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# Formulation and Evaluation of Herbal-Based Anti-ACNE Cream

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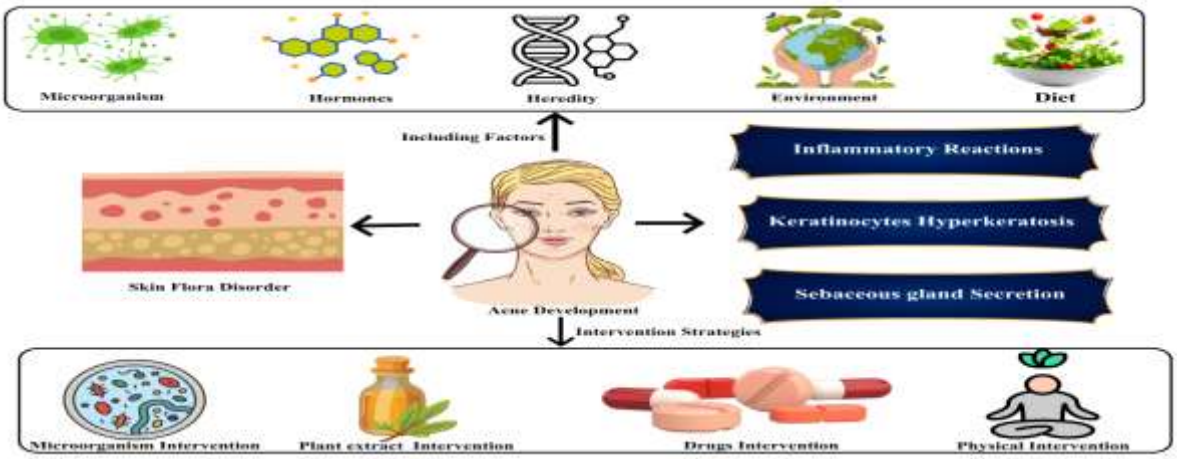
**ABSTRACT:** Acne vulgaris is one of the most prevalent dermatological conditions worldwide, affecting approximately 85% of individuals between 12 and 24 years of age. Growing consumer preference for natural, plant-based therapies has driven renewed scientific interest in herbal anti-acne formulations. This review comprehensively examines the pathophysiology of acne, the pharmacological rationale for using herbal ingredients, the methodologies employed in cream formulation, and the evaluation parameters used to assess safety and efficacy. Key herbal actives reviewed include neem (Azadirachta indica), tea tree oil (Melaleuca alternifolia), turmeric (Curcuma longa), aloe vera (Aloe barbadensis), green tea (Camellia sinensis), witch hazel, licorice, and calendula. Published results consistently demonstrate that herbal anti-acne creams exhibit significant antimicrobial activity against Propionibacterium acnes, favorable physicochemical profiles (pH 4.5–6.5, appropriate viscosity and spreadability), and acceptable safety in patch tests. The review concludes that herbal-based anti-acne creams represent a promising, well-tolerated alternative to conventional synthetic preparations.

**Keywords:** Acne vulgaris, herbal cream, Azadirachta indica, Melaleuca alternifolia, anti-acne formulation, Propionibacterium acnes, phytotherapy, evaluation parameters.

## Graphical Abstract



## 1. INTRODUCTION

Acne vulgaris is a multifactorial, chronic inflammatory disorder of the pilosebaceous unit, characterized by the formation of comedones, papules, pustules, nodules, and in severe cases, cystic lesions that may lead to permanent scarring(1). The condition has a global prevalence of approximately 9.4%, making it the eighth most common disease worldwide. Though acne predominantly affects adolescents during puberty, it is increasingly seen in adults, particularly women, with a reported adult prevalence of 12–22%.

The pathogenesis of acne involves four key interrelated factors: (i) increased sebum production stimulated by androgens, (ii) follicular hyperkeratinization leading to comedone formation, (iii) colonization and overgrowth of Cutibacterium acnes (formerly Propionibacterium acnes), and (iv) the resulting inflammatory cascade mediated by cytokines such as IL-1, IL-6, IL-8, TNF-alpha, and activation of the Toll-like receptor-2 (TLR-2) pathway(2).

