2026 Volume: 02 Issue: 01 ISSN 2347-7008 Review Article

International Journal Pharmaceutical Medicinal Research

Page: 01-18

MULTIFUNCTIONAL HERBAL GELS IN SKIN CARE: A REVIEW OF THEIR ROLE IN ACNE MANAGEMENT, SCAR REDUCTION, DEPIGMENTATION, AND UV PROTECTION

Samyuktha.Metta [1]*, Arunabha Mallik[2] , Gatla Rajaiah Eshwar[3], Kadiyala Vijaya Lakshmi [4], Anthamolla Sreeja Reddy[5], Chinnabathini Akhil Kumar[6]

[1]Department of Pharmaceutics, Marri Laxman Reddy Institute of Pharmacy, Hyderabad, Telangana-500043, India.
[2]Department of Pharmacology, Marri Laxman Reddy Institute of Pharmacy, Hyderabad, Telangana-500043, India.
[3,4,5]Marri Laxman Reddy Institute of Pharmacy, Hyderabad, Telangana-500043, India.

Article Received: 21 December 2025
Article Revised: 11 January 2026
Published on: 31 January 2026

***Corresponding Author: Samyuktha.Metta**
Department of Pharmaceutics, Marri Laxman Reddy Institute of Pharmacy, Hyderabad, Telangana-500043, India.
DOI: https://doi-doi.org/101555/ijpmr.2580

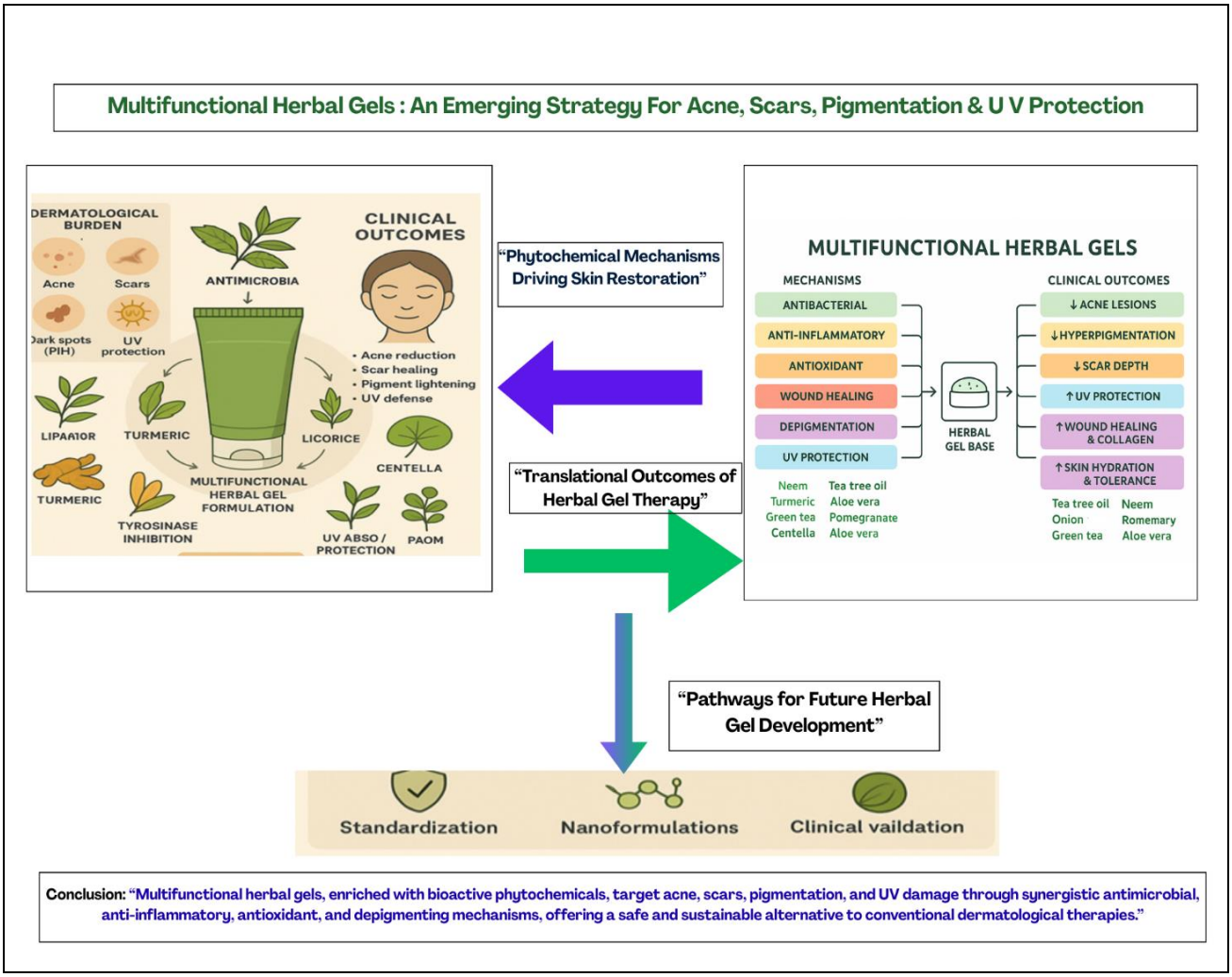
ABSTRACT:

