



Formulation And Evaluation Of Polyherbal Gel-Based Preparation For The Management Of Acne

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Abstract

Acne vulgaris remains one of the most widespread dermatological disorders, typically associated with increased sebum production, colonization by *Propionibacterium acnes*, inflammation, and follicular hyperkeratinization. Although conventional therapeutic agents—including benzoyl peroxide, retinoids, and antibiotics—are frequently prescribed, their prolonged use may result in adverse reactions such as dryness, skin irritation, and the development of antimicrobial resistance. In response to these limitations, herbal alternatives have gained increasing interest for their biocompatibility, broad-spectrum activity, and minimal side effects. This study investigates the development and assessment of a gel-based polyherbal formulation designed for acne management. The preparation integrates standardized extracts of *Azadirachta indica* (Neem), *Aloe barbadensis miller* (Aloe Vera), *Curcuma longa* (Turmeric), *Ocimum sanctum* (Basil), and *Centella asiatica* (Gotu Kola). These botanicals are selected for their synergistic antibacterial, anti-inflammatory, antioxidant, and wound-healing properties. Carbopol 934 was employed as the gelling agent, ensuring appropriate viscosity and stability of the formulation. The developed gel was subjected to rigorous physicochemical evaluations, including pH, spreadability, homogeneity, and stability analysis. Results suggest that this polyherbal gel could serve as a promising, naturally derived alternative to synthetic acne treatments. Further research should prioritize advanced delivery systems, such as nanoparticle-based carriers, to improve bioavailability and conduct long-term clinical studies for efficacy confirmation.

Keywords: Acne vulgaris, Polyherbal formulation, Herbal therapy, Antimicrobial-activity, Natural skincare, Dermatological gel.

Introduction

Acne vulgaris is a multifactorial skin condition that primarily targets the sebaceous glands and hair follicles. It affects a significant portion of the global population, with approximately 85% of individuals aged 12 to 24 experiencing some form of the disorder. [1] Although it typically emerges during puberty due to hormonal changes, many cases persist into adulthood. Adult-onset acne, particularly prevalent among women, is influenced by factors such as hormonal fluctuations, psychological stress, and the use of cosmetic products.

The disease is characterized by lesions including comedones, papules, pustules, nodules, and cysts. Without timely treatment, these lesions may result in post-inflammatory hyperpigmentation (PIH) and permanent scarring, posing both dermatological and psychological challenges.[2]

Pathophysiology of Acne Vulgaris

Acne vulgaris develops through the interplay of hormonal, microbial, and immunological factors. The following mechanisms play key roles in its pathogenesis:

Sebum Overproduction

Sebum is a lipid-rich substance secreted by sebaceous glands, essential for maintaining skin hydration. [3] However, in acne-prone individuals, androgens such as testosterone and dihydrotestosterone (DHT) significantly stimulate sebaceous activity, leading to excessive oil production. This increase in sebum creates an ideal environment for bacterial growth and contributes to follicular blockage.[4]

Key contributors to elevated sebum output include:

- Hormonal shifts during puberty, menstruation, pregnancy, and menopause.
- Elevated cortisol levels due to stress, which indirectly increase androgen production.
- Dietary patterns, especially consumption of high glycemic index foods and dairy, which enhance insulin-like growth factor-1 (IGF-1), further stimulating sebum secretion.[5]

Follicular Hyperkeratinization

This process involves the abnormal desquamation of keratinocytes within the follicular epithelium. Instead of shedding efficiently, these cells accumulate and combine with sebum, forming keratinous plugs known as microcomedones. These clogged follicles represent the initial stage of acne lesion formation.

Microbial Colonization

The skin's microbiota includes *Cutibacterium acnes* (formerly *Propionibacterium acnes*), a Gram-positive anaerobic bacterium that normally resides in sebaceous-rich regions. In acne-affected skin, the anaerobic conditions resulting from sebum accumulation allow for overgrowth of *C. acnes*. [6] This bacterial proliferation results in:

- Production of lipases that hydrolyze triglycerides into pro-inflammatory fatty acids.
- Stimulation of innate immune pathways through Toll-like receptors (TLR-2, TLR-4).
- Formation of biofilms that protect the bacteria and contribute to antimicrobial resistance.