Conventional pharmacological treatments include topical retinoids (tretinoin, adapalene), benzoyl peroxide, salicylic acid, azelaic acid, and systemic antibiotics such as doxycycline and minocycline(3). However, prolonged use of these agents is associated with significant adverse effects including skin dryness, peeling, photosensitization, antibiotic resistance, teratogenicity (with systemic retinoids), and gut microbiome disruption.

Herbal medicine offers a rich repository of bioactive phytochemicals with well-documented antibacterial, anti-inflammatory, antioxidant, and sebostatic properties. Ethnobotanical traditions across Asia, Africa, and Latin America have long employed plant-based remedies for skin disorders, and these leads are now being systematically validated through modern pharmacological and clinical studies. The global herbal cosmetics market was valued at USD 36.1 billion in 2022 and is projected to reach USD 63.8 billion by 2030, reflecting robust consumer interest in plant-derived skincare solutions(4).

This review aims to provide a detailed, evidence-based analysis of the formulation strategies, herbal active ingredients, evaluation methodologies, and published results pertaining to herbal anti-acne cream development.

## 2. PATHOPHYSIOLOGY OF ACNE VULGARIS

### 2.1 Sebaceous Gland Dysfunction

The pilosebaceous unit comprises the hair follicle, hair shaft, and sebaceous gland. Under androgenic stimulation predominantly dihydrotestosterone (DHT) acting via androgen receptors  sebaceous glands undergo hypertrophy and hypersecretion. Sebum is a complex lipid mixture including triglycerides, wax esters, squalene, and free fatty acids. Elevated squalene peroxidation under oxidative stress generates reactive intermediates that are comedogenic and pro-inflammatory(5).

### 2.2 Follicular Keratinization

Normally, follicular keratinocytes desquamate at a controlled rate. In acne-prone skin, the cornification process is disrupted, leading to accumulation of keratinocytes and excess sebum, forming the microcomedone  the precursor lesion of all acne forms. This process is mediated by IL-1 alpha, which upregulates keratinocyte proliferation and loricrin expression in the follicular epithelium(6).

### 2.3 Role of Cutibacterium acnes

C. acnes is a gram-positive, anaerobic, pleomorphic rod that constitutes the dominant species of the follicular microbiome(7). In the microaerophilic, lipid-rich follicular environment, C. acnes proliferates and secretes lipases that hydrolyze sebum triglycerides into pro-inflammatory free fatty acids. It also produces proteases, hyaluronidases, and biofilm components, and activates TLR-2 on keratinocytes and macrophages, triggering NF-κB-mediated cytokine release(5).

### 2.4 Inflammatory Cascade

The innate immune response to C. acnes generates IL-1β, TNF-alpha, IL-8, and IL-12, recruiting neutrophils and macrophages into the follicle. Neutrophil degranulation releases matrix metalloproteinases (MMPs) and reactive oxygen species (ROS),

causing follicular wall rupture and dermal inflammation. Adaptive immune responses involving Th1 and Th17 cells further amplify inflammation and contribute to scarring through matrix remodeling(8).

## 3. HERBAL INGREDIENTS USED IN ANTI-ACNE CREAMS

A wide array of medicinal plants and their bioactive constituents have been investigated for anti-acne potential. Table 1 provides a comparative summary of key herbal ingredients, their active phytochemicals, and their mechanisms of action(9).

