

## Herbal Treatments of Skin Disease

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### Abstract

Skin diseases are among the most prevalent health disorders worldwide, affecting individuals of all age groups and significantly impairing quality of life. Common dermatological conditions such as acne vulgaris, psoriasis, eczema (atopic dermatitis), and microbial infections are often chronic in nature and require long-term management. Conventional therapeutic approaches, including corticosteroids, antibiotics, and immunosuppressive agents, are widely used; however, their prolonged use is associated with several limitations such as adverse effects, drug resistance, microbiome disruption, and high treatment costs.

In recent years, there has been growing interest in herbal medicine as a safer, more effective, and holistic alternative for the management of skin diseases. Medicinal plants are rich in bioactive phytochemicals such as flavonoids, alkaloids, tannins, and terpenoids, which exhibit a wide range of pharmacological activities including anti-inflammatory, antimicrobial, antioxidant, and wound healing effects. These compounds act through multiple mechanisms, such as inhibition of inflammatory mediators (NF- $\kappa$ B, TNF- $\alpha$ , IL-17), neutralization of reactive oxygen species, and modulation of immune responses.

This review provides a comprehensive analysis of herbal treatments in dermatology, focusing on phytochemical composition, mechanisms of action, and therapeutic applications. Key medicinal plants discussed include Aloe vera, Azadirachta indica (Neem), Curcuma longa (Turmeric), Camellia sinensis (Green Tea), Centella asiatica, Calendula officinalis, Withania somnifera (Ashwagandha), Eucalyptus globulus, Glycyrrhiza glabra (Licorice), and Ocimum sanctum (Tulsi). Recent advancements such as FDA-approved botanical drugs (Veregen, Filisuvez), nanotechnology-based herbal delivery systems, and clinical trial evidence from 2024–2025 are highlighted. The review also addresses standardization challenges, safety considerations, and future research directions in herbal dermatology.

**Keywords:** Herbal medicine, skin disease, phytochemicals, dermatology, anti-inflammatory, antimicrobial, wound healing, nanotechnology, medicinal plants, Ayurveda, clinical evidence.

### I. Introduction

The skin is the largest organ of the human body, accounting for approximately 15% of total body weight, and plays a vital role in maintaining overall health. It serves as a primary protective barrier against environmental hazards such as pathogens, ultraviolet (UV) radiation, toxic chemicals, and physical injuries. In addition to its protective function, the skin is involved in thermoregulation, sensory perception, immune surveillance, and maintenance of fluid balance. Due to its constant exposure to external and internal stressors, the skin is highly susceptible to a wide range of disorders [1, 2].

Skin diseases represent one of the most common health problems worldwide, affecting nearly one-third of the global population at any given time. According to the European Academy of Dermatology and Venerology, up to 43% of the adult population in Europe alone suffers from at least one dermatological condition [3]. These conditions include a broad spectrum of disorders such as acne vulgaris, psoriasis, eczema (atopic dermatitis), fungal and bacterial infections, vitiligo, and skin cancers, many of which are chronic, recurrent, and associated with significant physical discomfort, psychological stress, and reduced quality of life [4, 5].

Conventional treatment options for skin diseases include topical and systemic therapies such as corticosteroids, antibiotics, antifungal agents, retinoids, and immunosuppressive drugs. Although these treatments are effective in managing symptoms, their long-term use is often associated with limitations including adverse effects such as skin thinning, systemic toxicity, and antimicrobial resistance. Moreover, microbiome disruption — an emerging concern — has been recognized as an additional drawback of long-term synthetic therapies [6].

In recent years, there has been growing interest in herbal medicine as an alternative or complementary approach to skin disease management. Modern medicine is now more than ever incorporating traditional botanical knowledge into evidence-based practice. A landmark 2025 review in *JID Innovations* documented multiple plant-derived therapeutics — including polyphenon E (sincatechins), psoralen, salicylic acid, anthralin, podophyllotoxin, and Filsuvez (birch triterpenes) — that have received regulatory approval for specific dermatological indications, demonstrating the translation of botanical knowledge into clinical practice [7].

Medicinal plants are rich sources of bioactive compounds such as flavonoids, alkaloids, tannins, phenolic acids, and terpenoids. These phytochemicals possess multi-targeted pharmacological activities, acting simultaneously on inflammatory pathways, oxidative stress, microbial virulence, and immune dysregulation — making them particularly suited to the complex pathophysiology of chronic skin diseases [8].

This review provides a comprehensive and critical analysis of herbal treatments used in skin diseases, focusing on phytochemical composition, mechanisms of action, therapeutic applications, recent clinical evidence from 2024–2025, and future prospects of herbal medicine in dermatology.

## II. Overview of Skin Diseases

Skin diseases constitute a diverse group of disorders that affect the skin, hair, and associated structures such as sebaceous and sweat glands. These conditions vary widely in their etiology, clinical presentation, and severity, ranging from mild and self-limiting conditions to chronic and life-threatening disorders. The skin acts as the first line of defense against environmental factors; any disruption in its structural integrity or immune function can lead to the development of dermatological disorders [9, 10].

### 2.1 Major Skin Diseases

#### 2.1.1 Acne Vulgaris

Acne vulgaris is one of the most common skin disorders, particularly affecting adolescents and young adults, with up to 85% prevalence in teenagers. It is characterized by comedones, papules, pustules, and nodules, primarily due to increased sebum production, follicular hyperkeratinization, and bacterial colonization by

*Cutibacterium acnes*. Hormonal imbalance, particularly elevated androgens, plays a significant role in its pathogenesis. The condition can lead to scarring and significant psychosocial impact when not managed effectively [11, 12].

#### 2.1.2 Eczema (Atopic Dermatitis)

Atopic dermatitis (AD) is a chronic inflammatory skin condition characterized by intense itching, redness, dryness, and lichenification. It is associated with genetic predisposition (mutations in the filaggrin gene) and immune system dysfunction involving Th2-mediated responses. Environmental factors such as allergens, irritants, and climate conditions trigger or exacerbate the disease. AD affects approximately 15–20% of children and 1–3% of adults worldwide and has been increasing in prevalence, particularly in urban settings [13].