Inflammatory Cascade

The overgrowth of *C. acnes* initiates an immune response that leads to the release of inflammatory cytokines, such as:

- Interleukin-1 (IL-1), which promotes follicular obstruction.
- Interleukin-6 (IL-6), which supports local inflammation.
- Tumor necrosis factor-alpha (TNF-α), which recruits immune cells, causing erythema and edema.

These immune mediators amplify the inflammatory response, resulting in the formation of more severe acne lesions.[3]

Clinical Classification of Acne

Acne can be broadly categorized based on the presence or absence of inflammation:

Non-Inflammatory Acne

This type includes open comedones (blackheads) and closed comedones (whiteheads).

- **Open comedones** develop when follicular plugs are exposed to air and undergo oxidation, turning dark.
- **Closed comedones** occur when the follicle remains sealed, trapping sebum and keratin beneath the surface.[7]

Inflammatory Acne

Inflammatory lesions are characterized by erythema, swelling, and tenderness:

- **Papules** are small, raised, and red lesions without visible pus.
- **Pustules** resemble papules but contain purulent material due to neutrophilic infiltration.
- **Nodules** are large, firm, and painful lesions located deeper within the dermis.
- **Cysts** represent the most severe form, featuring fluid-filled cavities that are often painful and prone to scarring.[7]

Conventional vs. Herbal Treatments for Acne

Aspect	Conventional Treatments	Herbal Treatments
Common Ingredients	Benzoyl peroxide, Clindamycin, Retinoids	Neem, Aloe vera, Tea tree oil, Turmeric
Mechanism	Kills bacteria, reduces oil production	Antimicrobial, anti-inflammatory, antioxidant
Side Effects	Irritation, dryness, antibiotic resistance	Minimal, rarely causes irritation
Effectiveness	High but short-term	Moderate to high, long-term relief
Sustainability	Synthetic chemicals	Eco-friendly, plant-based

Herbal Ingredients Commonly Used in Polyherbal Gels

Herbal Ingredient	Active Components	Role in Acne Treatment
Neem (<i>Azadirachta indica</i>)	Azadirachtin, Nimbidin	Antibacterial, anti-inflammatory
Aloe vera (<i>Aloe barbadensis</i>)	Polysaccharides, Aloin	Soothing, wound healing
Turmeric (<i>Curcuma longa</i>)	Curcumin	Antioxidant, anti-inflammatory
Basil (<i>Ocimum sanctum</i>)	Eugenol	Antimicrobial
Gotu Kola (<i>Centella Asiatica</i>)	Asiaticoside	Reduce Inflammation

Importance of Gel-Based Formulations for Acne Treatment

Gels are a preferred option for topical drug delivery because they offer several advantages. These include improved absorption of active compounds into the skin, extended duration of action, and a controlled release of the active ingredients, which ensures their effectiveness over time. [8] Unlike creams and lotions, gels are non-greasy, making them ideal for individuals with oily and acne-prone skin. They also provide faster absorption, which helps prevent the clogging of pores, a critical factor in acne treatment. Moreover, polyherbal gels are more stable than aqueous or emulsion-based formulations, ensuring that the active compounds retain their potency for an extended period.[9]

Herbal ingredients included in polyherbal gels offer additional therapeutic benefits due to their antibacterial, anti-inflammatory, and antioxidant activities. These properties are particularly important in acne treatment, as they help reduce the growth of acne-causing bacteria, alleviate skin irritation, and promote healing. Furthermore, polyherbal gels are more likely to improve patient compliance due to their lightweight, non-comedogenic nature and ease of application, which does not leave an oily residue on the skin.[10]

Selection of Herbs and Their Pharmacological Relevance

Neem (*Azadirachta indica*)

Commonly referred to as the "village pharmacy," neem has a long-standing reputation in traditional Indian medicine systems, including Ayurveda and Unani. Various parts of the neem tree—leaves, bark, seeds, and oil—are used in dermatological preparations.

