

## POLYHERBAL EMULGEL AS A TOPICAL STRATEGY FOR ACNE MANAGEMENT: A COMPREHENSIVE REVIEW

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Article Received on 15 April 2026,  
Article Revised on 05 May 2026,  
Article Published on 16 May 2026,

<https://doi.org/10.5281/zenodo.20200601>

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**How to cite this Article:** \*<sup>1</sup>Yadav Mamta Ramkisun, <sup>2</sup>Dr. Jay Narayan Mishra, <sup>3</sup>Dr. Dhaneshwar Kumar Vishwakarma. (2026). Polyherbal Emulgel As A Topical Strategy For Acne Management: A Comprehensive Review. World Journal of Pharmaceutical Research, 15(9), 306-317.

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### ABSTRACT

Acne vulgaris is a common inflammatory skin disorder associated with excessive sebum production, microbial colonization, and follicular blockage. Conventional treatments often cause side effects, such as skin irritation and antimicrobial resistance, necessitating safer alternatives. Polyherbal formulations have gained attention due to their synergistic antimicrobial, anti-inflammatory, and antioxidant properties. Emulgel systems, which combine the advantages of emulsions and gels, provide improved stability, enhanced skin penetration, and better patient compliance for topical delivery. Polyherbal emulgels enable the simultaneous delivery of multiple bioactive compounds, targeting various factors involved in acne pathogenesis. This review summarizes formulation strategies, key evaluation parameters, and the

therapeutic potential of polyherbal emulgel systems as an effective topical approach for acne management.

**KEYWORDS:** Polyherbal emulgel, acne management, topical delivery, herbal formulation, antimicrobial, anti-inflammatory.

### 1. INTRODUCTION

Acne vulgaris is one of the most prevalent dermatological disorders, affecting adolescents and adults worldwide. It is a chronic inflammatory condition of the pilosebaceous unit

characterized by excessive sebum production, follicular hyperkeratinization, microbial proliferation, and inflammation.<sup>[1]</sup> The primary microorganism associated with the development of acne is *Cutibacterium acnes*, which contributes to inflammation and lesion formation. Clinically, acne presents as comedones, papules, pustules, and nodules, and, in severe cases, may lead to permanent scarring and psychological distress.<sup>[2]</sup>

Conventional treatments for acne include topical and systemic antibiotics, retinoids, benzoyl peroxide, and hormonal therapies. Although these treatments are widely used, their long-term use may cause adverse effects, including skin irritation, dryness, photosensitivity, and the development of antimicrobial resistance. These limitations have encouraged researchers to explore alternative therapeutic approaches that are safer, effective, and suitable for long-term use.<sup>[3]</sup>

Herbal and polyherbal formulations have gained considerable attention in dermatological therapy due to their natural origin, biocompatibility, and diverse pharmacological properties. Many herbal bioactive compounds possess antimicrobial, anti-inflammatory, antioxidant, and wound-healing activities, which are beneficial in managing acne. Polyherbal systems, in particular, offer synergistic therapeutic effects by combining multiple plant-derived constituents that can target different stages of acne pathogenesis.<sup>[4-6]</sup>

Among various topical delivery systems, emulgels have emerged as a promising platform for dermatological applications. Emulgels combine the advantages of both emulsions and gels, resulting in improved drug stability, enhanced skin penetration, better spreadability, and patient acceptability. This system is especially useful for incorporating hydrophobic herbal extracts into a stable and easily applicable topical formulation.<sup>[7-9]</sup>

This review focuses on the role of polyherbal emulgel systems as a topical strategy for acne management. It discusses the pathophysiology of acne, the advantages of herbal formulations, the formulation principles of emulgels, and their therapeutic potential in dermatological applications.

## 2. Pathophysiology of Acne Vulgaris

Acne vulgaris is a multifactorial inflammatory disorder of the pilosebaceous unit involving complex interactions between hormonal, microbial, immunological, and environmental

factors.<sup>[10]</sup> The development of acne lesions is generally described through four major interconnected pathogenic mechanisms.

### 2.1 Sebum Overproduction

Sebum production is primarily regulated by androgenic hormones, particularly dihydrotestosterone (DHT), which stimulates sebaceous gland hypertrophy and lipid synthesis.<sup>[11]</sup> Increased sebum secretion creates an anaerobic and lipid-rich microenvironment favorable for the proliferation of *Cutibacterium acnes*. Excessive sebum also contributes to follicular obstruction and comedone formation. Recent studies suggest that alterations in sebum composition, including increased squalene oxidation, may further enhance inflammatory responses.<sup>[12]</sup>

### 2.2 Follicular Hyperkeratinization

Abnormal desquamation of keratinocytes within the follicular epithelium leads to hyperkeratinization and blockage of hair follicles. This process results in the formation of microcomedones, which represent the earliest detectable acne lesions.<sup>[13]</sup> The accumulation of corneocytes combined with sebum retention forms closed (whiteheads) or open comedones (blackheads). Dysregulation of keratinocyte proliferation is influenced by inflammatory mediators and oxidative stress.