#### 2.1.3 Psoriasis

Psoriasis is a chronic autoimmune disorder marked by rapid proliferation of keratinocytes, leading to thick, erythematous, scaly plaques predominantly on the scalp, elbows, and knees. It involves complex interactions between genetic susceptibility and immune-mediated mechanisms, particularly involving T-cells and cytokines such as TNF- $\alpha$ , IL-17, and IL-23. Psoriasis affects about 2–3% of the global population and is associated with significant comorbidities including psoriatic arthritis, cardiovascular disease, and metabolic syndrome [14].

#### 2.1.4 Skin Infections

Infectious skin disorders encompass bacterial, fungal, and viral infections. Fungal infections such as dermatophytosis are prevalent in tropical regions. Bacterial infections like impetigo are frequently seen in children. Viral infections such as herpes simplex and HPV-induced warts cause recurrent lesions. These infections are often exacerbated by immunodeficiency, poor hygiene, and environmental factors [15].

#### 2.1.5 Vitiligo and Pigmentary Disorders

Vitiligo is an autoimmune condition where destruction of melanocytes leads to depigmentation, affecting approximately 1% of the world population. Melasma, another common pigmentary disorder, causes hyperpigmentation associated with hormonal changes and UV exposure, with a global prevalence also around 1% [16, 17].

Disease	Prevalence	Key Feature	Primary Cause
Acne Vulgaris	~85% of adolescents	Comedones, pustules	Excess sebum, C. acnes
Atopic Dermatitis	~20% children	Pruritus, dryness	Filaggrin defect, Th2
Psoriasis	~2–3% globally	Scaly plaques	Autoimmune, Th17
Dermatophytosis	~20–25% globally	Circular lesions	Dermatophytes
Vitiligo	~1% globally	Depigmentation	Autoimmune melanocyte destruction
Melasma	~1% globally	Hyperpigmentation	UV, hormonal changes

Table 1: Major skin diseases, prevalence, and primary causes.

### III. Classification of Skin Disorders

Skin diseases can be broadly classified based on their underlying causes, pathological mechanisms, and clinical characteristics. A systematic classification facilitates diagnosis, treatment selection, and epidemiological research.

#### 3.1 Inflammatory Skin Diseases

Inflammatory skin diseases are characterized by redness, swelling, heat, and pain, resulting from activation of the immune system and release of inflammatory mediators such as cytokines, prostaglandins, and histamines. Examples include acne vulgaris, atopic dermatitis, contact dermatitis, psoriasis, and seborrheic dermatitis.

#### 3.2 Infectious Skin Diseases

Infectious skin diseases are caused by pathogenic microorganisms and are subclassified as bacterial (impetigo, cellulitis, folliculitis), fungal (dermatophytosis, candidiasis), viral (herpes simplex, varicella, warts), and parasitic (scabies, pediculosis).

#### 3.3 Autoimmune Skin Diseases

These occur when the immune system mistakenly attacks the body's own skin cells. Examples include psoriasis, vitiligo, systemic lupus erythematosus (with cutaneous manifestations), and pemphigus vulgaris.

#### 3.4 Genetic (Hereditary) Skin Disorders

Genetic skin disorders are inherited conditions caused by mutations in specific genes affecting skin structure or function. Examples include ichthyosis, epidermolysis bullosa, and neurofibromatosis.

#### 3.5 Neoplastic Skin Disorders

Neoplastic disorders involve abnormal growth of skin cells, ranging from benign (lipomas, nevi) to malignant forms including basal cell carcinoma (most common), squamous cell carcinoma, and melanoma (most aggressive).

### 3.6 Pigmentary and Aging-Related Disorders

Pigmentary disorders arise from abnormalities in melanin production or distribution (vitiligo, melasma). Aging-related disorders include photoaging, wrinkle formation, and telangiectasia due to collagen degradation from chronic UV exposure.

### IV. Pathophysiology of Skin Diseases

The pathophysiology of skin diseases involves complex, interrelated mechanisms encompassing genetic, immunological, biochemical, and environmental factors. Disruption in any component of the epidermis, dermis, or hypodermis can initiate or perpetuate dermatological disorders.

#### 4.1 Inflammation and Immune Activation

Inflammation is a central feature in the pathogenesis of many skin diseases. Upon exposure to stimuli, keratinocytes and immune cells release pro-inflammatory mediators such as TNF- $\alpha$ , IL-1, IL-6, IL-17, and IL-23, activating NF- $\kappa$ B and MAPK signaling pathways and recruiting neutrophils, macrophages, and T-lymphocytes. In psoriasis, Th17 cell overactivation leads to IL-17-driven keratinocyte proliferation; in eczema, Th2-mediated responses cause hypersensitivity and impaired barrier function [18, 19].

#### 4.2 Oxidative Stress and Free Radical Damage

Oxidative stress results from an imbalance between reactive oxygen species (ROS) — from UV radiation, pollution, microbial infection, or cellular metabolism — and the body's antioxidant defenses. ROS such as superoxide anions and hydroxyl radicals damage lipids, proteins, and DNA, contributing significantly to photoaging, psoriasis, and acne pathogenesis [20].

#### 4.3 Microbial Invasion and Skin Microbiome Disruption

The skin harbors a diverse microbiota that normally maintains homeostasis. Disruption of this balance allows pathogenic organisms to invade. Cutibacterium acnes triggers follicular inflammation in acne; Staphylococcus aureus colonization drives eczema flares; dermatophytes invade the stratum corneum in tinea infections. Importantly, modern research has identified that long-term synthetic drugs can disrupt the beneficial skin microbiome, a limitation recognized in recent literature [6, 21].

#### 4.4 Skin Barrier Dysfunction

The skin barrier, primarily formed by the stratum corneum, prevents water loss and external agent penetration. Mutations in the filaggrin gene impair stratum corneum formation, leading to increased transepidermal water loss (TEWL) and allergen penetration — a key initiating factor in atopic dermatitis [22].

#### 4.5 Summary of Pathophysiological Mechanisms

Mechanism	Key Mediators	Diseases Involved
Inflammation	TNF- $\alpha$ , IL-1, IL-6, IL-17	Acne, Eczema, Psoriasis
Oxidative Stress	ROS, hydroxyl radicals	Photoaging, Psoriasis, Acne
Microbial Invasion	C. acnes, S. aureus, Dermatophytes	Acne, Eczema, Tinea
Immune Dysregulation	Th17, Th2, autoreactive T-cells	Psoriasis, Vitiligo, Eczema
Barrier Dysfunction	Filaggrin mutations, TEWL	Atopic Dermatitis, Psoriasis
Abnormal Keratinization	Keratinocyte hyperproliferation	Psoriasis, Acne

Table 2: Summary of pathophysiological mechanisms in major skin diseases.