Acne vulgaris is a common dermatological disorder characterized by inflammation, bacterial colonization, and excess sebum production, often accompanied by post-acne complications such as scarring, hyperpigmentation, and heightened sensitivity to ultraviolet (UV) radiation. Conventional acne therapies frequently present limitations, including adverse effects, skin irritation, and antimicrobial resistance. The increasing interest in herbal-based formulations stems from their favorable safety profiles, multi-targeted actions, and consumer preference for natural therapies. This comprehensive review provides an in-depth analysis of the potential of multifunctional herbal gel formulations designed for acne control, scar reduction, depigmentation, and UV protection. The review summarizes the strategic formulation of such gels incorporating key herbal actives, including *Azadirachta indica*, *Melaleuca alternifolia*, *Aloe vera*, *Curcuma longa*, *Glycyrrhiza glabra*, *Centella asiatica*, *Camellia sinensis*, *Punica granatum*, *Nigella sativa*, and *Phyllanthus emblica*. These ingredients were selected for their complementary pharmacological actions antibacterial, anti-inflammatory, antioxidant, melanogenesis-inhibitory, and photoprotective properties providing a synergistic therapeutic effect in topical applications. Evidence from preclinical studies and selected clinical trials supports the efficacy of these herbal actives in reducing acne lesions, accelerating wound healing, diminishing pigmentation, and offering protection against UV-induced skin damage. Clinical trials on individual components such as tea tree oil, Centella asiatica, and licorice extract have demonstrated significant improvements in acne severity, scar reduction, and hyperpigmentation, respectively, with minimal adverse effects. Overall, this review highlights the potential of developing multifunctional herbal gel formulations as a safe and effective alternative or adjunct to conventional acne therapies. Future recommendations emphasize the need for more robust, large-scale

clinical trials to validate the combined efficacy of these herbal ingredients in optimized gel formulations, supporting their integration into mainstream dermatological care.

KEYWORDS: Herbal gel, Multifunctional skincare, Acne control, Scar reduction, Skin depigmentation, UV protection, Natural skincare, Phytochemicals, Anti-inflammatory properties, Antioxidant activity.

GRAPHICAL ABSTRACT:



INTRODUCTION:

Acne vulgaris is one of the most prevalent chronic inflammatory skin disorders worldwide, affecting approximately 9.4% of the global population[1]. While it is commonly associated with adolescence, acne also persists into adulthood in many individuals, often leading to post-acne complications such as atrophic scars, post-inflammatory hyperpigmentation (PIH), and increased vulnerability to ultraviolet (UV) radiation-induced damage[2,3]. These aftereffects not only compromise skin appearance but also impose a significant psychosocial burden, including anxiety, depression, and reduced quality of life[4].

Despite the availability of numerous topical and systemic agents for acne treatment, current therapies often target individual symptoms rather than offering comprehensive care. Synthetic antimicrobials and retinoids, while effective against active acne, frequently result in adverse effects such as dryness, irritation, and photosensitivity[5]. Similarly, treatments for pigmentation (e.g., hydroquinone) and scarring (e.g., retinoids, chemical peels) carry the risk of irritation or hyperpigmentation, especially in individuals with darker skin tones[6]. Addressing acne, pigmentation, scars, and photodamage simultaneously in a single, patient-friendly formulation remains a major challenge in dermatological therapeutics.

In this context, there has been growing global interest in multifunctional herbal formulations, driven by the increasing consumer preference for natural, safe, and holistic skin care products[7]. Herbal extracts are rich in bioactive compounds such as polyphenols, flavonoids, alkaloids, and terpenoids that exhibit diverse biological activities including antimicrobial, anti-inflammatory, antioxidant, and melanin-inhibitory effects[8,9]. The topical gel form, in particular, offers advantages like enhanced skin penetration, hydration, and ease of use, making it an ideal delivery system for incorporating multiple herbal actives[10].

Objective of the Review

This comprehensive review aims to:

1. Summarize the formulation strategies for multifunctional herbal gels targeting acne control, scar reduction, depigmentation, and UV protection;
2. Highlight key herbal actives supported by pharmacological and clinical evidence;
3. Discuss the efficacy, safety, and limitations of current herbal interventions; and
4. Provide future perspectives for developing clinically validated, patient-centric herbal formulations for integrated acne management.

HERBAL ACTIVES AND FORMULATION OVERVIEW:

2.1 Rationale for Herbal Ingredients

The rationale for incorporating herbal ingredients into multifunctional gel formulations lies in their broad-spectrum pharmacological actions, favorable safety profile, and ability to address multiple dermatological concerns simultaneously. Acne vulgaris and its sequelae are multifactorial in origin, involving bacterial overgrowth (Cutibacterium acnes), inflammation, oxidative stress, impaired wound healing, and dysregulated melanogenesis[11]. Conventional therapies often target only one or two of these pathways, whereas herbal actives contain diverse phytochemicals that modulate several mechanisms in parallel.

For instance, Azadirachta indica (neem) and Melaleuca alternifolia (tea tree oil) provide potent antibacterial and anti-inflammatory effects, directly suppressing acne-causing bacteria. Aloe vera and Centella asiatica accelerate wound healing and collagen synthesis, supporting scar repair. Curcuma longa (turmeric) and Camellia sinensis (green tea) exert strong antioxidant and anti-inflammatory activities, counteracting oxidative stress and UV-induced damage. Glycyrrhiza glabra (licorice), Punica granatum (pomegranate), and Phyllanthus emblica (amla) inhibit tyrosinase and reduce hyperpigmentation, while Nigella sativa and Rosmarinus officinalis contribute additional anti-inflammatory and photoprotective effects[12].

By combining such botanicals into a gel matrix, synergistic interactions are expected, resulting in enhanced therapeutic efficacy compared to single-herb or conventional formulations. Moreover, the gel dosage form provides sustained release, improved penetration, spreadability, and patient compliance, making it a suitable platform for multifunctional dermatological care[13].

2.2 Key Herbal Ingredients and Their Roles

The therapeutic potential of multifunctional herbal gels arises from the synergistic activity of carefully selected botanicals, each contributing distinct pharmacological effects relevant to acne control, scar reduction, depigmentation, and UV protection. The following herbs represent the most widely studied and effective agents incorporated in topical formulations (Table 1),(Figure1).