Key Phytochemicals and Mechanisms:

- **Limonoids (Azadirachtin, Nimbin, Salannin):** Exhibit potent antibacterial activity, especially against *Cutibacterium acnes* and *Staphylococcus aureus*, by disrupting biofilm formation and inhibiting bacterial growth.
- **Flavonoids and Polyphenols:** Neutralize free radicals, protect skin from UV-induced pigmentation, and reduce oxidative stress.
- **Nimbidin and Nimbin:** Suppress pro-inflammatory cytokines such as IL-6 and TNF- α , minimizing lesion inflammation.
- **Fatty Acids (Oleic, Linoleic, Palmitic acids):** Help maintain the skin's lipid balance while being non-comedogenic.
- **Tannins:** Tighten pores and regulate sebum output, aiding in the prevention of comedones.[11]

Aloe Vera (*Aloe barbadensis miller*)

Renowned for its soothing and hydrating properties, aloe vera is extensively used in dermatological and cosmetic formulations. Its gel contains a rich matrix of bioactive compounds beneficial for acne-prone and sensitive skin types.

Key Bioactive Compounds:

- **Polysaccharides (Acemannan, Mannose-6-phosphate):** Facilitate skin hydration and tissue regeneration.
- **Anthraquinones (Aloin, Emodin):** Possess antimicrobial and anti-inflammatory effects.
- **Flavonoids and Polyphenols:** Combat oxidative damage and inflammation.
- **Salicylic Acid:** Promotes keratolysis and pore decongestion.
- **Vitamins (A, C, E, B12) and Minerals (Zinc, Magnesium):** Support cellular repair, reduce sebum production, and enhance skin clarity.[12]

Turmeric (*Curcuma longa*)

Turmeric has long been a staple in traditional medicine for its broad pharmacological spectrum. Its active compound, curcumin, imparts most of its therapeutic properties.

Notable Constituents and Effects:

- **Curcuminoids (Curcumin, Demethoxycurcumin, Bisdemethoxycurcumin):** Offer anti-inflammatory and antioxidant effects by modulating nuclear factor-kappa B (NF-κB) and cytokine expression.
- **Volatile Oils (Ar-turmerone, Zingiberene):** Exhibit anti-inflammatory and neuroprotective properties.
- **Polysaccharides and Flavonoids:** Enhance immune function and reduce skin irritation.

These constituents synergize to improve skin tone, reduce inflammation, and combat bacterial proliferation.[13]

Holy Basil (*Ocimum sanctum*)

Known as "Tulsi" in Ayurveda, holy basil is a sacred and medicinal herb endowed with adaptogenic, antimicrobial, and anti-inflammatory properties.

Major Phytochemicals:

- **Essential Oils (Eugenol, Linalool, Methyl Chavicol):** Display antimicrobial and analgesic activities.
- **Flavonoids (Rosmarinic acid, Apigenin, Luteolin):** Contribute antioxidant and anti-inflammatory effects.
- **Polyphenols (Ursolic Acid, Caffeic Acid):** Protect against oxidative damage and modulate inflammatory pathways.
- **Saponins and Alkaloids:** Provide immunomodulatory and detoxifying actions, enhancing the herb's therapeutic potential.[14]

Gotu Kola (*Centella asiatica*)

Gotu Kola is acclaimed for its wound-healing and skin-rejuvenating capabilities, making it ideal for post-acne care.

Primary Bioactives and Their Actions:

- **Triterpenoids (Asiaticoside, Madecassoside):** Stimulate collagen production, improve skin elasticity, and accelerate tissue repair.
- **Flavonoids (Quercetin, Kaempferol):** Possess antioxidant activities that protect skin cells.
- **Phenolic Acids (Chlorogenic Acid):** Reduce inflammation and prevent bacterial colonization.
- **Saponins and Alkaloids:** Promote microcirculation and minimize inflammatory responses.[15]

Synergistic Potential in Polyherbal Formulations

Combining these herbs in a gel-based topical formulation may yield synergistic effects, enhancing therapeutic outcomes through complementary mechanisms. For instance, neem and turmeric provide robust antimicrobial effects, aloe vera and Gotu Kola support skin repair, while basil offers adaptogenic support and immune balance. Such formulations can address multiple pathophysiological aspects of acne without the drawbacks of synthetic agents.[16]

Selection of Gelling Agents

The gelling agent is a critical component in polyherbal gel formulations, as it provides viscosity, stability, and spreadability. Common gelling agents used in polyherbal formulations include:

- **Carbopol 934:** A synthetic polymer that forms stable, transparent gels with excellent consistency and smooth texture.
- **Aloe Vera Gel:** Used as both a natural gelling agent and a hydrating ingredient, aloe vera gel also provides soothing effects on the skin.