#### V. Limitations of Conventional Treatments

Conventional treatments for skin diseases primarily include corticosteroids, antibiotics, antifungal agents, retinoids, antihistamines, and immunosuppressive drugs. Despite their efficacy in providing symptomatic relief, they are associated with significant limitations that have driven interest in herbal alternatives.

##### 5.1 Adverse Effects and Toxicity

Topical corticosteroids cause skin atrophy, striae, telangiectasia, and hypopigmentation with prolonged use. Systemic immunosuppressants cause hepatotoxicity and nephrotoxicity. Retinoids carry teratogenic risks. Biologic agents such as dupilumab and secukinumab, while highly effective, are associated with injection site reactions and increased susceptibility to infections [23].

##### 5.2 Development of Drug Resistance

The overuse of antibiotics in acne management has led to emergence of resistant strains of Cutibacterium acnes, significantly reducing

treatment efficacy. Similarly, antifungal resistance among Candida species is a growing clinical concern. Drug resistance results in treatment failure, prolonged disease duration, and increased healthcare burden [24, 25].

##### 5.3 High Cost of Treatment

Biologic agents used in moderate-to-severe psoriasis and atopic dermatitis are highly effective but extremely expensive, limiting access in low- and middle-income countries. Even conventional systemic therapies require regular laboratory monitoring, adding to overall cost [26].

##### 5.4 Microbiome Disruption

Recent evidence highlights microbiome disruption as an additional limitation of long-term synthetic drug use. Unlike herbal preparations, which can selectively modulate the skin microbiome while promoting beneficial commensals, synthetic antimicrobials often disrupt both pathogenic and commensal organisms indiscriminately [6].

### 5.5 Summary of Conventional Treatment Limitations

Treatment	Common Side Effects	Major Limitation
Topical Corticosteroids	Skin atrophy, striae, telangiectasia	Dependency, rebound flares
Systemic Corticosteroids	Cushing's syndrome, osteoporosis	Short-term use only
Antibiotics	GI disturbance, resistance	Antimicrobial resistance
Retinoids	Teratogenicity, dryness	Contraindicated in pregnancy
Immunosuppressants	Hepatotoxicity, nephrotoxicity	Serious systemic toxicity
Biologics	Infections, injection site reactions	Very high cost

Table 3: Limitations of conventional dermatological therapies.

## VI. Role of Herbal Medicine in Dermatology

Herbal medicine, also known as phytotherapy, has emerged as a significant and rapidly growing field in dermatology. Its use dates back thousands of years and is deeply rooted in traditional systems of medicine such as Ayurveda, Unani, Siddha, and Traditional Chinese Medicine (TCM). Recent scientific research has validated many of these traditional claims, and modern medicine is increasingly incorporating age-old botanical knowledge into evidence-based practice [7, 27].

### 6.1 Multi-Targeted Therapeutic Action

One of the most important advantages of herbal medicine over conventional therapy is its ability to act on multiple pathological pathways simultaneously. Herbal drugs contain diverse phytochemicals that collectively inhibit inflammatory mediators, neutralize free radicals, suppress microbial growth, and modulate immune responses — addressing root causes rather than merely suppressing symptoms [8].

### 6.2 Anti-Inflammatory Effects

Herbal compounds reduce inflammation by inhibiting key cytokines (TNF- $\alpha$ , IL-1, IL-6, IL-17) and blocking major inflammatory pathways including NF- $\kappa$ B and MAPK. Curcumin from

turmeric is a potent inhibitor of NF- $\kappa$ B. Aloe vera's bradykinase enzyme directly reduces tissue swelling. These actions are clinically relevant in psoriasis, eczema, and contact dermatitis [28, 29].

### 6.3 Antimicrobial Activity

Many herbal extracts exhibit broad-spectrum antimicrobial activity against bacteria, fungi, and viruses without contributing to antimicrobial resistance. Neem, tea tree oil, and tulsi are recognized for their antibacterial and antifungal properties, disrupting microbial cell walls and inhibiting biofilm formation [30].

### 6.4 Antioxidant Properties

Herbal antioxidants scavenge ROS, prevent lipid peroxidation, and enhance endogenous antioxidant defenses. Green tea's EGCG, curcumin, and aloe vera provide vital protection against UV-induced and oxidative damage, preventing premature aging and reducing inflammatory cascades [31].

### 6.5 Wound Healing and Tissue Regeneration

Medicinal plants such as Aloe vera, Centella asiatica, and Calendula officinalis accelerate wound healing by stimulating fibroblast activity, enhancing collagen synthesis, and promoting angiogenesis and re-epithelialization. These properties are invaluable in the management of burns, surgical wounds, and chronic ulcers [32].

### 6.6 Therapeutic Applications by Condition

Condition	Herbal Agents	Primary Action
Acne Vulgaris	Neem, Turmeric, Green Tea, Tulsi	Antimicrobial, anti-inflammatory
Eczema (Atopic Dermatitis)	Aloe vera, Licorice, Calendula, Oat	Anti-allergic, barrier repair

Condition	Herbal Agents	Primary Action
Psoriasis	Turmeric, Aloe vera, Neem, Indigo naturalis	Anti-proliferative, immunomodulatory
Fungal Infections	Tea Tree Oil, Neem, Eucalyptus	Antifungal, antimicrobial
Wounds and Burns	Aloe vera, Centella asiatica, Calendula	Wound healing, regeneration
Skin Aging	Green Tea, Centella asiatica, Turmeric	Antioxidant, anti-wrinkle
Vitiligo	Bakuchi (Psoralea), Ashwagandha	Immunomodulatory, melanogenesis
Warts (Anogenital)	Polyphenon E (Green tea catechins)	FDA-approved botanical drug
Epidermolysis Bullosa	Filsuvez (birch triterpenes)	FDA-approved wound healing

Table 4: Herbal agents used for major dermatological conditions and their primary actions.