Azadirachta indica (Neem): Rich in limonoids such as azadirachtin and nimbidin, neem exhibits strong antibacterial activity against *Cutibacterium acnes* and anti-inflammatory properties that reduce erythema and pustule formation[14]. Its immunomodulatory effects further support skin healing and barrier restoration.

Melaleuca alternifolia (Tea Tree Oil): Tea tree oil contains terpinen-4-ol, a monoterpene with broad antimicrobial activity. Clinical studies have shown that 5% tea tree oil gel significantly reduces acne lesion counts with fewer side effects compared to benzoyl peroxide[15].

Aloe vera: The mucopolysaccharides, glycoproteins, and acemannan in *Aloe vera* enhance fibroblast proliferation, collagen synthesis, and epithelial regeneration[16]. These actions accelerate scar healing while its inherent anti-inflammatory properties soothe irritation.

Curcuma longa (Turmeric): Curcumin, the principal curcuminoid, inhibits NF-κB signaling and cyclooxygenase-2 activity, thereby reducing inflammatory cascades[17]. It also exhibits antioxidant and depigmenting effects by downregulating tyrosinase activity, making it valuable for acne and PIH management.

Glycyrrhiza glabra (Licorice): Licorice extract contains glabridin, a potent tyrosinase inhibitor, which reduces melanin synthesis and improves hyperpigmentation[18]. Additionally, its flavonoids provide anti-inflammatory benefits.

Centella asiatica: The triterpenoid saponins (asiaticoside, madecassoside) stimulate fibroblast proliferation and collagen production, accelerating wound repair and reducing atrophic scarring[19].

Camellia sinensis (Green Tea): Catechins, especially epigallocatechin gallate (EGCG), provide antioxidant, antimicrobial, and photoprotective effects[20]. Topical green tea reduces sebum secretion and protects against UV-induced oxidative stress.

Punica granatum (Pomegranate): Rich in polyphenols and anthocyanins, pomegranate extract exerts strong antioxidant activity and suppresses NF-κB signaling, reducing inflammation and UV-mediated skin damage[21].

Nigella sativa (Black Seed): Thymoquinone, the major bioactive compound, demonstrates antimicrobial, antioxidant, and anti-inflammatory effects, with proven efficacy in reducing acne lesions in small clinical studies[22].

Phyllanthus emblica (Amla): Amla is a rich source of vitamin C and tannins, which enhance collagen synthesis, provide antioxidant protection, and reduce pigmentation[23].

By combining these botanicals into a single gel base, complementary mechanisms act synergistically to provide comprehensive acne management, scar healing, depigmentation, and photoprotection.

Table 1. Key Herbal Actives in Multifunctional Herbal Gel Formulations for Dermatological Use.

Herb (Botanical Name)	**Major Bioactive Compounds**	**Primary Mechanism of Action**	**Intended Use**
Neem (*Azadirachta indica*)	Azadirachtin, Nimbidin, Quercetin	Antibacterial (inhibits Propionibacterium acnes), anti-inflammatory, antioxidant	Acne control, scar healing
Tea Tree (*Melaleuca alte rnifolia*)	Azadirachtin, Nimbidin, Quercetin	Antibacterial (inhibits *Propionibacterium acnes*), anti-inflammatory, antioxidant	Acne control, scar healing
Aloe vera (*Aloe barbadensis*)	Terpinen-4-ol, Cineole	Disrupts bacterial membranes, reduces sebum, anti-inflammatory	Acne reduction
Turmeric (*Curcuma longa*)	Aloin, Acemannan, Polysaccharides	Promotes collagen synthesis, antioxidant, wound healing	Scar reduction, hydration
Licorice (*Glycyrrhiza glabra*)	Curcumin	NF-κB inhibition, antioxidant, anti-inflammatory	Acne control, depigmentation, UV protection
Centella (*Centella asiatica*)	Glabridin, Liquiritin	Inhibits tyrosinase, anti-inflammatory	Depigmentation, acne relief
Green Tea (*Camellia sinensis*)	Asiaticoside, Madecassoside	Stimulates collagen, angiogenesis, antioxidant	Scar healing, anti-aging
Onion (Allium cepa)	Quercetin, sulfur compounds	Collagen modulation, anti-inflammatory	Scar reduction, pigmentation
Pomegranate (*Punica granatum*)	Epigallocatechin gallate (EGCG), Catechins	Reduces sebum, antioxidant, UV protection	Acne, photoprotection
Black Seed (*Nigella sativa*)	Ellagic acid, Punicalagin, Anthocyanins	Antioxidant, inhibits melanogenesis, photoprotection	Depigmentation, UV defense
Amla (*Phyllanthus emblica*)	Thymoquinone, Alkaloids	Anti-inflammatory, antibacterial, antioxidant	Acne, scar healing
Rosemary (*Rosmarinus officinalis*)	Ascorbic acid, Tannins, Polyphenols	Potent antioxidant, stimulates collagen, inhibits melanin	Depigmentation, scar reduction
Saffron (*Crocus sativus*)	Rosmarinic acid, Carnosic acid	Free radical scavenging, anti-inflammatory	UV protection, anti-aging

Herb (Botanical Name)	Major Bioactive Compounds	Primary Mechanism of Action
 Neem *(Azadirachta indica)*	 Tea Tree (*Melaleuca alternifolia*)	 Aloe Vera (*Aloe barbadensis*)
 Turmeric (*Curcuma longa*)	 *Licorice (Glycyrrhiza glabra)*	 Gotu Kola (*Centella Asiatica)*
 Green Tea (*Camellia sinensis*)	 Onion (*Allium cepa*)	 Pomegranate (*Punica granatum*)
 Black Seed (*Nigella sativa*)		 Amla (*Phyllanthus emblica*)
 Rosemary (*Rosmarinus officinalis*)		 Saffron (*Crocus sativus*)

Figure :1 Representative images of key herbal ingredients incorporated in multifunctional gel formulations.