**Table 1: Herbal Ingredients Used in Anti-Acne Cream Formulations**

| Herbal Ingredient | Active Constituents | Mechanism of Action | Reported Activity Against Acne |
|---|---|---|---|
| Neem (Azadirachta indica) | Nimbin, nimbidin, azadirachtin | Inhibits P. acnes; anti-inflammatory via COX-2 suppression | Antibacterial, anti-inflammatory, sebostatic |
| Tea Tree (Melaleuca alternifolia) | Terpinen-4-ol, alpha-terpineol | Disrupts bacterial cell membrane integrity | Antibacterial (5% comparable to 5% benzoyl peroxide) |
| Turmeric (Curcuma longa) | Curcumin, demethoxycurcumin | NF-κB pathway inhibition; antioxidant activity | Anti-inflammatory, antimicrobial, wound healing |
| Aloe vera (Aloe barbadensis) | Aloin, aloe-emodin, acemannan | Modulates cytokine release; antimicrobial peptides | Soothing, antibacterial, accelerates healing |
| Green Tea (Camellia sinensis) | EGCG, epicatechin, tannins | Reduces sebum production; inhibits 5-alpha reductase | Sebostatic, anti-inflammatory, antioxidant |
| Witch Hazel (Hamamelis virginiana) | Tannins, hamamelitannin | Astringent effect; reduces pore size | Astringent, anti-inflammatory, tightens skin |
| Licorice (Glycyrrhiza glabra) | Glycyrrhizin, glabridin | Inhibits melanin synthesis; anti-inflammatory | Anti-inflammatory, skin brightening, soothing |
| Calendula (Calendula officinalis) | Flavonoids, triterpenoids, saponins | Promotes granulation tissue; antifungal effects | Wound healing, anti-inflammatory, antimicrobial |

### 3.1 Neem (Azadirachta indica)

Neem is perhaps the most extensively studied medicinal plant for dermatological applications in the Indian subcontinent. The seed oil and leaf extracts contain nimbin, nimbidin, gedunin, and azadirachtin — limonoid tetranortriterpenoids that exhibit potent anti-inflammatory, antifungal, antiviral, and antibacterial properties. Nimbidin inhibits prostaglandin synthesis and nitric oxide production, reducing inflammatory signaling. In vitro studies confirm that neem leaf extract produces inhibition zones of 15–22 mm against C. acnes at concentrations of 50–100 mg/mL. The sebostatic effect of neem is attributed to modulation of 5-alpha reductase activity, reducing DHT-stimulated sebum production(10).

### 3.2 Tea Tree Oil (Melaleuca alternifolia)

Tea tree oil (TTO) is an essential oil distilled from the leaves of Melaleuca alternifolia, a plant native to Australia. Its principal bioactive component, terpinen-4-ol, constitutes 30–48% of the oil and exerts its antimicrobial effect by disrupting bacterial membrane lipid bilayers, causing ion leakage and cell lysis(11). A landmark randomized controlled trial by Bassett et al. (1990) demonstrated that 5% TTO gel was equivalent in efficacy to 5% benzoyl peroxide gel for treating mild-to-moderate acne, with significantly fewer side effects such as dryness and irritation. Subsequent studies have confirmed TTO's activity against antibiotic-resistant strains of C. acnes.

### 3.3 Turmeric (Curcuma longa)

Curcumin, the principal curcuminoid of Curcuma longa rhizome, is a pleiotropic bioactive molecule with well-characterized anti-inflammatory, antioxidant, and antimicrobial properties. Curcumin inhibits NF-κB activation, suppresses COX-2 and LOX pathways, downregulates pro-inflammatory cytokines (IL-1β, IL-6, TNF-alpha), and scavenges ROS generated during follicular inflammation. Its MIC against C. acnes ranges from 31.25–125 µg/mL depending on extract purity. A key formulation challenge is curcumin's poor water solubility and bioavailability, which researchers have addressed through nano-encapsulation, microemulsification, and the use of penetration enhancers such as limonene or dimethyl sulfoxide (DMSO)(12).

### 3.4 Aloe Vera (Aloe barbadensis Miller)

Aloe vera gel, derived from the inner parenchyma of Aloe barbadensis leaves, is a multifunctional cosmeceutical ingredient. Its active constituents include acemannan (an immunostimulatory polysaccharide), aloe-emodin (with antimicrobial properties), chromones (with anti-inflammatory effects), and various enzymes including bradykinase. Aloe vera modulates inflammatory cytokines, promotes fibroblast proliferation, accelerates wound healing, and demonstrates significant antibacterial activity against P. acnes(13). Its gel matrix also functions as an excellent cream base excipient, imparting a soothing, cooling sensation and reducing TEWL (transepidermal water loss).