### 2.3 Microbial Colonization

*Cutibacterium acnes*, a Gram-positive anaerobic bacterium, plays a central role in acne pathogenesis. It colonizes blocked follicles and metabolizes triglycerides in sebum into free fatty acids, which promote inflammation.<sup>[14]</sup> *C. acnes* activates toll-like receptors (TLR-2) on keratinocytes and immune cells, triggering the release of pro-inflammatory cytokines such as IL-1 $\beta$ , IL-6, IL-8, and TNF- $\alpha$ .<sup>[15]</sup> Emerging evidence also indicates that certain virulent strains of *C. acnes* are more closely associated with inflammatory acne lesions.

### 2.4 Inflammatory Cascade and Immune Response

Inflammation is a key driver of acne lesion progression. Activation of innate immune pathways results in neutrophil recruitment and increased production of reactive oxygen species (ROS), further damaging follicular walls.<sup>[16]</sup> The rupture of inflamed follicles releases keratin, bacteria, and lipids into the dermis, intensifying the inflammatory response. Nuclear factor-kappa B (NF- $\kappa$ B) signaling and inflammasome activation are critical molecular mechanisms involved in this process.<sup>[17]</sup>

Recent research also highlights the role of the skin microbiome imbalance and oxidative stress in sustaining chronic inflammation and lesion persistence.<sup>[18]</sup>

### 3. Role of Herbal Medicine in Acne Management

The growing concerns regarding antibiotic resistance, adverse drug reactions, and long-term safety of synthetic anti-acne therapies have accelerated interest in plant-based alternatives.<sup>[19]</sup> Herbal medicines offer a multi-targeted therapeutic approach due to the presence of diverse bioactive phytoconstituents capable of modulating various pathogenic pathways involved in acne.

#### 3.1 Antimicrobial Activity

One of the primary therapeutic goals in acne management is the inhibition of *Cutibacterium acnes*. Numerous medicinal plants contain flavonoids, tannins, alkaloids, terpenoids, and essential oils with demonstrated antibacterial activity against Gram-positive bacteria.<sup>[20]</sup> These phytochemicals disrupt bacterial cell walls, inhibit protein synthesis, and interfere with microbial enzyme systems. Unlike synthetic antibiotics, plant-derived antimicrobials exhibit a lower tendency to induce resistance due to their complex chemical composition and multi-site mechanisms of action.<sup>[21]</sup>

#### 3.2 Anti-Inflammatory Mechanisms

Inflammation plays a central role in acne lesion development. Herbal compounds such as quercetin, curcumin, and sesquiterpene lactones inhibit key inflammatory mediators including NF- $\kappa$ B, COX-2, and pro-inflammatory cytokines (IL-1 $\beta$ , IL-6, TNF- $\alpha$ ).<sup>[22]</sup> By modulating these molecular pathways, plant extracts reduce erythema, swelling, and lesion progression. Many herbal agents also stabilize mast cells and reduce oxidative stress-induced inflammatory signaling.

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### 3.4 Antioxidant Potential

Oxidative stress contributes significantly to acne pathogenesis through lipid peroxidation of sebum and activation of inflammatory cascades. Polyphenols and flavonoids present in medicinal plants act as free radical scavengers, protecting skin cells from oxidative damage.<sup>[23]</sup> The antioxidant activity of herbal extracts helps in reducing post-inflammatory hyperpigmentation and improving skin healing.

### 3.5 Sebum Regulation and Keratinization Control

Certain plant extracts exhibit sebostatic properties by regulating androgen-mediated lipid synthesis in sebaceous glands. Additionally, herbal compounds may normalize keratinocyte differentiation, thereby preventing follicular blockage.<sup>[24]</sup> This dual action supports their potential role in preventing both non-inflammatory and inflammatory acne lesions.

### 3.6 Advantages of Polyherbal Formulations

Polyherbal therapy is based on the principle of synergism, where multiple plant extracts work together to enhance therapeutic efficacy.<sup>[25]</sup> The advantages include:

- Multi-targeted mechanism
- Reduced individual extract concentration
- Lower toxicity
- Improved overall efficacy
- Enhanced stability when formulated appropriately

Such synergistic combinations are particularly suitable for acne, a disease with multifactorial pathogenesis.