2.3 Formulation Strategies for Herbal Gels

2.3.1 Gel bases and structuring polymers

Topical herbal gels are commonly structured with synthetic carbomers (Carbopol®), cellulose ethers (e.g., HPMC/HEC), and natural polymers (e.g., chitosan, alginate) to achieve desirable rheology, spreadability, residence time, and release characteristics. Carbomers provide high clarity, pseudoplastic flow, and pH-triggered thickening, enabling elegant, fast-absorbing gels ideal for facial use[24]. Cellulose ethers add shear-thinning behavior and stability across broad pH/ionic strengths, supporting actives prone to hydrolysis[25]. Natural biopolymers contribute bioadhesion and biological functionality: chitosan enhances muco/dermo-adhesion and exhibits intrinsic antimicrobial activity, while alginate forms ionotropically cross-linked networks that modulate release and water activity[26].

2.3.2 Factors governing stability and release of phytochemicals

- Phytochemicals such as polyphenols, terpenoids, and curcuminoids are often labile to light, oxygen, and alkaline pH, and may suffer from poor solubility.
- To address these challenges, formulation strategies prioritize:
- pH control (5.0–6.0) to ensure both skin compatibility and chemical stability[27].
- Antioxidant systems (e.g., tocopherol, ascorbyl derivatives) and protective packaging to minimize oxidative degradation[25].
- Solubilizers and stabilizers (e.g., cyclodextrins, glycerol) to maintain actives in molecular dispersion[28].
- Penetration enhancers to optimize dermal delivery without excessive irritation[29].

2.3.3 Synergistic combinations vs. single-herb gels

Combining botanicals acting on complementary mechanisms (antimicrobial + anti-inflammatory + antioxidant + antimelanogenic) offers additive or synergistic effects while reducing the required dose of each extract. Similarly, polymer combinations (e.g., carbomer for aesthetics + chitosan for bioadhesion) enhance performance[24,26]. Sequential release—fast-acting soothing herbs (aloe) with slower-releasing antioxidants (curcumin, licorice)—can match the evolving stages of acne and post-inflammatory sequelae[25].

2.3.4 Nano-enabled and novel delivery systems

Advanced delivery approaches further improve stability and efficacy:

- Nanoemulsion gels increase solubility of lipophilic actives and target follicular delivery[30].
- Solid lipid nanoparticles (SLN/NLC) provide photostability, occlusion, and controlled release[31].
- Vesicular systems (liposomes, transfersomes, ethosomes) enhance penetration and co-delivery of multiple actives[32].
- Hybrid hydrogels and cyclodextrin-in-gel systems stabilize labile compounds such as curcumin and improve release control[28].
- Collectively, optimized polymer selection, stabilization strategies, and nano-carrier integration enable multifunctional herbal gels to deliver clinically effective concentrations while ensuring cosmetic elegance and patient compliance.

2.3 Formulation Design and Delivery System

Gel Base Choice

A hydrogel formulation is selected for its superior aesthetics and enhanced skin penetration. Carbomer-based gels are preferred due to their excellent spreadability, light texture, and compatibility with a range of actives. Additionally, aloe vera gel can serve as a dual-purpose base—providing both structural consistency and therapeutic benefit.

Penetration Enhancers

To improve dermal delivery of active constituents, natural penetration enhancers such as menthol, propylene glycol, or squalene can be employed. These agents disrupt the stratum corneum lipid barrier slightly to allow deeper permeation of herbal extracts.

Stability Considerations

Herbal actives, especially essential oils and polyphenolic compounds, are prone to oxidation and degradation. To enhance shelf life and maintain efficacy:

- **Antioxidants** (e.g., vitamin E, rosemary extract) are included in the formulation.
- Packaging in air-tight, light-protective containers (e.g., aluminum tubes or amber glass) is recommended.
- pH buffering agents may be used to maintain stability in the range of 5.5–6.5, optimal for both skin compatibility and active ingredient stability.

Furthermore, microbial stability is ensured by including safe, broad-spectrum natural preservatives such as potassium sorbate or sodium benzoate in combination with chelating agents like EDTA.

3. Evidence from Preclinical and Clinical Studies

The efficacy of herbal actives in multifunctional gels is supported by a growing body of in vitro, in vivo, and clinical studies. These investigations demonstrate antimicrobial, antioxidant, wound healing, depigmenting, and photoprotective effects relevant to acne management, scar reduction, and UV protection.(Table 2)

3.1 In vitro studies

Antimicrobial assays confirm that Azadirachta indica and Melaleuca alternifolia extracts inhibit *Cutibacterium acnes*, with minimum inhibitory concentrations comparable to conventional antimicrobials[33]. Similarly, **green tea catechins** and **curcumin** show strong antioxidant and anti-inflammatory activity in keratinocyte and fibroblast cultures[34].

3.2 In vivo studies

Animal models validate wound healing and UV protection properties. Aloe vera significantly accelerates wound contraction and collagen deposition in rat excision models[35]. Pomegranate extract reduces UV-induced oxidative stress and preserves dermal architecture in murine models[36].

3.3 Clinical trials

Clinical validation highlights the translational potential of these herbs. Tea tree oil gel (5%) significantly reduced acne lesions in randomized trials compared to placebo, with fewer adverse effects than benzoyl peroxide[33]. Onion extract gel improved scar texture and erythema in post-surgical patients[37], while licorice extract creams reduced hyperpigmentation and melasma scores with minimal irritation[34].

