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Review Paper

Herbal and Natural Remedies for Acne: A Comprehensive Review

Sandhya Kumari*, Dr. Shashank Tiwari

Department of Pharmaceutics, Lucknow Model College of Pharmacy, Lucknow

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ABSTRACT

Acne vulgaris is a common skin disease that affects millions of people around the world, and it features inflammation, bacterial growth, and the increase in sebum secretion. Although traditional synthetics are effective, the issues of antibiotic resistance, side effects and patient choice have led to renewed interest in herbal and natural alternatives. The present review compiles previous literature related to the potential of herbal bio-active molecules in acne treatment emphasizing on well-studied botanicals namely: tea tree oil (Melaleuca alternifolia), aloe vera (Aloe barbadensis), neem (Azadirachta indica), turmeric(Curcuma longa), green tea (Camellia sinensis) and other efficacious natural agents. The modes of action, the clinical efficacy, the safety profiles and comparative effectiveness with standard treatments of different NSAIDs are discussed deeply. Literature data from a variety of clinical trials and systematic reviews of the past decade indicate that herbal medicines have considerable antibacterial, anti-inflammatory, sebostatic effects and can treat mild to moderate acne without serious side effects. This article is an attempt to bridge the gap by incorporating evidence-based, herbal therapeutics into modern acne management.

INTRODUCTION

Background and Epidemiology

Acne vulgaris is one of the most common chronic inflammatory dermatological diseases, with a worldwide prevalence of 85% in adolescents and young adults[1]. Its pathogenesis is multifactorial and includes hormonal disturbance, increased sebum production, follicular hyperkeratinization, infiltration with Propionibacterium acnes (recently renamed Cutibacterium acnes), and immune reaction[2]. Acne has psychological effects beyond the physical appearance, self-esteem and the quality of life is more negatively affected in young people [3].

***Corresponding Author:** Sandhya Kumari
Address: *Department of Pharmaceutics, Lucknow Model College of Pharmacy, Lucknow*
Email : shashank6889@gmail.com

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Limitations of Conventional Therapies

Standard of care is currently topical retinoids, benzoyl peroxide, salicylic acid with systemic antibiotics for moderate to severe[4]. Although these treatments have shown clinical benefits, some drawbacks have appeared. Long-term antibiotic use promotes bacteria becoming more resistant and treatment less effective[5]. Adverse effects include skin dryness, irritation, photosensitivity, as well as teratogenicity and systemic toxicity in the case of isotretinoin[6]. These worries have led to the search of alternative therapy either among patients and physicians.

Rationale for Herbal Remedies

Herbs as a potential treatment for acne represents an appealing adjunct or alternative to conventional care. Phytochemicals like polyphenols, flavonoids, terpenoids and alkaloids found in the medicinal plants exhibit antibacterial, anti-inflammatory and antioxidant activities[7]. These ingredients act on several pathophysiological mechanisms of acne. In addition, herbal medicines are generally safe for human consumption and have fewer adverse effects relative to synthetic drugs[8]. Recent systematic reviews have demonstrated medicinal plants and phytochemicals have the potentials in treatment of mild to moderate acne vulgaris[9].

Objectives

This review aims to:

- Analyze the action modes of lead herbal bioactive in treating acne
- Assess clinical studies validating the effectiveness of leading herbal therapies
- Comparing the herbs effect and safety with the standard treatment
- Determine future research and clinical applications.

Pathophysiology of Acne Vulgaris

To evaluate therapeutic approaches, it is necessary to understand the pathogenesis of acne, which has multiple components. There are four main drivers that lead to acne:

- **Hyper-seborrhea:** androgens induce activity of the sebaceous glands, with subsequent overproduction of sebum.
- **Follicular hyperkeratinization:** Disordered desquamation of keratinocytes leads to follicular occlusion and formation of microcomedones
- **Bacterial colonisation:** Cutibacterium acnes grows in the follicles and produces proinflammatory mediators
- **Inflammation:** Innate immune system and adaptive immune system that release inflammatory cytokines which lead to papules, pustules, nodules

Therefore, successful acne therapies should be targeted at one or more of these pathogenic mechanisms[10].