## 4. Emulgel as a Novel Topical Drug Delivery System

Emulgels are advanced topical drug delivery systems that combine the properties of both emulsions and gels to enhance the delivery of active compounds through the skin. Many herbal bioactive compounds used in dermatological therapy are hydrophobic in nature and exhibit limited solubility in aqueous gel systems. Incorporating these compounds into an emulsion and subsequently converting the system into a gel improves drug solubility, stability, and skin penetration. As a result, emulgels provide an effective platform for delivering lipophilic phytoconstituents in topical formulations.<sup>[26]</sup>

In an emulgel system, the emulsion (oil-in-water or water-in-oil) is incorporated into a gel base using suitable gelling agents such as carbopol or other polymers. This structure allows the formulation to exhibit desirable properties including good spreadability, enhanced viscosity, improved stability, and controlled drug release. The gel matrix also improves patient compliance due to its non-greasy texture and ease of application.<sup>[27]</sup>

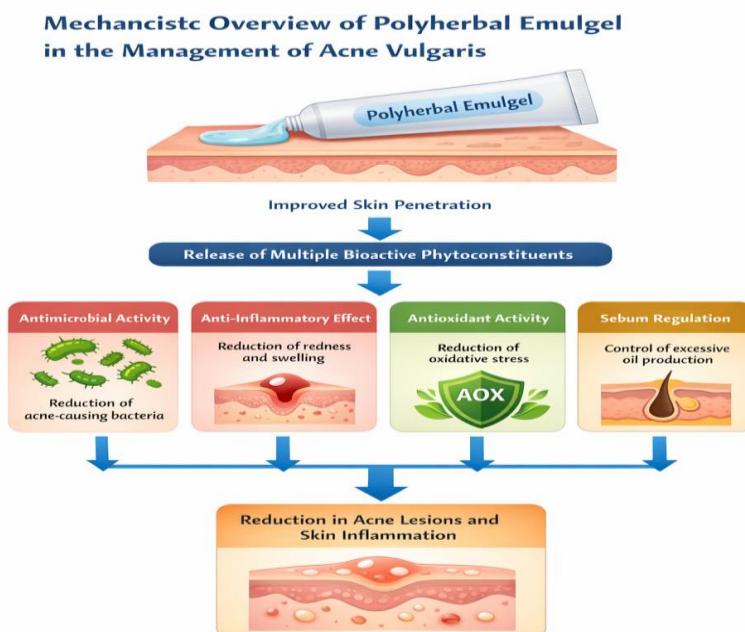
In the context of acne management, emulgels offer several therapeutic advantages. They enable better penetration of bioactive compounds into the pilosebaceous units, where acne lesions primarily develop. Additionally, the dual system helps maintain prolonged contact with the skin surface, allowing sustained release of active constituents. Because of these benefits, emulgels have gained increasing attention as a promising platform for the topical delivery of herbal and polyherbal formulations in dermatological therapy.<sup>[28]</sup>

### **5. Advantages of Polyherbal Emulgel in Acne Therapy**

Polyherbal emulgels have emerged as an effective approach for topical acne management due to their ability to deliver multiple bioactive compounds simultaneously. The combination of several herbal constituents can produce synergistic therapeutic effects, targeting different stages of acne pathogenesis, including microbial growth, inflammation, oxidative stress, and excess sebum production. This multi-targeted mechanism makes polyherbal formulations particularly suitable for complex skin disorders like acne.<sup>[29]</sup>

Another major advantage of polyherbal emulgels is their improved safety profile compared with synthetic medications. Herbal bioactive compounds generally exhibit lower toxicity and reduced adverse effects when used in topical formulations. The emulgel base further enhances the formulation's acceptability by providing a smooth, non-greasy texture that spreads easily on the skin.<sup>[30]</sup>

In addition, emulgels improve the stability and bioavailability of herbal constituents that may otherwise degrade rapidly or exhibit poor solubility. The emulsion phase allows incorporation of lipophilic phytochemicals, while the gel matrix provides viscosity and controlled release. These features contribute to prolonged therapeutic action and improved efficacy. Consequently, polyherbal emulgels represent a promising strategy for developing safer and more effective topical treatments for acne management.<sup>[31]</sup> The therapeutic mechanisms of polyherbal emulgel in acne management are illustrated in Figure 1.