Table 2. Representative preclinical and clinical evidence for key herbal ingredients in dermatology

Herbal Ingredient	Condition Studied	Formulation/Concentration	Clinical Outcome	Safety Profile
Tea Tree Oil (*Melaleuca alternifolia*)	Mild to moderate acne vulgaris	5% gel	Significant reduction in lesion count and acne severity vs. placebo	Mild, transient irritation only
Onion Extract (*Allium cepa*)	Post-surgical / traumatic scars	Gel containing onion extract + allantoin	Improved scar softness, texture, and redness	Well tolerated, minimal irritation
Licorice Extract (*Glycyrrhiza glabra*)	Hyperpigmentation / Melasma	Topical gel (2%)	Reduced pigmentation and improved skin brightness	No major adverse effects
Brahmi *(Centella asiatica)*	Atrophic acne scars	Gel/cream standardized extract	Increased collagen synthesis, improved scar remodeling	Safe, with minimal adverse reactions
Aloe vera ***(Aloe barbadensis)***	UV-induced erythema and wound healing	97.5% Aloe vera gel	Faster wound healing, reduced erythema, enhanced skin hydration	No adverse effects reported

4. Advantages of Multifunctional Herbal Gels

Multifunctional herbal gels offer several advantages over conventional mono-target therapies in dermatological care.

4.1 Multi-targeted effects

Unlike synthetic agents that often address only a single pathogenic factor, herbal gels provide multi-pronged activity—antimicrobial, anti-inflammatory, antioxidant, melanogenesis inhibition, and wound healing—within a single formulation. This integrative approach reduces the need for multiple topical agents and minimizes drug–drug interactions[38].

4.2 Improved patient compliance

Topical gels are easy to apply, non-greasy, fast absorbing, and cosmetically elegant, which enhances adherence to long-term regimens. Additionally, herbal gels generally exhibit fewer adverse effects compared to retinoids, hydroquinone, or benzoyl peroxide, making them more tolerable for patients with sensitive or acne-prone skin[39].

4.3 Sustainability and consumer preference

Growing global awareness of sustainability and natural wellness has increased consumer preference for herbal cosmeceuticals. Plant-based gels not only align with eco-friendly values but also capitalize on the perceived safety and holistic benefits of botanicals[40]. Market analyses indicate a robust and rising demand for herbal skincare, projected to surpass USD 12 billion by 2030, driven by consumer trust and reduced reliance on synthetic chemicals[41].

5. Safety Profile of Herbal Gels

A critical aspect in the development of multifunctional herbal gels is ensuring **safety and tolerability** for long-term dermal application. Although herbal actives are generally regarded as safe due to their traditional use, certain phytochemicals can exhibit dose-dependent toxicity, allergenicity, or photoreactivity if not standardized properly. For example, excessive concentrations of tea tree oil or neem oil may cause local erythema, dryness, or allergic contact dermatitis in sensitive individuals[42].

Skin irritation and sensitization testing are therefore essential steps in preclinical evaluation. Draize patch tests and repeated insult patch testing (RIPT) in human volunteers are commonly employed to determine irritation potential, while reconstructed human epidermis (RHE) models are increasingly used for ethical and mechanistic assessments[43].

Clinical safety evaluations have reported that properly formulated herbal gels containing Aloe vera, Centella asiatica, and licorice extracts are generally well tolerated, with fewer incidences of dryness, burning, or peeling compared to synthetic anti-acne drugs[44]. Importantly, most adverse effects are linked to improper concentrations or poor formulation practices rather than the botanical extracts themselves.

From a **regulatory perspective**, herbal gels often fall into the category of cosmeceuticals, which occupy a "grey zone" between cosmetics and pharmaceuticals. Regulatory frameworks such as the US FDA, European Medicines Agency (EMA), and India's AYUSH guidelines emphasize the need for safety substantiation through patch testing, dermal toxicity studies, and stability data before market approval[45]. Standardization of botanical extracts and adherence to Good Manufacturing Practices (GMP) are therefore critical for ensuring reproducible safety profiles across batches. Comparative Overview of Herbal vs. Synthetic Gels in Skin Care shown in table 3.

6. Comparison with Existing Therapies

6.1 Herbal gels vs. conventional topicals

Conventional acne regimens (topical antibiotics, benzoyl peroxide, retinoids) are effective but typically mono-targeted and often combined to cover multiple pathways. They carry predictable drawbacks—antibiotic resistance with prolonged clindamycin/erythromycin use, irritant dermatitis with benzoyl peroxide, and dryness/photosensitivity with retinoids[46]. By contrast, multifunctional herbal gels combine antimicrobial, anti-inflammatory, antioxidant, antimelanogenic, and wound-healing actions in a single vehicle, potentially reducing the number of products needed while maintaining tolerability.

6.2 Pigmentation care: herbal depigments vs. hydroquinone

Hydroquinone remains a gold-standard depigmenting agent but is associated with irritation, rebound hyperpigmentation, and rare exogenous ochronosis, risks that are heightened with improper concentration or prolonged use—especially in darker phototypes[47]. Herbal alternatives (e.g., licorice, turmeric, green tea, amla) act via tyrosinase inhibition, anti-inflammatory and antioxidant pathways, offering a gentler profile suitable for maintenance or combination regimens, albeit with typically slower onset.

6.3 UV protection: botanical photoprotective vs. sunscreens

Broad-spectrum organic/inorganic sunscreens remain the primary, evidence-based method of preventing UV-induced erythema and photoaging, with robust clinical data for reducing actinic damage and skin-cancer risk[48]. Herbal gels rich in polyphenols (e.g., green tea, pomegranate, licorice) provide adjunctive photoprotection via ROS scavenging, MMP inhibition, and mild UV absorption, but they should complement—not replace—SPF-rated sunscreens in daily care.

6.4 Side-effect profile and adherence

Compared to conventional agents, herbal gels generally show lower rates of stinging, peeling, and photosensitivity, which can improve adherence in sensitive or acne-prone skin. Conventional agents may achieve faster lesion reduction, but tolerability trade-offs often necessitate moisturizers or step-down protocols[46–48].