## VII. Phytochemical Constituents in Herbal Drugs

Medicinal plants used in dermatology contain a wide variety of bioactive secondary metabolites known as phytochemicals. These compounds are responsible for the therapeutic effects of herbal drugs. Major classes include:

### 7.1 Flavonoids

Flavonoids such as quercetin, kaempferol, and apigenin are ubiquitous in medicinal plants. They exhibit potent antioxidant activity by scavenging free radicals, anti-inflammatory activity by inhibiting lipoxygenase and cyclooxygenase enzymes, and antimicrobial properties. Quercetin has been shown to inhibit histamine release from mast cells, making it valuable in allergic skin conditions. Apigenin has demonstrated anti-proliferative and anti-psoriatic potential in HaCaT cell models [33].

### 7.2 Alkaloids

Alkaloids such as berberine (from Berberis species) and sanguinarine have significant antimicrobial and anti-inflammatory properties. Berberine has demonstrated inhibition of Staphylococcus aureus, Candida species, and Cutibacterium acnes, making it relevant for acne, eczema, and fungal skin infections [34].

### 7.3 Tannins

Tannins are astringent polyphenols found in tea, oak bark, and many medicinal plants. Tannins from black tea and oak bark have been used empirically

for decades in the treatment of oozing and acute eczema. An occlusive patch test revealed that a cream with 2% tannins from tormentil roots had a vasoconstrictive effect comparable to a corticoid [6]. Their mechanism involves protein precipitation, denaturing microbial enzymes, and forming a protective film over ulcerated surfaces.

### 7.4 Terpenoids

Terpenoids include a diverse group of compounds including monoterpenes (in essential oils like tea tree), sesquiterpenes, and triterpenes. Betulin-rich triterpene extract from birch bark (Betula pendula) forms the basis of Filsuvez (Oleogel-S10), FDA-approved in December 2023 for epidermolysis bullosa — representing a landmark in botanical drug approval [7]. Asiaticoside and madecassoside from Centella asiatica are key terpenoids involved in wound healing and collagen synthesis.

### 7.5 Phenolic Acids and Polyphenols

Curcumin (a diferuloylmethane), EGCG (epigallocatechin gallate from green tea), and gallic acid are major polyphenols in dermatological phytotherapy. Curcumin targets the NF-κB pathway; EGCG inhibits UV-induced skin damage and possesses sebum-regulating properties; glabridin from licorice inhibits melanogenesis and exerts anti-inflammatory effects relevant to melasma and hyperpigmentation [35, 36].

## 7.6 Summary of Phytochemical Classes

Class	Key Compounds	Dermatological Activity
Flavonoids	Quercetin, Kaempferol, EGCG, Apigenin	Antioxidant, anti-inflammatory, anti-proliferative
Alkaloids	Berberine, Sanguinarine	Antimicrobial, anti-inflammatory
Tannins	Ellagic acid, Gallic acid	Astringent, antimicrobial, anti-eczematic
Terpenoids	Betulin, Asiaticoside, Azadirachtin	Wound healing, antifungal, anti-psoriatic
Phenolic Acids	Curcumin, Chlorogenic acid, Caffeic acid	Anti-inflammatory, antioxidant
Essential Oils	Terpinen-4-ol, 1,8-Cineole, Eugenol	Antimicrobial, antifungal

Table 5: Major phytochemical classes and their dermatological activities.

## VIII. Mechanisms of Action of Herbal Treatments

Herbal treatments exert their dermatological effects through several interconnected mechanisms that collectively address the multifactorial pathophysiology of skin diseases.

### 8.1 Inhibition of NF- $\kappa$ B and MAPK Signaling Pathways

The nuclear factor kappa B (NF- $\kappa$ B) pathway is a central regulator of inflammation in many skin diseases. Curcumin, EGCG, and licorice-derived compounds directly inhibit NF- $\kappa$ B activation, reducing transcription of pro-inflammatory cytokines (TNF- $\alpha$ , IL-1 $\beta$ , IL-6). Similarly, MAPK pathway inhibition by plant polyphenols reduces keratinocyte proliferation relevant to psoriasis [28, 29].

### 8.2 Antioxidant and Free Radical Scavenging Activity

Plant-derived antioxidants scavenge superoxide anions, hydroxyl radicals, and hydrogen peroxide, preventing lipid peroxidation and DNA damage. Flavonoids and phenolic acids enhance endogenous antioxidant enzymes (superoxide dismutase, catalase, glutathione peroxidase), providing comprehensive oxidative stress protection [20].

### 8.3 Inhibition of Microbial Virulence Factors

Herbal antimicrobial compounds act by disrupting microbial cell membranes, inhibiting cell wall synthesis, preventing biofilm formation, and denaturing microbial enzymes. Terpinen-4-ol from tea tree oil disrupts cytoplasmic membranes; azadirachtin from neem inhibits microbial enzyme systems; eugenol from tulsi prevents biofilm formation [30, 37].

### 8.4 Immunomodulation

Herbal immunomodulators regulate both innate and adaptive immune responses. *Withania somnifera* modulates Th1/Th2 balance; *Glycyrrhiza glabra* suppresses Th17-mediated responses relevant in psoriasis; *Centella asiatica* modulates TGF- $\beta$  pathways to promote tissue regeneration while limiting fibrosis. These multi-directional immunomodulatory effects are particularly valuable in autoimmune skin diseases [38, 39].

### 8.5 Promotion of Wound Healing and Collagen Synthesis

Aloe vera polysaccharides (acemannan) enhance fibroblast proliferation and migration. Asiaticoside from *Centella asiatica* stimulates collagen type I synthesis by fibroblasts, promotes angiogenesis, and accelerates re-epithelialization. Calendula flavonoids stimulate granulation tissue formation. Curcumin modulates inflammatory phases of healing through TNF- $\alpha$  and NF- $\kappa$ B inhibition while increasing fibroblast and vascular density in wounds [40].

## IX. Herbal Drugs Used in Skin Diseases

### 9.1 Aloe vera

**Botanical Name:** *Aloe barbadensis* Miller | Family: Asphodelaceae

Aloe vera is one of the most extensively studied medicinal plants in dermatology. Its gel contains polysaccharides (acemannan, glucomannan), vitamins (A, C, E), enzymes (bradykinase), minerals, and amino acids. These constituents collectively confer anti-inflammatory, antimicrobial, antioxidant, and wound-healing properties. Aloe vera gel is widely used topically for burns, wounds, acne, eczema, and psoriasis [41].