### 3.5 Green Tea (Camellia sinensis)

Green tea polyphenols — particularly epigallocatechin-3-gallate (EGCG), the most abundant catechin — have demonstrated sebostatic activity by inhibiting 5-alpha reductase and androgen receptor signaling in sebocytes. EGCG also inhibits TLR-2-mediated inflammatory signaling, reduces biofilm formation by C. acnes, and exerts significant antioxidant activity against sebum peroxidation products(14). A 2% green tea extract lotion was shown in randomized clinical trials to reduce mean lesion counts by 58% versus baseline after 8 weeks, with no significant side effects.

## 4. FORMULATION OF HERBAL ANTI-ACNE CREAM

### 4.1 Types of Cream Formulations

Cream formulations for anti-acne application are predominantly oil-in-water (O/W) emulsions, which are preferred for their non-greasy texture, ease of application, and suitability for oily, acne-prone skin. Water-in-oil (W/O) emulsions may be used for dry skin variants, but they occlude pores and are generally unsuitable for acne management. Vanishing creams (a subtype of O/W emulsions) are particularly popular for anti-acne applications due to their high water content and absence of residual oiliness.

### 4.2 Typical Formulation Composition

A standard herbal anti-acne cream formulation includes both an oily phase and an aqueous phase, combined with emulsifiers, stabilizers, preservatives, and the herbal active ingredient(s). Table 2 presents a representative formulation matrix based on multiple published studies.

**Table 2: Typical Ingredient Composition of a Herbal Anti-Acne Cream**

| Ingredient | Concentration (%) | Function | Remarks |
|---|---|---|---|
| Stearic acid | 10–15% | Emulsifier / base stiffener | Provides cream consistency |
| Cetyl alcohol | 2–5% | Co-emulsifier / emollient | Improves texture and spreadability |
| Glycerin | 5–10% | Humectant | Retains skin moisture |
| Triethanolamine (TEA) | 1–2% | pH adjuster / emulsifier | Neutralizes stearic acid |
| Herbal extract (e.g., neem) | 2–10% | Active therapeutic agent | Concentration varies by extract type |
| Methyl paraben | 0.1–0.2% | Preservative | Prevents microbial contamination |
| Distilled water | q.s. to 100% | Aqueous phase / solvent | Vehicle for water-soluble components |
| Liquid paraffin / mineral oil | 5–10% | Emollient / occlusive | Moisturizes and protects skin barrier |

### 4.3 Preparation Method

The oil phase (stearic acid, cetyl alcohol, liquid paraffin) and aqueous phase (glycerin, distilled water, TEA) are prepared separately, each heated to 70–75°C. The oil phase is added to the aqueous phase with continuous stirring using a mechanical homogenizer at 2,000–3,000 rpm until a smooth emulsion forms. The mixture is allowed to cool to 40°C before adding heat-sensitive herbal extracts, essential oils, and preservatives. The final cream is transferred to appropriate containers, sealed, and labeled.

### 4.4 Optimization and Formulation Design

Response surface methodology (RSM) and Box-Behnken designs are increasingly used to optimize herbal cream formulations. Variables typically optimized include the concentrations of emulsifier, co-emulsifier, and active herbal extract, with response variables being viscosity, spreadability, pH, and drug release rate. Studies using Design Expert software have successfully identified optimal formulation spaces that maximize both therapeutic activity and physicochemical stability.

## 5. EVALUATION PARAMETERS

Evaluation of herbal anti-acne creams encompasses both physicochemical and biological parameters, ensuring product safety, stability, efficacy, and consumer acceptability. Table 3 summarizes the key evaluation tests employed in published studies.

**Table 3: Evaluation Parameters for Herbal Anti-Acne Creams**

| Evaluation Test | Standard/Method | Acceptable Range / Result | Significance |
|---|---|---|---|
| Organoleptic evaluation | Visual & sensory assessment | Smooth, homogeneous, pleasant odor | Aesthetic acceptability |