The selection of a suitable gelling agent depends on factors such as the desired consistency, stability, and compatibility with the herbal extracts used in the formulation.[17]

Preservatives and Antioxidants

Herbal extracts are prone to microbial contamination, necessitating the inclusion of preservatives to enhance stability and extend shelf life. Common preservatives in polyherbal gels include:

- **Methylparaben and Propylparaben:** Synthetic preservatives that help prevent microbial growth and enhance the stability of the formulation.

pH Adjusters

Since human skin has a natural pH of approximately 5.5, it is crucial to adjust the pH of polyherbal gel formulations to match this level in order to maintain skin compatibility and minimize irritation. Common pH adjusters used in gel formulations include:

- **Triethanolamine (TEA):** Frequently used in Carbopol-based formulations to adjust and stabilize the pH.

General Method for Formulating Polyherbal Gels

The formulation of a polyherbal gel involves several key steps to ensure proper consistency, stability, and therapeutic efficacy. The process begins with the preparation of herbal extracts, where dried plant materials are extracted using methods such as maceration, Soxhlet extraction, or solvent extraction. After filtration and concentration, the active phytochemicals are isolated for use in the gel formulation.

Next, the selected gelling agent (Carbopol934) is dispersed in distilled water and stirred at high speed to ensure uniform dispersion. The gel base is then allowed to hydrate for 24 hours to achieve complete swelling of the gelling agent.[18]

The formulation is as follow :

Ingredients	Quantity
Carbopol	0.5g
Distilled Water	71.5ml
Triethanolamine	0.6ml
Aloe Vera	10ml
Neem (Conc ⁿ Extract)	1.7ml
Turmeric (Conc ⁿ Extract)	0.2ml
Centella Asiatica (Conc ⁿ Extract)	2ml
Tulsi (Conc ⁿ Extract)	12.5ml
Rosewater	1.5ml

Once the gel base is prepared, the herbal extracts are gradually incorporated into the gel, with continuous stirring to ensure uniform distribution. The pH of the formulation is adjusted using a suitable pH adjuster (Triethanolamine), and preservatives are added to enhance stability. Finally, the gel is homogenized to ensure a smooth, uniform texture, and is then packaged in tubes or jars for storage at room temperature.[19]

Quality Control and Stability Testing

Quality control of the gel formulations was conducted by evaluating several parameters including appearance, pH, viscosity, spreadability, and homogeneity. These properties were assessed as follows:

1. **Visual Inspection:** The color and clarity of the gel were inspected to ensure uniformity.
2. **pH Measurement:** A digital pH meter was used to assess the pH of the gel to ensure skin compatibility.
3. **Viscosity Testing:** Viscosity was measured using a Brookfield viscometer.
4. **Spreadability:** Spreadability was determined using the parallel plate method.
5. **Homogeneity:** The gel's consistency was evaluated by rubbing a small sample between the fingers.

Stability testing was conducted by storing the gel at three different temperatures (4°C, 25°C, and 40°C) for a period ranging from 1 month. Changes in pH, color, viscosity, and microbial growth were monitored to assess long-term stability.[4]

Result :**Organoleptic Properties**

- **Appearance:** The gel was found to be clear, with a smooth and consistent texture.
- **Odor:** The gel had a pleasant herbal scent without any overpowering or unpleasant odor.

Physicochemical Properties

- **pH:** The gel had a pH of 5.8, which is ideal for topical application on the skin.
- **Viscosity:** The gel exhibited moderate viscosity, making it easy to apply without being too runny or too thick.
- **Spreadability:** The gel spread easily on the skin, offering good coverage.
- **Extrudability:** The gel was easily extruded from the container.

Stability Studies

The gel remained stable at all tested temperatures. No significant changes were observed in its appearance, consistency, or pH for 1 month.