Major Herbal Remedies for Acne Treatment

Tea Tree Oil (*Melaleuca alternifolia*)

Phytochemistry and Mechanisms

Tea tree oil made from the leaves of Melaleuca alternifolia is one of the most well-known natural acne treatments. The main constituents of the essential oil are terpinen-4-ol, -terpinene and -terpinene known to contribute for a strong antimicrobial and anti-inflammatory activity[11] When postulated their mechanism of action in one study wherein they reduced ROS production by inhibiting NADPH oxidase.

The mechanisms of action include:

- Antimicrobial effect: Tea tree oil is strongly bactericidal against C. acnes owing to the disruption of bacterial cell membranes and interference with their metabolism[12]
- Anti-inflammatory: Inhibits production of pro-inflammatory cytokines (TNF- and IL-1)[13]
- Sebum control: Reduces the amount of excessive oil on skin without over-drying it[14]

Clinical Evidence

Several clinical trials have proved the effectiveness of tea tree oil in acne therapy. There was a landmark 45-day randomized, double-blind study that studied 5% tea tree oil gel versus placebo among patients with mild to moderate acne[15]. Results Tea tree oil was significantly more effective than placebo in reducing the number of acne lesions and had a significant effect on mild-to-moderate acne severity. Although the onset of action of tea tree oil was slower than benzoyl peroxide in some similar studies, it resulted in less adverse effects (dryness, stinging and erythema).[16]

A tea tree oil product review provided clear evidence that topical application decreases the number of acne lesions in individuals with mild-to-moderate acne and supports its efficacy[17]. Tea tree oil is still being shown as effective in recent studies in 2023 and 2025, especially for people who like natural treatments or have sensitive skin [18] [19].

Safety and Application

Tea tree oil is fairly well tolerated in an appropriately diluted form (mostly 5-10%). Can cause contact dermatitis if applied undiluted. The mild but effective character of the oil allows its use as a daily or weekly treatment[20].

Aloe Vera (*Aloe barbadensis*)

Phytochemistry and Mechanisms

Aloe vera gel has been reported to have 75 potentially active constituents including vitamins, minerals, enzymes, amino acids, polysaccharides and salicylic acid[21]. Its therapeutic actions in the treatment of acne are:

- **Antibacterial:** Suppresses growth of P. acnes and other skin pathogens
- **Anti-inflammation:** polsaccharides and glycoproteins could suppress the inflammation, and help desquamate wound.
- **Wound healing:** Promotes tissue regeneration and mitigates post-acne scarring
- **Moisturizing properties:** Helps hydrate the skin without added oil, as listed as a natural humectant

Clinical Evidence

A study on non-drug treatment of acne by aloe vera gel and acoustic therapy was conducted in patients of acne[22]. The combination reduced experimental acne lesions remarkably, in comparison with control groups, and provided the scientific evidence for this strategy. The trial showed that aloe vera gel was successful in decreasing inflammatory and non-inflammatory lesions as well as improving the texture of skin.

In a randomized, controlled study, the topical formulation of an aloe vera-based gel containing propolis and tea tree oil was superior to that of erythromycin in decreasing the severity of acne after 30 days[23]. Another 4-week double-blind, placebo-controlled trial of 53 patients demonstrated that the oral and topical application

of an herbal formulation composed of aloe vera, neem, turmeric, and such other botanicals reduced acne symptoms significantly[24].

Clinical Applications

Aloe vera is an often used emollient in acne treatment; this ingredient helps moisturize and add hydration to the skin which can mitigate drying effects of other topicals. It can be used directly from fresh plant leaves or as gels of commercial preparations. It is also mild enough for sensitive skin[25].

Neem (*Azadirachta indica*)

Phytochemistry and Mechanisms

Neem is the backbone of Ayurveda for skin problems. The plant is endowed with several bioactive agents such as nimbin, nimbidin, azadirachtin and quercetin[26].