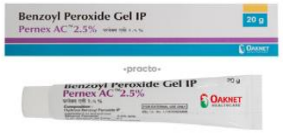
6.5 Cost and sustainability

Herbal gels can be cost-efficient by consolidating multiple functions (acne control, scar care, pigment modulation, adjunctive photoprotection) into one product, and many botanicals are renewable inputs. Conversely, costs may rise if standardized extracts or nano-delivery are used. Lifecycle impacts vary by supply chain; however, plant-derived actives and simpler gel bases generally align with sustainability-oriented consumer preferences compared with multi-product synthetic routines.

Table 3. Comparative Overview of Herbal vs. Synthetic Gels in Skin Care

Category	Brand Name	Key Ingredients	Intended Use	Mechanism / Notes	Advantages	Limitations	Illustration
	Aloe Vera Gel	Aloe polysaccharides, vitamins	Acne soothing, scar healing, anti-aging	Stimulates collagen, anti-inflammatory	Safe, soothing, consumer-preferred	Stability issues, batch variability	
	Caret Gel	Aloe, Neem, Tulsi, Lemon	Antioxidant & antibacterial acne care	Multi-targeted herbal activity	Natural, sustainable	Limited Randomized Controlled Trials(RCTs)	
	Pimpewin Gel	Neem, Yashtimadhu, Turmeric	Anti-acne, reduces redness	Antimicrobial + anti-inflammatory	Gentle, multi-target	Variability in actives	

🌿 Herbal Gels	Vicco Turmeric Gel	Turmeric (Curcumin)	Acne, pigmentation	Anti-inflammatory, anti-tyrosinase	Time-tested, safe	Mild efficacy	
	Kumkumadi Gel	Saffron, Sandalwood, Herbs	Depigmentation, skin glow	Antioxidant + melanogenesis modulation	Ayurvedic popularity	Poor stability	
	Himalaya Acne-N-Pimple Gel	Neem, Aloe	Acne reduction	Antimicrobial + soothing	Easily available	Variable potency	
	Excex Gel	Clindamycin + Adapalene	Acne vulgaris	Antibacterial + retinoid keratolysis	Proven efficacy	Resistance, irritation	
	Benzamycin Gel	Erythromycin + Benzoyl peroxide	Mild–moderate acne	Antimicrobial + oxidizing	Effective combo	Irritation, dryness	

💊 **Synthetic Gels**	Epiduo Gel	Adapalene + Benzoyl peroxide	Moderate acne	Retinoid + oxidizing	High efficacy	Irritation, photosensitivity	
	Differin Gel	Adapalene	Acne, PIH prevention	Retinoid action	Well-studied, FDA approved	Irritation	
	Pernox Gel	Benzoyl peroxide	Acne	Oxidative antimicrobial	Cheap, effective	Dryness, peeling	
	Clinagel®	Clindamycin phosphate	Acne vulgaris	Inhibits C. acnes by blocking protein synthesis (50S ribosome)	Effective, well tolerated	Resistance risk, mild irritation	
	Forscar® UV Scar Recovery Gel	Patented silicone blend + SPF 30 + 5% squalane	Management of keloids & hypertrophic scars; scar prevention with UV protection	Silicone forms protective barrier; squalane hydrates; SPF prevents UV-induced scar darkening	Softens & flattens scars, hydrates skin, protects from UV	Expensive; requires prolonged use for visible effect	

7. LIMITATIONS AND CHALLENGES

Despite the therapeutic promise of multifunctional herbal gels, several critical challenges hinder their translation into mainstream dermatological care.

7.1 Variability in phytochemical composition

The concentration of bioactive compounds in herbal extracts is highly dependent on factors such as plant species, geographic origin, cultivation methods, harvesting time, and extraction techniques. Such variability results in inconsistent efficacy and batch-to-batch differences in finished products[49].

7.2 Lack of standardization

Most herbal gels lack standardized markers or validated quality-control protocols to ensure reproducible phytochemical content. Unlike synthetic drugs, which undergo stringent dose calibration, many herbal formulations are marketed with limited characterization of their active fractions, undermining clinical reliability[50].

7.3 Limited large-scale clinical data

Although small clinical trials support the efficacy of herbal actives such as tea tree oil, licorice, and onion extract, there is a paucity of robust, multicentric, randomized controlled trials (RCTs). This limits the ability to establish definitive therapeutic equivalence with conventional agents, hindering widespread clinical adoption[50].

7.4 Regulatory hurdles

Herbal gels often occupy a gray zone between cosmetics, cosmeceuticals, and pharmaceuticals. Differing regulatory frameworks across countries complicate approval, labeling, and marketing. For example, in the U.S., botanical gels may be regulated as cosmetics unless therapeutic claims are made, whereas in the EU and India they may fall under drug or ayurvedic categories. Such regulatory ambiguity limits standard clinical pathways and global commercialization[51].

8. FUTURE DIRECTIONS

The development of multifunctional herbal gels presents a promising frontier in dermatology, but systematic research and innovation are essential to ensure clinical reliability and global acceptance.

8.1 Standardization of herbal extracts

Establishing phytochemical markers and validated analytical methods (e.g., HPLC, LC-MS, DNA barcoding) will help overcome variability issues and ensure reproducible quality. Adoption of pharmacopeial standards for key herbal actives is critical for both regulatory approval and clinical confidence[52].

8.2 Advanced nanotechnological formulations

Emerging delivery platforms such as nanogels, nano emulsions, solid lipid nanoparticles, and liposomal gels can significantly improve solubility, stability, and skin penetration of poorly bioavailable phytochemicals (e.g., curcumin, catechins). These systems also allow controlled release, thereby enhancing therapeutic outcomes in acne, pigmentation, and UV protection[53].

8.3 Personalized skincare integration

With the rise of dermato-genomics and personalized medicine, multifunctional herbal gels could be tailored to an individual's skin microbiome, pigmentation profile, and inflammatory tendencies. Such customized formulations may enhance efficacy while

minimizing adverse effects, aligning with current consumer demand for precision skincare[53].