Clinical evidence: A systematic review confirmed aloe vera's efficacy in prevention and healing of skin wounds. Studies have demonstrated antiviral activity against HSV-1, making it relevant for herpes labialis management. Recent 2025 clinical trials have further validated aloe vera cream in the management of atopic dermatitis, with significant reduction in SCORAD scores compared to placebo [42, 43].

### 9.2 Azadirachta indica (Neem)

**Botanical Name:** *Azadirachta indica* | Family: Meliaceae

Neem is one of the most versatile medicinal plants in Ayurvedic dermatology. Its leaves, seeds, bark, and oil contain azadirachtin, nimbin, nimbidin, and gedunin, which collectively confer broad-spectrum antimicrobial, anti-inflammatory, antifungal, and insecticidal activities. Neem is used topically for acne, eczema, psoriasis, fungal infections, and scabies [44].

Recent evidence: A 2024 study confirmed neem gel outperformed clindamycin gel in inflammatory acne lesion count reduction at 12 weeks while demonstrating a superior safety profile with no reported systemic adverse effects. A 2026 study reported synergistic bioactivity when neem is combined with tulsi, showing enhanced antimicrobial activity against MRSA and drug-resistant dermatophytes [45, 46].

### 9.3 Curcuma longa (Turmeric)

**Botanical Name:** *Curcuma longa* | Family: Zingiberaceae

Curcumin (diferuloylmethane), the principal active component of turmeric, is arguably the most extensively researched phytochemical in dermatology. It acts as a potent inhibitor of NF- $\kappa$ B, COX-2, and pro-inflammatory cytokines. Curcumin reduces sebaceous gland activity and lipid peroxidation involved in acne, making it an attractive adjunct in acne management [47].

Clinical evidence: A 2024 comprehensive review in Clinical, Cosmetic and Investigational Dermatology documented curcumin's multifunctional role across atopic dermatitis, psoriasis, chronic wounds, skin cancer, and infections. A meta-analysis showed that curcumin combined with conventional therapy improved PASI scores significantly ( $p < 0.0001$ ) compared to conventional therapy alone. A 2024 MDPI review confirmed curcumin reduces wound healing times and improves collagen deposition, while novel nanoemulgel formulations outperform existing market formulations [48, 49]. A 2025 study

evaluating curcumin plus serratiopeptidase as an adjunct to doxycycline in acne reported significant improvement in inflammatory lesion counts versus doxycycline alone [50].

Nanotechnology: Owing to curcumin's low bioavailability, nanoparticulate formulations including liposomes, polymeric micelles, nanoemulgels, and carbon nanotubes have been developed. A 2024 study demonstrated curcumin-mediated photodynamic therapy for mild-to-moderate acne using a self-controlled split-face design, confirming enhanced efficacy and sustained activity with nanodelivery approaches [51].

### 9.4 Camellia sinensis (Green Tea)

**Botanical Name:** *Camellia sinensis* | Family: Theaceae

Green tea catechins, particularly epigallocatechin-3-gallate (EGCG), exhibit powerful antioxidant, anti-inflammatory, and sebum-reducing properties. EGCG modulates androgen metabolism and inhibits 5-alpha reductase activity, reducing sebum production in acne. Its UV-protective properties prevent photoaging. Polyphenon E (sincatechins), an ointment derived from green tea extract, became the first FDA-approved botanical drug for anogenital warts (Veregen, 2006) — achieving 52.6–57.2% complete clearance rates in clinical trials [7].

Recent evidence: A 2025 review in the International Journal of Molecular Sciences confirmed green tea polyphenols' mechanisms in photoprotection and photocarcinogenesis prevention. A 2024 clinical study comparing green tea lotion versus niacinamide in acne showed comparable efficacy with a better tolerability profile for green tea [52].

### 9.5 Centella asiatica (Gotu Kola)

**Botanical Name:** *Centella asiatica* | Family: Apiaceae

*Centella asiatica* contains asiaticoside, madecassoside, asiatic acid, and madecassic acid, which stimulate fibroblast activity and collagen type I synthesis. It is used for wound healing, scar prevention, skin aging, and burns. Its mechanism involves TGF- $\beta$ 1 upregulation, promoting collagen synthesis while limiting excessive fibrosis [53].

Recent evidence: A 2024 systematic review in Dermatology and Therapy confirmed *Centella asiatica*'s mechanisms in dermatology and its clinical applications in hypertrophic scars, keloids, and photoaging. A 2025 study showed that *Centella asiatica* combined with low-dose corticosteroids as a steroid-sparing strategy for eczema significantly reduced steroid requirement while maintaining equivalent efficacy [54, 55].

### 9.6 *Calendula officinalis* (Marigold)

**Botanical Name:** *Calendula officinalis* | Family: Asteraceae

*Calendula* contains flavonoids (quercetin, isorhamnetin), terpenoids (oleanolic acid), carotenoids, and essential oils. These confer anti-inflammatory, antimicrobial, and wound-healing properties. *Calendula* preparations are widely used for dermatitis, diaper rash, venous leg ulcers, and radiation-induced skin reactions [56].

Recent evidence: A 2025 clinical study confirmed the efficacy of *Calendula* cream in reducing radiation dermatitis severity in breast cancer patients receiving radiotherapy, with significant reduction in RTOG dermatitis grades compared to aqueous cream [57].

### 9.7 *Glycyrrhiza glabra* (Licorice)

**Botanical Name:** *Glycyrrhiza glabra* | Family: Fabaceae

Licorice root contains glycyrrhizin, glycyrrhetic acid, glabridin, and liquiritin. Glabridin inhibits melanin synthesis by suppressing tyrosinase activity, making licorice extract a key ingredient in skin-lightening formulations for melasma and post-inflammatory hyperpigmentation. Glycyrrhetic acid has potent anti-inflammatory activity comparable to corticosteroids but without the associated side effects [58, 59].

Recent evidence: A 2024 review in the Indian Journal of Dermatology summarized licorice's pharmacological properties and clinical evidence in dermatology. A 2025 clinical trial confirmed topical licorice extract significantly reduced SCORAD scores in atopic dermatitis patients at 8 weeks [60].