**Figure 1:** Schematic illustration showing the mechanism of action of polyherbal emulgel in acne management, including antimicrobial, anti-inflammatory, antioxidant, and sebum-regulating effects leading to reduction of acne lesions.

## 6. Formulation Components of Polyherbal Emulgel

Formulating a polyherbal emulgel requires careful selection of components to ensure stability, efficacy, and desirable physicochemical properties. Typically, an emulgel formulation consists of an oil phase, aqueous phase, emulsifying agents, gelling agents, preservatives, and sometimes penetration enhancers.<sup>[32]</sup>

The oil phase generally contains lipophilic components that help dissolve hydrophobic herbal extracts and enhance skin penetration. Oils also contribute to the formation of a stable emulsion system. The aqueous phase contains water-soluble components and serves as the continuous phase in oil-in-water emulsions commonly used for topical preparations.<sup>[33]</sup>

Emulsifying agents play a crucial role in stabilizing the emulsion by reducing interfacial tension between the oil and water phases. These agents ensure uniform dispersion of droplets and prevent phase separation. Gelling agents, such as carbopol or natural polymers, are added to convert the emulsion into a gel system. They increase viscosity, improve spreadability, and enhance the overall stability of the formulation.<sup>[34]</sup>

Additionally, preservatives are incorporated to prevent microbial contamination during storage, while penetration enhancers may be used to facilitate the diffusion of active constituents through the skin barrier. Proper optimization of these formulation components is essential to obtain a stable and effective polyherbal emulgel suitable for topical acne therapy.<sup>[35]</sup>

## 7. Recent Advances and Future Perspectives

In recent years, significant advancements have been made in the development of herbal-based topical delivery systems for dermatological applications. Polyherbal emulgels have attracted increasing research interest due to their ability to combine traditional herbal medicine with modern pharmaceutical technology. Several studies have reported improved antimicrobial, anti-inflammatory, and antioxidant activities in polyherbal formulations designed for acne treatment.<sup>[36]</sup>

Recent innovations include the incorporation of nano-sized herbal extracts, advanced emulsifying systems, and natural polymer-based gel matrices to enhance drug penetration and stability. These technological developments have improved the therapeutic efficiency of herbal topical formulations while maintaining safety and patient compliance.<sup>[37]</sup>

Despite promising outcomes from experimental studies, further research is required to standardize herbal extracts, optimize formulation parameters, and conduct large-scale clinical evaluations.<sup>[38]</sup> Future investigations may also focus on the integration of nanotechnology and targeted delivery systems to further enhance the effectiveness of polyherbal emulgels. With continued scientific validation, these formulations have the potential to become reliable alternatives to conventional acne therapies.<sup>[39-40]</sup> The table summarizes representative studies reporting the development and evaluation of herbal or polyherbal emulgel formulations for topical acne therapy.

**Table 1: Summary of Recent Studies on Herbal and Polyherbal Emulgel Formulations for Acne Management.**

Study	Type of Formulation	Key Therapeutic Properties	Major Findings	References
Study 1	Herbal Emulgel	Antimicrobial, Anti-inflammatory	Showed significant inhibition of acne-causing bacteria and improved skin compatibility	[41]
Study 2	Polyherbal Emulgel	Antioxidant, Anti-inflammatory	Demonstrated improved spreadability, viscosity, and	[42]

			enhanced antimicrobial activity	
Study 3	Herbal Emulgel	Antibacterial	Formulation exhibited effective inhibition against acne-associated microorganisms and good stability	[43]
Study 4	Polyherbal Emulgel	Antimicrobial, Sebum-regulating	Showed improved drug release profile and enhanced topical therapeutic efficacy	[44]
Study 5	Herbal Emulgel	Anti-inflammatory, Antioxidant	Reported good skin penetration and controlled drug release characteristics	[45]

## 8. CONCLUSION

Polyherbal emulgels represent a promising topical delivery system for the management of acne vulgaris. By combining multiple herbal bioactive compounds within an emulsion-gel matrix, these formulations provide synergistic therapeutic effects targeting various factors involved in acne pathogenesis, including microbial proliferation, inflammation, and oxidative stress. The emulgel system further enhances drug stability, skin penetration, and patient acceptability due to its non-greasy texture and ease of application.

Compared with conventional synthetic treatments, polyherbal emulgels offer a safer and potentially more effective alternative with reduced risk of adverse effects and antimicrobial resistance. However, further research is required to standardize herbal ingredients, optimize formulation techniques, and validate clinical efficacy through well-designed studies. Overall, polyherbal emulgels hold significant potential as innovative topical formulations for improved acne management.

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