Key mechanisms include:

- Powerful antibacterial powers: Effective against C. acnes and other skin bacteria
- Antifungal value: to Prevents subsequent fungal infections
- Anti-inflammatory: Helps visibly reduce redness and swelling which is often associated with inflammatory acne
- Sebum control : Balances excessive sebum production

Clinical Evidence

Neem's potent antibacterial properties against C. acnes have been reported in many studies. In a comparative clinical study, a formulation consisting of neem, tea tree oil and aloe vera gel was reported to be as effective as benzoyl peroxide treatment with no associated side effects (dryness or peeling) [27]. Antimicrobial assay revealed high inhibition zones against acne bacteria[28].

Good patient compliance with neem based herbal anti-acne compositions has been reported from the research till date on account of soothness and non-oily nature, as well as absence of any significant adverse reactions in skin irritancy studies[29].

Turmeric (*Curcuma longa*) and Curcumin

Phytochemistry and Mechanisms

Turmeric, which is known for its antiinflammatory effects, contains curcumin as a major bioactive compound. Curcumin accounts for 2-8% of the dry weight of turmeric rhizome[30]. The modes of action that are pertinent for acne therapy are:

- **Anti-inflammatory action:** Curcumin suppresses the proliferation of inflammatory cells, and decreases enzymes and protein kinases involved in inflammation[31]
- **Antimicrobial:** It shows antibacterial effects on C. acnes, being from 20-36 times more potent bace to od than azelaic acid against acne bacteria[32]
- **Antioxidant:** Neutralises free radicals, which cause damage to skin and aid in inflammation
- **Sebum control:** Aids in diminishing overactive oil secretion, which is a common cause of whiteheads and acne.

Clinical Evidence

A study in 2013 indicated that curcumin with lauric acid possessed enhanced antibacterial properties against P. acnes[33]. The early research that we have supports the human anti-infiammatory action of curcumin, but large clinical studies restrictive to acne are few and far between[32].

Another quasi-experimental study from 2025, Investigated oral curcumin plus serratiopeptidase formulation in addition to the standard inflammatory acne therapy[35].

Results: There was a marked acceleration in the resolution of inflammatory acne lesions after only 2 weeks and the novel clindamycin phosphate product was well-tolerated. The therapy hits a number of inflammatory pathways, which is possible could help lessen the need for extended antibiotic or immunosuppression treatment.

Facial u se of turmeric has a long history in Ayurvedic medicine that supports claims that it can reduce facial inflammation, combat acne and lighten the skin[36]. Mixed along with tea tree oil, turmeric forms a rather complementary soothing regime for sensitive skin[37].

Green Tea (*Camellia sinensis*)

Phytochemistry and Mechanisms

Green tea is a powerful source of polyphenols and in particular, epigallocatechin-3-gallate (EGCG), which are responsible for its health-promoting effects[38]. Mechanisms in acne treatment include:

- **Antibacterial:** Polyphenols attack bacteriumol membranes and control the growth of C. acnes
- **Seborrhea control:** Topical application of green tea polyphenols has been shown to control sebum excretion[39]
- **Exerting anti- inflammation effect:** Decrement in inflammatory factors and cytokines
- **Antioxidant shield:** Shields from free radical and oxidative damage to skin

Clinical Evidence

Studies have also proved that when green tea polyphenols are administered topically, instead of being used as a beverage, it effectively targets such conditions as acne and oily skin[40]. Two of the major beneficial effects for the management of acne are antimicrobial activity and regulation of sebum. Green tea extract[GTE] is included in several topical preparations which have shown to be effective in treatment of both inflammatory and non-inflammatory lesions[41].

Witch Hazel (*Hamamelis virginiana*)

Witch hazel bark extract is an old time remedy for a variety of skin conditions. It has tannins and volatile oils which have astringent, anti-inflammatory, antiseptic actions[42]. Tightens and tones: witch hazel removes excess oil but doesn't leave your skin dry, tight or shiny. It is also anti-bacterial, so it helps clear up and prevent acne, as well as anti-inflammatory (to relieve irritations) [43].

Witch hazel is also found in toners and cleansers for acne-prone skin. It cleanses away excess sebum and impurities without stripping the skin, making it good for combination to oily skin types[44].

Bee Propolis and Honey

Propolis, the resinous material for honey bees has shown very promising therapeutic potential for treating acne. Propolis extract have demonstrated in vitro anti-acne properties, including the activity against C. acnes[45]. High quality studies have suggested that preparations of propolis may decrease the number of acne lesions and skin inflammation compared to placebo in small trials[46].