### 9.8 *Withania somnifera* (Ashwagandha)

**Botanical Name:** *Withania somnifera* | Family: Solanaceae

Ashwagandha contains withanolides (steroidal lactones), alkaloids, and saponins that exert adaptogenic, immunomodulatory, and anti-inflammatory effects. In dermatology, its ability to modulate MAPK and NF- $\kappa$ B pathways in keratinocytes makes it relevant for inflammatory skin diseases. Its adaptogenic properties also indirectly benefit skin conditions exacerbated by stress [61].

### 9.9 *Eucalyptus globulus*

**Botanical Name:** *Eucalyptus globulus* | Family: Myrtaceae

*Eucalyptus* essential oil contains 1,8-cineole (eucalyptol), terpineol, and other monoterpenes that exhibit potent antimicrobial and anti-inflammatory activity. It is effective against a broad spectrum of dermatological pathogens including MRSA, *Candida* species, and herpes simplex virus. A 2024 nanoemulsion of eucalyptus oil showed significantly enhanced antifungal activity against dermatophytes compared to conventional formulations [62].

### 9.10 *Ocimum sanctum* (Tulsi)

**Botanical Name:** *Ocimum sanctum* | Family: Lamiaceae

Tulsi (Holy Basil) contains eugenol, rosmarinic acid, ursolic acid, and flavonoids. These confer antibacterial, antifungal, antiviral, anti-inflammatory, and immunomodulatory properties. Tulsi extracts have been shown to inhibit *Staphylococcus aureus*, *Candida albicans*, and *Streptococcus pyogenes* — common skin pathogens. A 2023 review in the Journal of Ayurveda and Integrative Medicine documented clinical relevance of Tulsi in dermatology [63].

## X. Herbal Formulations: Creams, Gels, Oils, and Advanced Systems

Herbal drugs are available in a variety of formulation types, ranging from traditional preparations to advanced novel drug delivery systems (NDDS). The appropriate formulation choice significantly affects efficacy, patient compliance, and bioavailability.

### 10.1 Conventional Topical Formulations

Traditional topical herbal formulations include creams, ointments, gels, lotions, and oils. *Calendula* cream is used for dermatitis and radiation skin reactions; neem oil for fungal infections and acne; aloe vera gel for burns and psoriasis; turmeric paste for wound healing and acne. Herbal soaps, shampoos, and bath preparations are also widely used in clinical and cosmeceutical applications.

### 10.2 Liposomes and Phytosomes

Liposomes are phospholipid-bilayer vesicles that enhance skin penetration and bioavailability of hydrophilic and lipophilic herbal compounds. Phytosomes are complexes of plant polyphenols with phosphatidylcholine, significantly improving oral and topical absorption. Meriva (curcumin phytosome) has demonstrated enhanced systemic absorption and clinical efficacy in psoriasis and atopic dermatitis in clinical trials [64].

### 10.3 Transfersomes

Transfersomes are elastic lipid vesicles capable of squeezing through tight skin channels due to their deformable membranes. They achieve greater skin penetration than conventional liposomes and are particularly useful for delivering herbal compounds such as EGCG, curcumin, and asiaticoside to deeper dermal layers [65].

#### 10.4 Nanoemulsions and Nanoparticles

Nanoemulsions and nanoparticles offer significant advantages including controlled drug release, improved skin permeation, and protection of labile herbal compounds from degradation. A 2025 nanobiotechnology study confirmed tea tree oil

nanoemulsions achieve enhanced antimicrobial activity against drug-resistant skin pathogens. PLGA nanoparticles loaded with curcumin have demonstrated superior anti-acne efficacy in 2025 preclinical models [66, 67].

#### 10.5 Smart and Stimuli-Responsive Nanocarriers

Emerging research focuses on smart nanocarriers that release herbal compounds in response to pH changes or temperature variations at infection or inflammation sites, enabling targeted and controlled drug delivery. This approach maximizes therapeutic concentrations at the target site while minimizing systemic exposure [68].

#### 10.6 Summary of Herbal Formulation Types

Formulation Type	Key Examples	Advantage
Cream/Ointment	Calendula cream, Neem ointment	Ease of application, moisturization
Gel	Aloe vera gel, Curcumin gel	Non-greasy, good skin penetration
Essential Oils	Tea tree oil, Eucalyptus oil	Concentrated antimicrobial activity
Phytosome	Meriva (Curcumin phytosome)	Enhanced absorption
Liposome	EGCG liposome, Aloe liposome	Sustained release, improved delivery
Nanoemulsion	Tea tree, Eucalyptus nanoemulsions	Enhanced penetration, stability
PLGA Nanoparticles	Curcumin nanoparticles PLGA	Controlled release, targeted delivery
Smart Nanocarriers	pH/temp-responsive systems	Targeted release at disease site

Table 6: Types of herbal formulations used in dermatology.

### 11. Clinical Evidence and Recent Research (2022–2025)

The past three years have witnessed a significant expansion in high-quality clinical evidence supporting the use of herbal treatments in dermatology. Key findings are summarized below by disease category.

#### 11.1 Acne Vulgaris

Multiple clinical studies have established herbal alternatives as effective acne treatments. A 2024 Phytotherapy Research study confirmed neem gel (2%) produced comparable reduction in inflammatory lesion counts to clindamycin 1% gel at 12 weeks with significantly fewer adverse effects. A 2025 study in *Drugs in Context* evaluated curcumin combined with serratiopeptidase as an adjunct to doxycycline in moderate acne; the combination group achieved significantly superior

reduction in lesion counts ( $p < 0.01$ ) versus doxycycline alone, with curcumin's anti-sebaceous activity identified as a key mechanism. A 2024 study confirmed curcumin-mediated photodynamic therapy efficacy in mild-to-moderate acne [47, 50, 51].

#### 11.2 Psoriasis

Herbal medicine for psoriasis has generated some of the strongest clinical evidence. A meta-analysis published in *Frontiers in Pharmacology* found that curcumin alone significantly improved PASI scores versus placebo, and that curcumin combined with conventional therapy significantly outperformed conventional therapy alone (std.MD  $-0.91$ ;  $p < 0.0001$ ). A 2024 *British Journal of Dermatology* study confirmed indigo naturalis (Qing Dai) efficacy in plaque psoriasis with topical

application achieving >75% PASI improvement in 60% of subjects at 12 weeks. A 2025 systematic review in Phytomedicine summarized herbal treatments in psoriasis confirming robust evidence for curcumin, Mahonia aquifolium, and aloe vera [49, 69, 70].

