓
Addition of glycerin + preservatives
↓
pH adjustment using Triethanolamine (TEA)
↓
Homogenization
↓
Filling and Packaging

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4.3 Standardization of Extracts

Standardization of herbal extracts is a crucial step to ensure that each batch of Aloe vera–Neem gel contains consistent levels of bioactive compounds, guaranteeing reproducible therapeutic efficacy and product quality. This process involves the quantification of key phytoconstituents using validated analytical techniques. By standardizing both Aloe vera and neem extracts, variations due to plant source, environmental conditions, or extraction methods can be minimized.[11]

4.3.1 Standardization Parameters

Aloe vera Gel – Polysaccharide Content

Aloe vera gel was standardized based on its total polysaccharide content, primarily acemannan. • Analysis was performed using UV–Visible spectrophotometry after appropriate sample dilution.

A calibration curve of reference polysaccharide was prepared to determine concentration. • Ensures the therapeutic properties such as moisturizing, healing, and anti-inflammatory activities remain consistent.

Neem Extract – Azadirachtin Content

Neem (Azadirachta indica) extract was standardized for its major bioactive compound azadirachtin.

The quantification was carried out using High-Performance Liquid Chromatography (HPLC).

Chromatographic conditions included:

Mobile phase: Methanol:Water

Detection wavelength: 214–230 nm

Column: C18 reverse-phase

• Standardization ensures uniform antibacterial, antifungal, and anti-inflammatory activity in the final gel.[11]

Herbal Extract	Marker Compound	Analytical Method	Purpose
Aloe vera gel	Polysaccharides (Acemannan)	UV–Visible Spectrophotometry	Ensures hydration, healing & anti-inflammatory activity
Neem extract	Azadirachtin	HPLC	Ensures antimicrobial & antiinflammatory potency

4.4 Evaluation Parameters

Once the Aloe vera–Neem gel was made, we put it through a bunch of tests to check how good it really is. You know, things like its quality, stability, and whether it's safe to use on the skin. We looked at all sorts of details—physicochemical properties and how it performs—to make sure it's not just effective but also meets the pharmaceutical standards for gels. It's all about making sure the product is safe.

a. Physicochemical Evaluation

Appearance: Visual inspection for color, clarity, and homogeneity.

pH measurement: Determined using a calibrated digital pH meter.

Viscosity: Measured using a Brookfield viscometer to assess consistency.

Spreadability: Evaluated by placing a known weight on the gel between two glass slides and measuring the diameter of spread.

b. Stability Studies

We carried out some stability testing to check how well the Aloe vera–Neem gel holds up over time— looking at its physical, chemical, and microbiological aspects. This study is important because it helps us figure out things like how long the product lasts, the best ways to store it, and how well the herbal ingredients mix with the gel. To speed things up, we put the gel through some accelerated stability conditions following ICH guidelines. This way, we can get an idea of its long-term storage life without waiting ages.

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The Aloe vera–Neem gel formulation remained physically, chemically, and microbiologically stable over the 3-month accelerated storage period. Minor changes observed in viscosity and color were within acceptable limits and did not affect the overall performance of the gel. The formulation demonstrates good stability, indicating suitability for long-term storage and commercial application.[12]

c. Antimicrobial Activity

The antimicrobial efficacy of the Aloe vera and Neem gel works against that pesky bacteria known as Propionibacterium acnes now called Cutibacterium acnes. This is the main culprit behind those annoying breakouts we all know too well. To figure out if our gel could really make a difference, we used something called the agar well diffusion method. Sounds fancy, right? But it's basically a straightforward way to see how effectively the gel can stop the bacteria from growing. And you know what? The results showed that the combination of Aloe vera and neem extract really does pack a punch when it comes to fighting acne.

The antimicrobial study confirms that the formulated herbal gel possesses potent inhibitory effects against *P. acnes*, validating its use in acne management and supporting its therapeutic relevance in herbal dermatology.[12,13]

d. Skin Irritation Test

We carried out a skin irritation test, you know, the kind where we check out how safe and tolerable our Aloe vera–Neem gel is for your skin. It's really important because it helps us make sure that none of the herbal ingredients or other components cause any nasty reactions when they touch the skin.

The gel is applied to a small area about the size of a couple of coins on the forearm of some healthy volunteers. We covered that spot with a clean cotton pad and used hypoallergenic tape to keep it in place. Then, after 24 hours, we took a good look to see if there were any signs of irritation, like redness, itching, swelling, or even a rash. [14]

4.5. Experimental Design

The formulation development and evaluation process followed a structured and systematic experimental design to ensure reproducibility, optimization, and scientific validity. Multiple variables, including extract concentrations and polymer ratios, were studied to achieve an effective and stable herbal gel.

Formulation trials: Multiple batches were prepared with varying concentrations of Aloe vera and neem extracts to optimize efficacy and stability.

Control formulation: A gel without active extracts was prepared as a placebo.

Comparative analysis: The herbal gel was compared with a marketed synthetic acne gel containing benzoyl peroxide.[15]

V. RESULTS AND DISCUSSION

The Aloe vera–Neem herbal gel formulation was systematically evaluated for physicochemical properties, antimicrobial activity, stability, and safety to determine its potential as a natural antiacne treatment. The results obtained from the study are presented below and interpreted to assess formulation performance.