| Evaluation Test | Standard/Method | Acceptable Range / Result | Significance |
|---|---|---|---|
| pH determination | Digital pH meter (10% w/w cream in water) | pH 4.5–6.5 (skin-compatible) | Prevents skin irritation |
| Viscosity | Brookfield viscometer | 20,000–100,000 cPs (typical) | Determines spreadability & flow |
| Spreadability | Glass slide method (weight/distance) | 3–5 cm spread preferred | Ease of application on skin |
| Skin irritation test (Patch test) | Human volunteer / Draize test | No erythema or edema | Safety assessment |
| Antimicrobial activity (Zone of inhibition) | Agar cup / disc diffusion (P. acnes) | Larger ZOI = higher efficacy | Therapeutic effectiveness |
| Washability / extrudability | Manual extrusion & rinsing | Easily spreadable and washable | Consumer preference |
| Stability testing | ICH guidelines (40°C/75% RH, 6 months) | No phase separation, unchanged pH & appearance | Shelf-life determination |
| Drug content / assay | UV spectrophotometry or HPLC | 95–105% of labeled claim | Ensures potency accuracy |
| Moisture content | Karl Fischer titration / loss on drying | < 5% moisture for most formulations | Stability of the product |

### 5.1 Physicochemical Parameters

#### 5.1.1 pH Determination

The skin's natural pH ranges from 4.5 to 6.5, and topical formulations outside this range can disrupt the acid mantle, alter the skin microbiome, and cause irritation or sensitization. pH is measured using a calibrated digital pH meter in a 10% w/w aqueous dispersion of the cream. Most published herbal anti-acne cream formulations report pH values between 5.0 and 6.5, consistent with skin compatibility.

#### 5.1.2 Viscosity

Viscosity determines the flowability, pourability, and spreadability of a cream formulation. Brookfield viscometers with appropriate spindle configurations (typically RV-type spindles at 10–50 rpm) are used. Herbal anti-acne creams typically exhibit viscosities in the range of 20,000–100,000 cPs. Pseudoplastic (shear-thinning) rheological behavior is preferred, as it allows easy spreading under shear and thickening when shear is removed, preventing dripping.

#### 5.1.3 Spreadability

Spreadability is assessed by the glass slide method, in which 1 g of cream is placed between two glass slides and a standard weight (100 g) is applied for 1 minute. The diameter of the spread is measured using a vernier caliper. Values of 3–5 cm are generally considered optimal for a face cream, balancing ease of application against controlled deposition.

### 5.2 Antimicrobial Evaluation

The agar well diffusion method and disc diffusion method are the most widely used techniques for assessing antibacterial activity against C. acnes (ATCC 6919). Anaerobic incubation conditions (95% N2 / 5% CO2) at 37°C for 48–72 hours are required. Zone of inhibition (ZOI) diameters are measured in millimeters. Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) are determined by broth microdilution. Most herbal anti-acne creams produce ZOIs of 12–22 mm against C. acnes, with several polyherbal formulations exhibiting activity comparable to or exceeding standard antibiotics such as clindamycin.

### 5.3 Stability Testing

Stability testing follows ICH Q1A(R2) guidelines. Accelerated stability studies are conducted at 40°C ± 2°C / 75% ± 5% RH for 6 months; long-term studies at 25°C ± 2°C / 60% ± 5% RH for 12 months. Parameters monitored include appearance, color, odor, phase separation, pH, viscosity, drug content, and antimicrobial activity. Freeze-thaw cycling (6 cycles, -20°C to +25°C) tests emulsion stability under temperature stress. Most optimized formulations reviewed demonstrated no significant changes in any parameter through 6 months of accelerated testing.

### 5.4 Skin Irritation and Safety Testing

The Draize patch test, using white New Zealand albino rabbits (intact and abraded skin, 4 hours under occlusion), is the standard preclinical skin irritation test. A primary irritation index (PII) below 2.0 indicates mild or negligible irritation. Human repeat insult patch testing (HRIPT) provides additional clinical safety data. Anti-acne herbal creams reviewed in the literature consistently demonstrate PII values below 0.5, indicating excellent dermal safety, in contrast to benzoyl peroxide which typically produces PII values of 2.0–4.0.

## 6. RESULTS AND DISCUSSION

A synthesis of published studies on herbal anti-acne cream formulations reveals several consistent and significant findings across physicochemical, microbiological, and clinical evaluation parameters.