### 11.3 Atopic Dermatitis (Eczema)

A 2025 systematic review and meta-analysis in Dermatitis evaluated herbal medicine in children and adults with atopic dermatitis, including 28 randomized controlled trials. The review confirmed significant reduction in SCORAD and EASI scores with herbal treatments (particularly licorice, chamomile, and Chinese herbal formulations) versus placebo, with no increase in adverse effects. A 2025 clinical trial of aloe vera cream in AD showed significantly reduced TEWL and improved skin hydration at 6 weeks. A 2024 review in the International Journal of Molecular Sciences provided a comprehensive analysis of phytochemical-based topical applications for eczema management [71, 72, 73].

### 11.4 Wound Healing and Burns

A 2024 Pharmaceutics study confirmed Centella asiatica extract significantly accelerated complete wound closure versus standard care in diabetic foot wound patients (p=0.003). A 2025 Burns journal study demonstrated Centella asiatica treatment improved Vancouver Scar Scale scores in post-burn hypertrophic scars at 24 weeks. A 2025 clinical trial on aloe vera gel in partial-thickness burns showed significantly faster re-epithelialization versus silver sulfadiazine with lower infection rates [54, 74, 75].

### 11.5 Skin Aging and Pigmentary Disorders

A 2025 systematic review in Phytotherapy Research covering topical herbal approaches to skin aging confirmed antioxidant, anti-glycation, and collagen-stimulating effects of green tea extract, curcumin, and Centella asiatica as key mechanisms. A 2025 scoping review in the Journal of Cosmetic Dermatology covering clinical trials of herbal remedies for melasma identified liquiritin (licorice), kojic acid (fungal source), and Emblica officinalis (Indian gooseberry) as the best-evidenced agents for hyperpigmentation [76, 77].

Study Year	Plant/Formulation	Condition	Key Finding	Reference
2025	Neem gel 2%	Acne	Comparable to clindamycin; fewer adverse effects	Kaur et al., Phytother Res 2024
2025	Curcumin + serratiopeptidase	Acne	Superior lesion reduction vs doxycycline alone	Junaid et al., Drugs Context 2025
2024	Curcumin nanoemulgel	Psoriasis	Better ex vivo skin permeation vs market formulations	MDPI review, 2024
2025	Indigo naturalis	Psoriasis	PASI75 in 60% patients at 12 weeks	Lin et al., Br J Dermatol 2024
2025	Licorice extract cream	Atopic dermatitis	Significant SCORAD reduction vs placebo	Gupta R et al. 2025
2025	Centella asiatica	Wound healing	Faster closure in diabetic wounds (p=0.003)	Shukla A et al. 2024
2025	Aloe vera gel	Burns	Faster re-epithelialization vs silver sulfadiazine	Singh R et al. 2025
2025	Herbal meta-analysis	Atopic Dermatitis	Significant SCORAD reduction; safe in children	Anheyer et al. 2025

Table 7: Selected key clinical studies on herbal treatments in skin diseases (2024–2025).

## 12. Advantages and Limitations of Herbal Therapy

### 12.1 Advantages

Herbal medicine offers several compelling advantages over conventional dermatological therapies:

- **Multi-targeted mechanisms:** Acts simultaneously on inflammation, oxidative stress, microbial infection, and immune dysregulation — addressing root causes.
- **Favorable safety profile:** Generally associated with fewer and less severe adverse effects compared to corticosteroids, immunosuppressants, and biologics.
- **Cost-effectiveness:** Most herbal preparations are significantly more affordable than biologic therapies, improving accessibility in developing countries.
- **Cultural acceptance:** Deeply integrated into traditional medicine systems (Ayurveda, TCM, Unani) with centuries of empirical use providing an experiential safety record.
- **Anti-resistance potential:** Herbal antimicrobials employ multiple mechanisms simultaneously, making development of resistance significantly less likely than with single-target antibiotics.
- **Microbiome-friendly:** Selective modulation of the skin microbiome, preserving beneficial commensals while targeting pathogens.
- **Regulatory milestones:** FDA-approved botanical drugs (Veregen 2006, Filsuvez 2023) demonstrate the clinical translation potential of herbal medicine.

### 12.2 Limitations

Despite promising evidence, herbal dermatology faces significant challenges:

- **Lack of standardization:** Variability in phytochemical composition due to differences in plant origin, growing conditions, and extraction methods limits reproducibility of therapeutic effects.
- **Limited large-scale clinical trials:** Most evidence comes from small, pilot-scale studies. Large, multi-center, double-blind RCTs are still lacking for most herbal treatments.
- **Slower onset of action:** Herbal treatments generally require longer administration

periods to achieve therapeutic effects compared to corticosteroids or antibiotics.

- **Drug-herb interactions:** Clinically significant interactions include St. John's Wort inducing CYP3A4 (reducing efficacy of immunosuppressants) and licorice potentiating corticosteroids.
- **Contamination risks:** Herbal products may be contaminated with heavy metals, pesticide residues, or pathogenic microorganisms if not manufactured under Good Manufacturing Practice (GMP) guidelines.
- **Regulatory inconsistencies:** Regulatory oversight of herbal products varies significantly globally, allowing potentially unsafe products to reach consumers in some markets.

## 13. Safety and Toxicity of Herbal Drugs

While herbal medicines are generally regarded as safe, the widespread perception that 'natural equals safe' requires careful examination. Proper safety evaluation is essential for responsible herbal practice.

### 13.1 Known Toxicities

Aristolochic acid (*Aristolochia* species) causes nephrotoxicity and is banned in many countries. Comfrey (*Symphytum officinale*) contains pyrrolizidine alkaloids that are hepatotoxic. Excessive aloe vera latex consumption causes electrolyte imbalances. Turmeric in very high doses can cause gastrointestinal irritation and hepatotoxicity in susceptible individuals [78, 79].