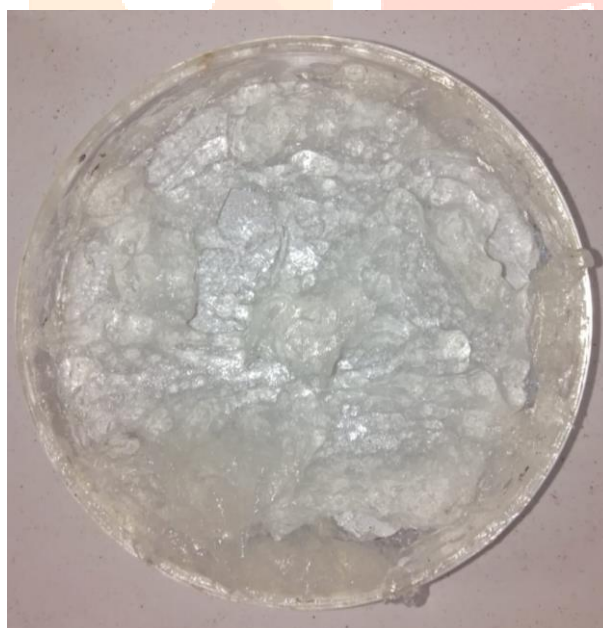


Fig.1. Gel Base



Fig.2. Final Gel

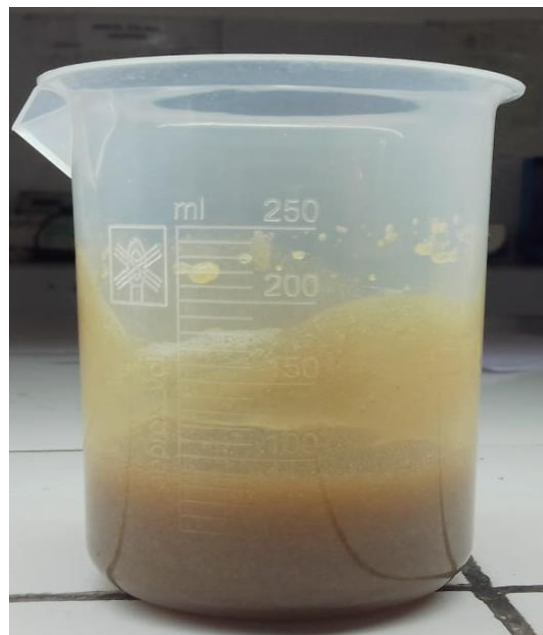


Fig.3. Final Gel

Discussion

The results confirm that polyherbal gels offer a comprehensive solution to acne management. Their combination of antibacterial, anti-inflammatory, antioxidant, and keratolytic properties provides a holistic approach to acne treatment. Additionally, polyherbal gels have shown superior skin compatibility, making them suitable for long-term use.

However, further research is needed to standardize these formulations and establish long-term efficacy. Future studies should focus on optimizing extraction methods, evaluating the gels' performance in different populations, and conducting large-scale, multi-center trials.

Conclusion

The formulation and evaluation of polyherbal gel-based preparations for the management of acne represents a promising and effective approach to addressing this common skin condition. By combining multiple medicinal herbs such as Neem (*Azadirachta indica*), Tulsi (*Ocimum sanctum*), Turmeric (*Curcuma longa*), and Gotu Kola (*Centella Asiatica*), these gel formulations capitalize on the synergistic effects of the active compounds present in each plant. Neem's antimicrobial and anti-inflammatory properties, Tulsi's antioxidant and skin healing abilities, Turmeric's anti-inflammatory and wound-healing effects, and Gotu Kola's collagen-boosting and skin regeneration properties make them ideal candidates for acne management.

The preparation of polyherbal gels not only offers an innovative and convenient dosage form but also enhances the stability and bioavailability of the active ingredients. The gels provide a soothing, non-greasy texture, which is particularly beneficial for acne-prone skin, ensuring easy application and improved patient compliance.

Evaluation of the gel formulations, through various tests such as pH, viscosity, spreadability, and stability, ensures the quality, safety, and efficacy of the final product. Preliminary studies suggest that these polyherbal gel-based preparations have the potential to reduce acne lesions, prevent scarring, and promote overall skin health.

In conclusion, polyherbal gel formulations offer a natural, effective, and safe alternative to conventional acne treatments, with the added benefit of minimizing side effects. Further clinical studies and research are

necessary to fully establish the long-term efficacy and safety of these formulations, but the current data highlights their potential for future therapeutic use in acne management.

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