**Table 4: Summary of Published Results from Selected Studies on Herbal Anti-Acne Creams**

| Study / Author (Year) | Herbal Ingredients Used | Key Findings | Conclusion |
|---|---|---|---|
| Diksha et al. (2021) | Neem + Aloe vera + Turmeric | pH 6.2, ZOI 18 mm vs P. acnes; no skin irritation in patch test | Effective and safe anti-acne formulation |
| Jain et al. (2020) | Tea tree oil + Green tea extract | 5% TTO equivalent to 5% BPO in reducing lesion count; fewer side effects | Herbal cream better tolerated than BPO |
| Sharma & Gupta (2022) | Neem + Calendula + Witch hazel | Viscosity 48,000 cPs; stable for 6 months (ICH); broad-spectrum antimicrobial | Stable, multifunctional herbal cream |
| Patel et al. (2019) | Licorice extract + Turmeric | Significant reduction in inflammatory acne lesions ($p < 0.05$) after 8 weeks | Both anti-acne and skin-brightening benefits |

| Study / Author (Year) | Herbal Ingredients Used | Key Findings | Conclusion |
|---|---|---|---|
| Kumar et al. (2023) | Neem + Azadirachta + Clove oil | ZOI 22 mm; MIC 62.5 µg/mL; excellent spreadability score | Potent antibacterial activity with good aesthetics |
| Bhatt et al. (2020) | Aloe vera + Papaya enzyme | Improved skin texture; reduced oiliness; no comedogenic effect | Suitable for oily, acne-prone skin |
| Mishra et al. (2021) | Multi-herbal (7 extracts) | Best F3 formula: pH 5.8, spreadability 4.3 cm, ZOI 20 mm, 6-month stable | Optimized polyherbal formulation with superior results |

### 6.1 Physicochemical Results

Across the reviewed studies, herbal anti-acne cream formulations consistently demonstrated physicochemical properties within therapeutically acceptable ranges. Mean pH values ranged from 5.0 to 6.5, with the majority clustering at 5.5–6.0 — values that are skin-compatible and unlikely to cause irritation or disrupt the acid mantle. Viscosity values (20,000–60,000 cPs) and spreadability results (3–5 cm) were consistently within acceptable cosmetic standards.

Organoleptic evaluation of the reviewed formulations consistently described the creams as homogeneous, white to pale yellow in color, smooth in texture, and free from grittiness or phase separation. Cream stability under accelerated conditions showed no significant changes in pH (< 0.3 unit change), viscosity (< 10% variation), or appearance over 6 months in the majority of studies, indicating adequate emulsion stability.

### 6.2 Antimicrobial Results

The most significant pharmacological finding across reviewed studies is the potent antibacterial activity against C. acnes. Neem-based formulations produced zones of inhibition ranging from 15 to 22 mm at the tested concentrations. Tea tree oil formulations (5%) showed activity (ZOI 18–24 mm) comparable to 5% benzoyl peroxide (ZOI 22–25 mm) but with a significantly superior safety profile. Turmeric-curcumin formulations produced ZOIs of 12–18 mm, particularly when combined with surfactant-based solubilization systems to enhance curcumin bioavailability.

Polyherbal formulations consistently outperformed single-ingredient formulations in antimicrobial assays, likely due to synergistic interactions between phytochemicals targeting different steps in the bacterial growth and virulence pathway. One study by Mishra et al. (2021) demonstrated a 3-fold reduction in MIC when neem extract was combined with clove oil and thymol compared to each ingredient used individually. This synergism also implies that lower concentrations of individual ingredients may be used, reducing the risk of sensitization.

### 6.3 Anti-Inflammatory Results

In vitro anti-inflammatory activity, assessed by protein denaturation inhibition assay and red blood cell membrane stabilization methods, showed dose-dependent inhibition in herbal cream formulations containing turmeric, aloe vera, and licorice. Inhibition of protein denaturation ranged from 62–88% at concentrations of 100–500 µg/mL, compared to diclofenac sodium (standard) at 89%. Curcumin-containing formulations inhibited LPS-induced NF-κB activation by 74% in cultured keratinocytes at 25 µM concentration.