8.4 Need for multicentric clinical validation

Large-scale, randomized multicentric clinical trials (RCTs) remain the gold standard to validate herbal gel formulations. Collaborative research involving dermatologists, pharmacologists, and cosmetic scientists is necessary to establish therapeutic equivalence with conventional therapies and ensure broader adoption into evidence-based dermatology[54].

9. CONCLUSION

Multifunctional herbal gels represent a novel and holistic approach in dermatological care by addressing acne, scars, pigmentation, and UV-induced damage simultaneously. Unlike conventional therapies that often act on single pathways and carry risks such as irritation, photosensitivity, or resistance, herbal gels harness the synergistic actions of diverse phytochemicals to provide broad-spectrum benefits with an improved safety profile. The synergistic effects of herbs like tea tree oil, neem, turmeric, licorice, aloe vera, and Centella asiatica provide broad-spectrum antimicrobial, anti-inflammatory, antioxidant, skin-lightening, and photoprotective benefits. Clinical studies, though still emerging, indicate promising outcomes in lesion reduction, pigmentation control, scar remodeling, and patient satisfaction, with minimal adverse effects. However, for herbal gels to become mainstream therapeutic options, critical challenges must be addressed including the need for high-quality clinical trials, standardization of botanical actives, and advanced delivery systems to ensure efficacy and reproducibility. Their gel-based delivery system further enhances patient compliance by offering ease of application, cosmetic elegance, and sustained release of actives.

Growing consumer demand for natural, eco-friendly, and sustainable skin care solutions positions herbal gels as a viable alternative or adjunct to existing therapies. However, challenges remain in standardization, large-scale clinical validation, and regulatory harmonization. With advances in nanotechnology, personalized skincare, and phytochemical standardization, multifunctional herbal gels hold strong potential to transition from experimental formulations into mainstream, evidence-based dermatology, bridging traditional herbal wisdom with modern scientific validation.

ACKNOWLEDGEMENT

The authors sincerely acknowledge the management and the Principal of Marri Laxman Reddy Institute of Pharmacy, Telangana, India, for their constant encouragement and support in the successful completion of this review article.

FUNDING

This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to the content of this review.

REFERENCES:

1. Tan JKL, Bhate K. A global perspective on the epidemiology of acne. *Br J Dermatol.* 2015;172(S1):3-12.
2. Zaenglein AL. Acne vulgaris. *N Engl J Med.* 2018;379(14):1343-1352.
3. Dreno B et al. post-inflammatory hyperpigmentation. *J Eur Acad Dermatol Venereol.* 2016;30(5):760-772.
4. Magin P et al. The psychological impact of acne vulgaris. *Br J Dermatol.* 2006;154(3):678-684.
5. Gollnick HP. Current concepts of the pathogenesis of acne: implications for drug treatment. *Drugs.* 2003;63(15):1579-1596.
6. Taylor SC, Cook-Bolden F, Rahman Z, Strachan D. Acne vulgaris in skin of color. *J Am Acad Dermatol.* 2002;46(2): S98-S106.
7. Mukherjee PK et al. Indian herbal medicines in dermatology: present status and future perspectives. *J Ethnopharmacol.* 2016; 177:201-219.
8. Petrović GM et al. Natural products in acne vulgaris treatment. *Curr Med Chem.* 2018;25(22):2619-2643.
9. Sharma A et al. Herbal medicines for acne vulgaris: a review. *Pharmacogn Rev.* 2021;15(29):16-22.
10. Nayak BS et al. Herbal gels: Formulation and characterization. *J Young Pharm.* 2010;2(1):104-109.
11. Zaenglein AL, Pathy AL, Schlosser BJ, Alikhan A, Baldwin HE, Berson DS, et al. Guidelines of care for the management of acne vulgaris. *J Am Acad Dermatol*. 2016;74(5):945-73.
12. Mukherjee PK, Maity N, Nema NK, Sarkar BK. Phytocosmetics: An overview. *Clin Dermatol Rev*. 2019;3(1):41-9.
13. Saraf S, Saraf S. Herbal gels: A modern formulation approach in cosmeceuticals. *J Cosmet Dermatol*. 2020;19(12):3182-92.
14. Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay U. Biological activities and medicinal properties of neem (*Azadirachta indica*). *Curr Sci*. 2002;82(11):1336-45.
15. Bassett IB, Pannowitz DL, Barnetson RS. A comparative study of tea-tree oil versus benzoyl peroxide in the treatment of acne. *Med J Aust*. 1990;153(8):455-8.
16. Surjushe A, Vasani R, Saple DG. Aloe vera: A short review. *Indian J Dermatol*. 2008;53(4):163-6.
17. Hewlings SJ, Kalman DS. Curcumin: A review of its effects on human health. *Foods*. 2017;6(10):92.
18. Pastore MN, Kalia YN, Horstmann M, Roberts MS. Licorice (*Glycyrrhiza glabra*) in dermatology: Antimicrobial and anti-inflammatory properties. *Phytother Res*. 2015;29(12):1947-53.
19. Hashim P. Centella asiatica in food and beverage applications and its potential antioxidant and neuroprotective effect. *Int Food Res J*. 2011;18(4):1215-22.
20. Katiyar SK. Green tea prevents non-melanoma skin cancer by enhancing DNA repair. *Arch Biochem Biophys*. 2011;508(2):152-8.
21. Afaq F, Saleem M, Krueger CG, Reed JD, Mukhtar H. Anthocyanin- and hydrolyzable tannin-rich pomegranate fruit extract modulates MAPK and NF-κB