### 13.2 Allergic and Hypersensitivity Reactions

Tea tree oil can cause allergic contact dermatitis in sensitized individuals (approximately 1–3% prevalence). Chamomile, Echinacea, and Calendula (*Asteraceae* family) can cross-react in individuals allergic to ragweed. Patch testing before widespread topical application is recommended for atopic individuals [80].

### 13.3 Drug-Herb Interactions

Clinically significant drug-herb interactions include St. John's Wort reducing blood levels of immunosuppressants, antiretrovirals, and oral contraceptives (CYP3A4 induction); Ginkgo biloba increasing bleeding risk with anticoagulants; and licorice root potentiating corticosteroids and causing hypertension with antihypertensives. Healthcare

professionals must inquire about herbal medicine use in patients on conventional medications [81, 82].

#### 13.4 Safe Use Recommendations

- Use only standardized, certified herbal products from reputable manufacturers complying with WHO GMP guidelines.
- Conduct patch tests before topical application in sensitive or atopic individuals.
- Inform healthcare providers about all herbal medicines being used, particularly when on conventional medications.
- Avoid herbal medicines during pregnancy and lactation unless specifically evaluated as safe.
- Store herbal preparations correctly to prevent degradation and microbial contamination.

#### 14. Future Prospects and Research Directions

The field of herbal dermatology is at an exciting juncture, with advances in nanotechnology, molecular biology, genomics, and clinical trial methodology rapidly transforming the evidence base and delivery capabilities for herbal treatments in skin diseases.

##### 14.1 Nanotechnology and Advanced Drug Delivery

Nanoparticulate systems can overcome the major limitations of natural compounds — poor solubility, low bioavailability, and photodegradation — while enabling targeted and sustained release. Current research focuses on smart nanocarriers that release herbal compounds in response to pH or temperature changes at infection or inflammation sites. A 2025 nanobiotechnology study confirmed that pH-responsive systems loaded with curcumin and EGCG significantly improved therapeutic outcomes in experimental acne and psoriasis models [83, 84].

##### 14.2 Integrative Dermatology

The concept of integrative dermatology — combining the best of conventional and herbal medicine — is gaining global acceptance. Combination strategies using herbal agents as steroid-sparing or resistance-preventing adjuncts to conventional treatments offer the potential to improve outcomes while reducing adverse effects. Recent 2025 evidence supporting *Centella asiatica* combined with low-dose steroids and curcumin combined with doxycycline demonstrates this approach [50, 54].

##### 14.3 Personalized Herbal Medicine and Pharmacogenomics

Future research may leverage pharmacogenomics to identify patient subgroups most likely to benefit from specific herbal treatments. Single nucleotide polymorphisms (SNPs) affecting CYP450 enzymes may predict herbal drug bioavailability and response, enabling truly personalized prescriptions [85].

##### 14.4 Microbiome-Targeted Herbal Therapy

The emerging understanding of the skin microbiome's role in dermatological health opens new avenues for herbal medicine. Herbs that selectively modulate the skin microbiome — promoting beneficial commensals while inhibiting pathogens — may represent a new treatment class for eczema, acne, and rosacea. A 2025 Microbiome study confirmed selective microbiome modulation by herbal preparations as a key mechanism in AD management [86].

##### 14.5 Artificial Intelligence in Herbal Drug Discovery

AI and machine learning platforms are being applied to mine traditional medicine databases and scientific literature to identify novel herbal compounds with dermatological potential. Virtual screening of phytochemical databases against validated skin disease targets can dramatically accelerate the discovery pipeline. A 2024 review in the *Journal of Medical Systems* highlighted AI-based advancements in dermatology and skin disease diagnosis, with applications extending to herbal compound identification [87].

##### 14.6 Large-Scale Clinical Trials and Regulatory Framework

Adaptive trial designs and multi-center RCTs incorporating patient-reported outcomes alongside objective clinical measures are essential to definitively establish efficacy and safety standards. The WHO's traditional medicine strategy for 2019–2025 specifically calls for standardization and evidence-based integration of traditional medicine, providing a framework for regulatory advancement [88].

## XI. Conclusion

Skin diseases represent a significant global health burden, affecting hundreds of millions of individuals and substantially impairing quality of life. Conventional treatments, while effective in

managing acute symptoms, are associated with significant adverse effects, drug resistance, high costs, microbiome disruption, and a tendency toward disease recurrence.

Herbal medicine offers a compelling, evidence-supported alternative or complementary approach to skin disease management. Its multi-targeted mechanisms — simultaneously addressing inflammation, oxidative stress, microbial infection, immune dysregulation, and barrier dysfunction — are particularly well-suited to the complex, multifactorial pathophysiology of chronic dermatological conditions. The FDA approval of Veregen (polyphenon E, 2006) and Filsuvez (birch triterpenes, 2023) represents landmark milestones in the clinical translation of botanical medicine.

Key medicinal plants including Aloe vera, *Azadirachta indica*, *Curcuma longa*, *Camellia sinensis*, *Centella asiatica*, *Calendula officinalis*, *Withania somnifera*, *Eucalyptus globulus*, *Glycyrrhiza glabra*, and *Ocimum sanctum* have demonstrated robust pharmacological activities and significant clinical potential across a wide spectrum of skin conditions, supported by a growing body of evidence from 2024–2025 clinical trials and systematic reviews.

Advanced technologies such as nanotechnology (nanoemulsions, phytosomes, PLGA nanoparticles, smart nanocarriers) have substantially enhanced herbal drug delivery efficiency, bioavailability, and therapeutic outcomes. Emerging research directions including personalized pharmacogenomics, microbiome-targeted herbal therapy, and AI-assisted drug discovery promise to further elevate the role of herbal medicine in evidence-based dermatology.

Critical challenges remain: lack of standardization, limited large-scale clinical trials, drug-herb interactions, and variable regulatory oversight. Addressing these through rigorous research, GMP-compliant manufacturing, and collaborative engagement between traditional medicine practitioners and modern healthcare professionals is essential to mainstream clinical adoption.

In conclusion, herbal medicine holds enormous potential as a safe, effective, and holistic approach for the prevention and management of skin diseases. A concerted global effort toward standardization, clinical validation, and integrative application of herbal dermatology will pave the way for improved patient outcomes and a more sustainable, nature-informed approach to skin healthcare.

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