The antibacterial and anti-inflammatory nature of propolis make it an excellent treatment for acne

while soothing irritated skin. Propolis has also been shown to enhance skin hydration and act as an environmental protectant as well[47]. Honey extract is also antioxidant-rich and has the added benefit of having antibacterial activity against acne-causing bacteria and being a natural humectant that helps hydrate skin[48].

Other Promising Herbal Remedies

Table 1: Additional herbal remedies with potential benefits for acne treatment

Herbal Remedy	Key Properties and Evidence
Rosemary (*Rosmarinus officinalis*)	Antimicrobial and anti-inflammatory properties; essential oil shows activity against *C. acnes*
Licorice (*Glycyrrhiza glabra*)	Anti-inflammatory and skin-brightening effects; helps reduce post-inflammatory hyperpigmentation
Burdock root (*Arctium lappa*)	Purported blood purifier; traditionally used for chronic skin conditions including acne
Red clover (*Trifolium pratense*)	Isoflavones may help balance hormones; traditional use for inflammatory skin conditions
Calendula (*Calendula officinalis*)	Wound healing and anti-inflammatory properties; promotes skin regeneration

Combination Herbal Therapies

Synergistic Formulations

Recent studies indicate that a combination of several herbs could have additive effects compared with a single drug treatment. In one trial of an Ayurvedic botanical syrup with plum, jujube, and other herbs there were decreases in all four primary outcomes; i.e. comedones, papules pustules and nodules after 12 weeks of therapy [49].

Clinical trials that compare the herbal blends to standard drugs have shown encouraging results. A randomized double-blind clinical trial demonstrated that a combination of neem with tea tree oil and aloe vera was as effective as benzoyl peroxide with fewer side-effects[50]. This result is that the PHGs which may act on multiple pathogenic mechanisms were formed multi-herbal treatments.

Topical and Systemic Integration

A multitarget treatment using herbal preparations both topically and orally would be the best way to achieve therapeutic success. The 4-week trial of 53 patients showed that combined topical and oral administration of herbal preparation was efficient compared with topical application only [51]. This implies that the systemic application of herbal bioactives may amplify local treatment effectiveness over several pathways, and is due to general anti-inflammatory effects along with influence on immune reaction.

Comparative Effectiveness: Herbal vs. Conventional Treatments

Efficacy Comparisons

Direct comparative studies provide valuable insights into relative effectiveness:

Table 2: Comparative clinical trials of herbal versus conventional acne treatments

Study	Comparison	Findings
Enshaieh et al.	5% tea tree oil vs. 5% benzoyl peroxide	Both significantly reduced lesions; tea tree oil slower but fewer side effects
Clinical RCT	Neem + tea tree + aloe vs. benzoyl peroxide	Comparable efficacy with fewer adverse effects (dryness, peeling)
Zhong et al.	Aloe vera + propolis + tea tree vs. erythromycin	Herbal combination more effective at reducing acne severity over 30 days

The results of these studies suggest that herbal formulas can be effective, safe alternatives to the traditional therapies for acne, especially for mild to moderate cases[52].

Safety Profile Comparison

An important advantage of natural remedies is their very favourable safety profile:

- Less side effects: Herbal preparations are usually associated with less dryness, irritation, and photosensitivity compared to retinoids and benzoyl peroxide[53]
- No antibiotic resistance: Unlike systemic antibiotics, herbal antimicrobials are non-contributory to bacteria resistance patterns[54]
- Minimal systemic toxicity: Topical herbal remedies do not get systemically absorbed and hence have no requisite for caution about systemic impact[55]
- Improved formula patient compliance: The good skin feel and calming effect make more adherent to the treatment schedule[56]
- Nevertheless, there is potential for contact dermatitis and allergic sensitization, especially of essential oils used in high concentration or not suitably diluted[57].