pathways and inhibits skin tumorigenesis in CD-1 mice. *Int J Cancer*. 2005;113(3):423-33.
22. Al-Ghamdi MS. The anti-inflammatory, analgesic and antipyretic activity of *Nigella sativa*. *J Ethnopharmacol*. 2001;76(1):45-8.
23. Krishnaveni M, Mirunalini S. Therapeutic potential of *Phyllanthus emblica* (amla): The ayurvedic wonder. *J Basic Clin Physiol Pharmacol*. 2010;21(1):93-105.
24. Gupta P, Vermani K, Garg S. Hydrogels: from controlled release to pH-responsive drug delivery. *Drug Discov Today*. 2002;7(10):569-79.
25. Peppas NA, Bures P, Leobandung W, Ichikawa H. Hydrogels in pharmaceutical formulations. *Eur J Pharm Biopharm*. 2000;50(1):27-46.
26. Boateng JS, Matthews KH, Stevens HNE, Eccleston GM. Wound healing dressings and drug delivery systems: a review. *J Pharm Sci*. 2008;97(8):2892-923.
27. Tonnesen HH, Masson M, Loftsson T. Studies of curcumin and cyclodextrins: solubility, chemical and photochemical stability. *Int J Pharm*. 2002;244(1-2):127-35.
28. Loftsson T, Duchêne D. Cyclodextrins and their pharmaceutical applications. *Int J Pharm*. 2007;329(1-2):1-11.
29. Benson HAE. Transdermal drug delivery: penetration enhancers. *Adv Drug Deliv Rev*. 2005;57(4):411-36.
30. Moghassemi S, Hadjizadeh A. Nanoemulsions: formulation, applications, and characterization. *Adv Colloid Interface Sci*. 2014;205:164-76.
31. Souto EB, Wissing SA, Barbosa CM, Müller RH. Development of lipid nanoparticles for dermal application: a review. *Drug Dev Ind Pharm*. 2004;30(9):885-99.
32. Honeywell-Nguyen PL, Bouwstra JA. Vesicles as a tool for transdermal and dermal delivery. *Drug Discov Today Technol*. 2005;2(1):67-74.
33. Enshaieh S, Jooya A, Siadat AH, Iraji F. The efficacy of 5% topical tea tree oil gel in mild to moderate acne vulgaris: a randomized clinical trial. *Indian J Dermatol Venereol Leprol*. 2007;73(1):22–5.
34. Sharma RA, Gescher AJ, Steward WP. Curcumin: the story so far. *Eur J Cancer*. 2005;41(13):1955–68.
35. Chithra P, Sajithlal GB, Chandrakasan G. Influence of Aloe vera on the healing of dermal wounds in diabetic rats. *J Ethnopharmacol*. 1998;59(3):195–201.
36. Afaq F, Malik A, Syed D, Maes D, Matsui MS, Mukhtar H. Pomegranate fruit extract modulates UV-B–mediated damage in human reconstituted skin. *J Invest Dermatol*. 2005;125(2):393–402.
37. Draelos ZD, Yaroshinsky A. The effect of an onion extract gel on the cosmetic appearance of postsurgical scars. *J Clin Aesthet Dermatol*. 2010;3(12):29–32.
38. Mukherjee PK, Maity N, Nema NK, Sarkar BK. Bioactive compounds from natural resources against skin aging. *Phytomedicine*. 2011;19(1):64–73.
39. Kligman AM, Thorne EG. Acne therapy with topical retinoids: patient acceptability and compliance. *J Am Acad Dermatol*. 1996;34(5 Pt 2):S60–2.
40. Dureja H, Kaushik D, Gupta M, Kumar V, Lather V. Cosmeceuticals: an emerging concept. *Indian J Pharmacol*. 2005;37(3):155–9.

41. Grand View Research. Herbal Skincare Products Market Size, Share & Trends Analysis Report, 2022–2030. Grand View Research; 2022.
42. Hausen BM. Tea tree oil: contact allergy and chemical composition. *Contact Dermatitis*. 1999;41(1):3-6.
43. Basketter DA, et al. Predictive tests for skin sensitization: current status and future prospects. *Toxicol In Vitro*. 2012;26(5):1170-1176.
44. Kligman AM, et al. Safety and benefits of herbal cosmeceuticals in dermatology. *Clin Dermatol*. 2009;27(5):479-486.
45. Mukherjee PK, et al. Regulatory aspects of herbal products: worldwide review. *Phytother Res*. 2019;33(12):3064-3080.
46. Zaenglein AL, Pathy AL, Schlosser BJ, et al. Guidelines of care for the management of acne vulgaris. *J Am Acad Dermatol*. 2016;74(5):945-973.e33.
47. Bandyopadhyay D. Topical hydroquinone as a depigmenting agent: the risks of ochronosis. *J Eur Acad Dermatol Venereol*. 2009;23(5):605-608.
48. Narayanan DL, Saladi RN, Fox JL. Ultraviolet radiation and skin cancer. *Int J Dermatol*. 2010;49(9):978-986.
49. Ekor M. The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. *Front Pharmacol*. 2014;4:177.
50. Mukherjee PK, Bahadur S, Harwansh RK, et al. Development of Ayurveda–tradition to trend. *J Ethnopharmacol*. 2017;197:10-24.
51. Izzo AA, Hoon-Kim S, Radhakrishnan R, Williamson EM. A critical approach to evaluating clinical efficacy, adverse events and drug interactions of herbal remedies. *Phytother Res*. 2016;30(5):691-700.
52. Mukherjee PK, Banerjee S, Kar A, Chanda J, et al. Phytochemical standardization and quality control of herbal medicine. *Drug Discov Today*. 2018;23(6):1170–81.
53. Sharma N, Bansal M, Visht S, Sharma PK, Kulkarni GT. Nanotechnology: a promising approach for delivery of herbal bioactives. *J Drug Deliv Ther*. 2013;3(3):91–6.
54. Posadzki P, Watson LK, Ernst E. Controversy and debate: are randomized controlled trials the best way to assess herbal medicines? *J Clin Epidemiol*. 2013;66(6):575–7.