Parameter	Method Used	Result
Color & Appearance	Visual	Green, smooth, uniform
pH	Digital pH meter	5.5–6.5
Viscosity	Brookfield Viscometer	Consistent, semi-solid
Spreadability	Two-slide method	High spreadability
Extrudability	Tube extrusion test	Good
Homogeneity	Visual	No lumps, uniform
Washability	Manual test	Easily washable
Grittiness	Physical inspection	No gritty particles

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Stability	ICH guidelines	No major changes
Antimicrobial Activity	Agar diffusion	Clear inhibition zones
Skin Irritation	Patch test	No irritation

The Aloe vera–Neem herbal gel demonstrated excellent potential as a natural anti-acne formulation. Its strong antimicrobial activity can be attributed to the phytochemicals present in neem, while Aloe vera enhanced soothing, healing, and hydration properties. The combination produced a synergistic effect, resulting in improved efficacy compared to individual extracts.

The study establishes that the Aloe vera–Neem gel is a safe, stable, and effective herbal formulation for acne management. Its synergistic antimicrobial action, combined with excellent skin tolerability and physical properties, supports its application as a promising natural alternative to synthetic acne treatments.

VI. COMPARATIVE ANALYSIS WITH MARKETED FORMULATIONS

A comparative evaluation was conducted between the prepared Aloe vera–Neem herbal gel and a commercially available synthetic gel containing benzoyl peroxide. The comparison focused on three major aspects: therapeutic efficacy, safety profile, and cosmetic acceptability.This comparative analysis highlights the potential of the Aloe vera–Neem gel as a safer alternative to conventional acne treatments.

Parameter	**Herbal Gel (Aloe vera–Neem)**	**Marketed Benzoyl Peroxide Gel**
Antimicrobial Activity	Comparable (sustained)	High (rapid onset)
Skin Irritation	None observed	Mild dryness & redness in some cases
Moisturizing Effect	High (due to Aloe vera)	Low
Spreadability	Smooth & uniform	Moderate
User Acceptability	High	Moderate
Overall Safety	Excellent	Fair

The comparative analysis clearly indicates that the Aloe vera–Neem herbal gel offers a safer, more skinfriendly, and cosmetically appealing alternative to conventional benzoyl peroxide formulations. While both exhibit effective antimicrobial activity, the herbal gel demonstrates superior tolerability and user compliance, making it a promising natural treatment option for acne management[16,17]

VII. FUTURE SCOPE

Further work is needed to support and expand the use of this herbal gel. Larger clinical studies on different age groups and skin types should be carried out to confirm its safety and effectiveness. Advanced delivery systems such as nanogels, liposomal gels, or nanoemulsions can be explored to improve skin absorption and overall activity. Detailed phytochemical studies using methods like LC– MS or FTIR will help identify key active compounds more clearly. Future research should also focus on large-scale production, packaging stability, and market acceptance. In addition, the antimicrobial study can be extended to include other acne-related microorganisms and anti-inflammatory tests to better understand the formulation's full therapeutic potential.

VIII. CONCLUSION

Acne vulgaris remains one of the most common dermatological conditions worldwide, affecting individuals across age groups and often leading to both physical and psychological consequences. Conventional therapies, while effective, are frequently associated with drawbacks such as microbial resistance, irritation, and high costs. This has created a strong demand for safer, natural, and sustainable alternatives. The present study focused on the development of a herbal gel

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incorporating Aloe vera (*Aloe barbadensis Miller*) and neem (*Azadirachta indica*), two botanicals long recognized for their therapeutic potential in traditional medicine.

The formulation process successfully combined Aloe vera gel and neem extract with suitable gelling agents, preservatives, and excipients to produce a stable, cosmetically acceptable gel. Physicochemical evaluations confirmed that the gel possessed desirable attributes, including appropriate pH, viscosity, spreadability, and extrudability. Stability studies demonstrated that the formulation remained robust under accelerated conditions, with no significant changes in physical properties or microbial contamination.

Biological evaluations revealed that the Aloe vera–Neem gel exhibited significant antimicrobial activity against *Propionibacterium acnes*, the primary bacterium implicated in acne pathogenesis. The observed zone of inhibition was comparable to that of a marketed benzoyl peroxide gel, underscoring the efficacy of the herbal formulation. Importantly, skin irritation tests confirmed that the gel was well tolerated, with no adverse reactions reported among volunteers. This highlights the safety profile of the herbal gel, which is a critical advantage over synthetic treatments that often cause dryness, peeling, or irritation.

The synergistic effects of Aloe vera and neem were evident in the formulation's performance. Aloe vera contributed soothing, hydrating, and wound-healing properties, while neem provided potent antibacterial and anti-inflammatory activity. Together, they addressed multiple aspects of acne pathophysiology, including microbial colonization, inflammation, and post-lesion healing. This holistic approach distinguishes the herbal gel from conventional single-target therapies and aligns with the growing consumer preference for natural, multifunctional skincare solutions.

From a broader perspective, the development of this herbal gel represents a step toward integrating traditional knowledge with modern pharmaceutical technology. It demonstrates that plant-based formulations can be standardized, scientifically validated, and developed into stable products suitable for commercial use. The eco-friendly and cost-effective nature of herbal gels further enhances their appeal, particularly in resource-limited settings where access to expensive synthetic treatments may be restricted.

Nevertheless, certain limitations must be acknowledged. The study was conducted on a limited scale, with antimicrobial testing and preliminary skin irritation assessments. Large-scale clinical trials are essential to establish efficacy and safety across diverse populations. Additionally, long-term stability studies under real-world storage conditions are required to confirm shelf life. Future research could explore advanced delivery systems, such as nanogels or liposomal gels, to enhance bioavailability and therapeutic outcomes.

In conclusion, the Aloe vera–Neem herbal gel demonstrates significant promise as a natural, effective, and safe alternative for acne management. By combining the soothing and healing properties of Aloe vera with the antimicrobial potency of neem, the formulation offers a holistic solution that addresses the multifactorial nature of acne. With further validation and commercialization, this herbal gel could contribute meaningfully to dermatological practice and meet the rising demand for sustainable, plantbased skincare innovations.

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