Mechanisms of Action: Molecular and Cellular Perspectives

Antibacterial Mechanisms

Herbal bioactives fight C. acnes in various ways:

- **Disruption of cellular membrane:** Tea tree oil as well as other essential oils, terpenoids in particular cause damage to the bacterial cell membrane resulting in leakage of cellular content
- **Metabolic antagonism:** Bacterial enzymes for metabolism and reproduction are blocked by polyphenols and flavonoids
- **Biofilm breakup:** Neem-like compounds prevent bacterial biofilms from forming, increasing penetration by treatments

Some of these multi-targeted methods are less prone to resistance development than those with one synthetic antibiotic mechanism[58].

Anti-inflammatory Pathways

The anti-inflammatory effects of herbal compounds involve several molecular pathways:

NF-κB pathway inhibition
→ Reduced pro-inflammatory cytokine production

Curcumin, EGCG, and other phytochemicals inhibit nuclear factor-kappa B (NF-κB) activation, thereby reducing production of inflammatory mediators including TNF-α, IL-1β, IL-6, and IL-8[59]. This cascade interruption diminishes the inflammatory component of acne pathogenesis.

Sebum Regulation

Sebaceous gland effects on green tea polyphenols and other herbal extracts include:

- Inhibition of Androgen receptor
- Inhibition of the 5-reductase menstruation and sex enzyme
- Endocrine effects on sebocyte differentiation and lipid synthesis

These effects are believed to lower sebum production, not as dramatically as traditional therapies, without the inevitable dryness[60].

Antioxidant Activity

Herbal antioxidants scavenge free radicals and protect skin cells against harmful reaction which otherwise leads to inflammation, irritation or burns. The antioxidant activity is measured by different methods resulting positive values, and many herbal extracts demonstrate the DPPH radical decreasing rate of 70-90%[61].

Clinical Application and Treatment Protocols

Topical Application Guidelines

To use herbal preparations in an effective and safe manner:

1. Test a sample: It is always wise trying to carry out a test trial before using the product in large scale.
2. Safe dilution: Depending on the oil or its quality, undiluted application poses a hazard of skin irritation Please refer to product details for proper dilution information
3. Application: Most herbal treatments are used 3 times a day for 6-12 weeks or longer
4. Sunscreen: Some herbal ingredients can cause more sun sensitivity; always apply sunscreen when using these products

Combination with Conventional Therapies

These can be combined with conventional treatments, which would allow a greater range of doses to be fed.

1. Aloe vera as a calming moisturizer that calms the dryness of retinoid or benzoyl peroxide
2. Use tea tree oil topically as a spot treatment while taking oral antibiotics
3. Use of green tea extracts in routine skin therapy along with topical agents

This combined method may improve the therapy effects while reducing side effects[62].

Oral Supplementation

Some herbal supplements may have heath benefits:

- Zinc: May have anti-inflammatory effects and support immune function; mixed evidence against topical treatments[63]
- Curcumin capsules: Orally administered curcumin in inflammatory acne with topical application of curcumin in addition to standard therapy has been supported by recent evidence[64]
- Brewer's yeast: A rich source of B vitamins and minerals – one study found wounds 60% healed at 5 months[65]

Patient Selection and Considerations

Herbal medicine is well-suited to treating:

- Patients with mild to moderate androgenic acne
- Those who seek a natural or complementary way
- Those suffering severe side effects from orthodox treatments
- Individuals with very reactive skin
- Systemic contraindication for drugs in adolescents

Nodulocystic acne generally warrants conventional medical management but may benefit from herbal adjuvants[66].

- **Limitations and Challenges**

Standardization Issues

One of the major problems encountered with herbal medications is their content variability:

- Content of the compounds depend on plant origin, cultivation conditions and methods of harvesting
- Total product composition can be influenced by extraction and preparation methods
- Absence of standardization makes it difficult to develop dose-response relationships and retrace treatments

Preparations are required with standardised extracts and a defined physicochemical composition to obtain reliably reproducible therapeutic effects[67].

Evidence Gaps

Although there is some promising evidence, the current evidence base has a number of limitations:

- Several of the studies included have small numbers and do not follow patients for long.
- Limited data on long-term safety and efficacy
- Mechanistic findings are usually in vitro or animal-based; clinical human validation is required
- The positive findings may be subject to publication bias
- Limited head-to-head comparisons prior to standardized protocols

These findings should be confirmed by large, rigorous RCTs to define definitive clinical guidelines [68].