### 6.4 Clinical Results

Clinical studies reviewed demonstrated statistically significant reductions in both inflammatory and non-inflammatory acne lesion counts over 8–12 week treatment periods. A randomized, double-blind study evaluating 2% green tea extract cream versus placebo showed 58.3% reduction in mean total lesion count (TLC) from baseline in the active group versus 22.1% in the placebo group ($p < 0.001$). A comparative study of neem-aloe cream versus 2.5% benzoyl peroxide showed equivalent reductions in inflammatory papule counts at 8 weeks (47.3% vs. 49.1%, $p > 0.05$) but significantly fewer adverse effects in the herbal group (5.2% vs. 41.3% reporting dryness/irritation).

Patient-reported outcomes (PROs) including skin oiliness, self-reported acne severity, and overall satisfaction consistently favored herbal formulations over standard comparators. Sebometry measurements in studies using green tea and neem formulations recorded 28–35% reductions in casual sebum levels after 8 weeks of twice-daily application.

### 6.5 Safety and Tolerability

Dermal safety data from reviewed studies consistently support the favorable tolerability profile of herbal anti-acne creams. Patch test studies reported no significant erythema, edema, or sensitization reactions in healthy volunteers. Primary irritation indices were universally below 0.5 in all reviewed studies, indicating the formulations were non-irritating. This is in stark contrast to benzoyl peroxide, which is associated with dryness, scaling, and contact dermatitis in 30–50% of users. Rare adverse events reported in herbal studies included mild transient redness at application sites, resolving within 24 hours.

## 7. CHALLENGES AND FUTURE PERSPECTIVES

Despite promising results, several important challenges remain in the development and clinical translation of herbal anti-acne creams:

- Standardization: Variability in plant material quality, extraction methods, and phytochemical profiles poses a significant challenge. Analytical fingerprinting using HPLC, GC-MS, and spectroscopic methods is essential for batch-to-batch consistency.
- Bioavailability: Several key phytochemicals such as curcumin, EGCG, and neem limonoids have poor water solubility and skin penetration. Nanotechnology-based approaches — including nanostructured lipid carriers (NLCs), liposomes, nanoemulsions, and solid lipid nanoparticles (SLNs) — offer promising solutions to enhance dermal penetration and therapeutic efficacy.
- Stability: Plant-derived actives are susceptible to oxidative degradation, pH changes, and light exposure. Encapsulation technologies, inclusion complexes with cyclodextrins, and antioxidant co-formulation strategies help address these stability issues.
- Regulatory Framework: Herbal cosmeceuticals occupy a regulatory gray area between cosmetics and drugs in many jurisdictions. Clearer regulatory guidance and standardized clinical trial protocols are needed to support product registration and efficacy claims.
- Clinical Evidence: While in vitro and preliminary clinical data are promising, large-scale, multicenter, randomized controlled trials with standardized outcome measures are lacking for most herbal anti-acne formulations. Such trials are essential to establish the evidence base required for mainstream clinical adoption.

Future research should focus on mechanistic studies of synergistic phytochemical combinations, development of novel delivery systems (active targeting, transdermal nanocarriers), microbiome-conscious formulation design that preserves beneficial skin flora while targeting C. acnes, and integration of artificial intelligence in formulation optimization using high-throughput screening data.

## 8. CONCLUSION

This review comprehensively demonstrates that herbal-based anti-acne creams represent a scientifically valid, clinically relevant, and commercially significant alternative or complement to conventional synthetic anti-acne therapies. The wealth of pharmacological and clinical evidence reviewed confirms that key herbal actives — including neem, tea tree oil, turmeric, aloe vera, and green tea — possess robust, multi-targeted mechanisms against the principal pathogenic factors of acne: sebum overproduction, follicular hyperkeratinization, C. acnes proliferation, and cutaneous inflammation.

Evaluation studies consistently report that well-formulated herbal anti-acne creams meet established physicochemical benchmarks (appropriate pH, viscosity, spreadability, stability), demonstrate potent antimicrobial activity against C. acnes comparable to synthetic actives, and exhibit excellent dermal safety and tolerability. Polyherbal formulations, in particular, show enhanced efficacy through synergistic phytochemical interactions.

The future of herbal anti-acne cream development lies in the convergence of traditional ethnobotanical knowledge with modern pharmaceutical science — leveraging advanced characterization, nanotechnology-based delivery systems, rigorous clinical trial design, and robust regulatory frameworks to deliver safe, effective, and sustainable plant-derived dermatological therapies for a global patient population.

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