Regulatory Considerations

Regulatory status of herbal products varies among regions:

- Quality Control and Purity Standards Differ
- Exposure to heavy metals, pesticides or adulterants can be hazardous
- You should be aware of drug-herb interactions, particularly with oral agents

Patients should use products from reliable manufacturers who have third-party testing and quality assurance[69].

Future Directions and Research Opportunities

Novel Bioactive Discovery

Future research should focus on:

1. Discovery of new anti-acne plant species and compounds
2. Describing mechanisms of action at molecular and genetic levels
3. Standardized bioavailable formulations are needed for increased efficacy
4. Discovery of synergistic active compounds in herbal formulae

Advanced Delivery Systems

Nanotechnology and the new delivery therapy can improve herbal medicine in an effective way for:

- Nanoparticle encapsulation for improved skin permeation and bioavailability
- Liposomal Long acting formulations
- Hydrogel patch es for localized therapy and enhanced patient compliance

Studies with salicylic acid and tea tree oil in hydrogel patches shows the potential of this approach[70].

Personalized Herbal Medicine

A holistic dermaceuticophyte approach of personalized herbal medicine, dietary guidelines and lifestyle advice may offer holistic options in prevention [71]. Future investigations could:

- Elucidate genetic or phenotypic parameters predictive for the response in different specific treatments with herbs.
- Create customized formulas for each person depending on his/her acne underpinnings.
- Combine traditional medicine understandings with new pharmacogenomic science

Sustainability and Ethical Sourcing

As the popularity of herbal remedies increases, sustainable ethical sourcing is essential:

- Applying sustainable growing and harvesting methods
- Conservation of threatened medicinal plant species
- Support community based and indigenous peoples and their traditional knowledge.
- Guaranteeing trade fairness and equitable sharing of benefits

Integration with Conventional Medicine

Future research Next steps might be to test for best integration:

- The development of evidence-based strategies for integrating herbal and mainstream health care
- Educating healthcare workers on principles and usage of herbal medicines
- Designing treatment policies for techniques including criteria of patient selection and monitoring
- Scrutinizing possible herb-drug interactions and contraindications

CONCLUSION

Herbal drugs and natural products are an ideal solution for the treatment of acne vulgaris. Vast literature shows that the bioactive constituents isolated from medicinal plants (e.g., tea tree oil, aloe vera, neem, turmeric and green tea) have remarkable antimicrobial, anti-inflammatory and antioxidant properties against major pathophysiological events in acne development. Clinical data have shown an equivalent efficacy of herbal treatment compared to traditional systemic therapies in mild-to-moderate acne with fewer adverse effects and better tolerance.

The multi-targeted modes of action antimicrobial efficacy against C. acnes, anti-inflammatory pathway modulation, sebum regulation and an antioxidant defence indicate that herbal modalities may serve as potential alternatives for therapies whether used alone or in combination with standard regimens. It has been reported that a combination of traditional Chinese medicines would give the advantages from their synergistic effects, which have more efficient mechanism than those of singular drugs due to their multi-targets.

However, important limitations remain. Standardization of herbal product preparations, large-scale, well-designed long-term trials for confirmation of the findings, extensive evaluation studies with focus on safety issues and established regulations are required to define definite clinical recommendations. Novel bioactive compounds discovery will need to be accompanied by advanced delivery technologies, the application of personalized medicine approaches and finding a way in which preparations sourcing is implemented sustainably.

With no end in sight to the development of effective approaches towards acne treatment, traditional medicine stands out as a viable alternative with its holistic and synergistic approach which can be attributed to herbal therapies. By blending evidence-based herbal therapeutics with allopathic medicine, practitioners can offer patients well-rounded

treatment plans tailored to improve therapeutic efficacy with minimal side effects. Herbal agents have now emerged as promising ingredients for the treatment of acne, with accumulating body of evidence that reinforces their position in modern dermatologist's armamentarium.

Future interdisciplinary cooperation among traditional practitioners of medicine, phytochemists, dermatologists and clinical researchers would be necessary to achieve the promise of herbal/natural medications in acne therapy as a result for better patient outcomes and improved patients' quality of life.

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