

From tradition to technology: Herbal remedies in modern acne therapy

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Abstract

Acne vulgaris, one of the most common chronic inflammatory skin diseases, affects approximately over 85% of teenagers and a large percentage of adults worldwide. Standard therapeutic options such as antibiotics, retinoids and hormonal treatment can be associated with side effects causing skin irritation, development of resistance to the antibiotic or systemic toxicity. In recent years, natural remedies have been extensively studied as safer and ecofriendly substitutes for acne treatment. Herbal medicines have certain pharmacological properties such as antimicrobial, anti-inflammatory, antioxidant, and sebum-controlling effects. In this article, the authors discuss acne pathogenesis, shortcomings of current treatments and medicinal plants that have traditionally been used or scientifically proven to treat acne. Special attention is focused on frequently employed herbal drugs, *Azedarach indica*, *Curcuma longa*, *Aloe vera*, *Camellia sinensis*, *Ocimum sanctum*, *Glycyrrhiza glabra* and *Hippophage rhomboids* (Sea Buckthorn). The phytochemical constituents, mechanisms of actions, formulation strategies and future directions of herbal antiacne agents are also discussed in the review.

Keywords: Acne Vulgaris; Herbal Medicine; Phytotherapy; Anti-Inflammatory; Antimicrobial; Natural Cosmetics; Medicinal Plants

1. Introduction

Acne vulgaris is a chronic inflammatory disease that involves the pilosebaceous unit and is one of the most pervasive dermal diseases globally. It is predominantly a disease of young adolescents and adults, but persistence of the condition into adulthood has been described more frequently. Epidemiological studies have described that almost 85–90% of people develop acne at least once in their life, rendering it a medical problem but also a psychosocial one. Acne is characterized by the presence of comedones, papules, pustules, nodules and, in its worst stages, cysts and permanent scars. It is frequently associated with emotional distress, low self-esteem, and compromised quality of life.

There are four key, interconnected factors in the pathogenesis of acne: increased sebum production, follicular hyperkeratinization, the bacterium *Cutibacterium acnes* (previously *Propionibacterium acnes*) and inflammation. These elements interact with each other in a complicated way, eliciting the immunity-related responses and oxidative stress, which exacerbate the disease. Classical therapeutic approaches mainly focus on the above pathways and, until recently can be local or systemic (retinoids, anti-biotics, benzoyl peroxide and hormones).

Although the established anti-acne treatments are effective, they commonly have some limitations ranging from skin irritation and erythema to dryness, photosensitivity, hormonal defect, and the emergence of antimicrobial resistance worldwide. The long-term usage of antibiotics, in particular, has been a serious concern due to the potential side effect of antimicrobial resistance and disruption of normal skin bacterial communities. Such limitations have led to the search for alternative and adjunct therapeutic options that are safer, ecofriendly, sustainable and long-term usage.

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Herbal medicine forms an essential part of traditional systems of healthcare among which include Ayurveda, Traditional Chinese Medicine (TCM), Unani, folk medicine and has been employed for the treatment of skin diseases since antiquity. Phytotherapeutic agents containing bioactive principles like flavonoids, alkaloids, terpenoids, phenolic acids and essential oils have antimicrobial, anti-inflammatory, antioxidant and wound healing properties. These combined pharmacological activities render them particularly attractive when targeting the multifactorial pathogenesis of acne.

Interest in herbal anti-acne products is currently on the rise due to developments in modern phytochemistry, pharmacology, and cosmetic formulation science. Various plant extracts such as Neem (*Azadirachta indica*), Turmeric (*Curcuma longa*), Aloe vera, green tea (*Camellia sinensis*) Tulsi (*Ocimum sanctum*) *Glycyrrhiza glabra*, Sea Buckthorn (*Hippophae rhamnoides*) have shown excellent potential against acne using in-vitro and clinical studies. These are known to be antimicrobial against acne bacteria, decrease inflammation pathways and increase skin healing.

In addition, increasing consumer demand for natural products and “clean-label” cosmetics has promoted the fermentation of herbal cosmeceuticals and dermaceuticals. The stability, bioavailability, and therapeutic potential of herbal active ingredients have been further improved by the modern pharmaceutical science by means of designing drug delivery systems (DDS) including gels, nanoemulsions, liposomes and phytosomes thereby bringing the traditional knowledge a step closer to reach its optimal potential.

It is in this backdrop that this review was conceptualized and aims to explore the contemporary role of herbal medicines in the management of acne vulgaris. It covers pathophysiology of acne, shortcoming in current treatment modalities and involvement of plant-based options while focusing on its phytoconstituents, mechanisms of action, formulation strategies and future avenues. Through fusing evidence based on traditional knowledge and scientific validation, the present review draws attention to significance of herbal therapeutics as a potential, comprehensive strategy in management of acne.

2. Pathophysiology of Acne

Acne vulgaris is a multifactorial inflammatory disease of the pilosebaceous unit, comprising hair follicle and accompanying sebaceous gland. The etiology of acne is multifactorial including hormonal, microbial, immunological and environmental factors. The four main pathogenic factors are: (i) sebum over production, (ii) follicular hyperkeratosis, (iii) colonization of the pilosebaceous unit by *Cutibacterium acnes* (formerly *Propionibacterium acnes*) and iv) inflammation. These pathways are interrelated and all together influence the onset and evolution of acne lesion.

2.1. Sebum Overproduction

The secretion of sebum is primarily under the control of androgens, in particular DHT, which also induces hypertrophy and hyperplasia of the sebaceous glands. Due to increased androgen levels in puberty, excessive amounts of sebum are secreted and a lipid-rich environment that is conducive for growth of microbes develops. Sebum not only provides nutrients to *C. acnes* but it is also oxidatively modified, resulting in pro-inflammatory lipid mediators which are involved in the pathogenesis of acne.

Recent studies indicate that changing lipid composition, particularly of squalene and free fatty acids, is central to comedogenesis as well as inflammation. Oxidized squalene is able to upregulate keratinocyte hyperproliferation and inflammatory cytokine release and enhance acne development.

2.2. Follicular Hyper keratinization

Follicular hyperkeratinisation and abnormal growth with desquamation of the follicular epithelium. This results in a blockage of the pilosebaceous duct, resulting in microcomedones, which are the earliest lesions of subclinical acne. As the keratinocytes pile up, they join forces with extra sebum to create open (what we typically refer to as blackheads) or closed comedones (known to us lay folk as whiteheads).

The disrupted keratins, elevated IL-1 α and abnormal lipid metabolism all significantly affect the keratinization. This obstruction leads to an anerobic environment where bacteria may cling and cause inflammation.

2.3. Colonization by Cuti bacterium acnes

Cutibacterium (Propionibacterium) acnes is a Gram-positive anaerobe that constitutes the normal skin flora. In disease state, excessive sebum and follicular occlusion predispose to overgrowth of *C. acnes*. A lipase synthesized by the bacterium breaks down triglycerides to free fatty acids, which irritate the follicular wall and lead to inflammation.

C. acnes also stimulate toll-like receptors (TLRs) on keratinocytes and immune cells to produce pro-inflammatory mediators, including IL-1 β , IL-8, and TNF- α . These mediators attract neutrophils and macrophages, leading to enhancement of the inflammatory response.

2.4. Inflammation and Immune Response

Inflammation is now considered an early and central pathway in acne pathogenesis rather than a secondary reaction. Innate immune system cascade, let by pattern recognition receptors, results in cytokines/chemoattractant secretion and oxidative stress with tissue damage.

Neutrophils, as well as keratinocytes secondarily produce the ROS and thereby contribute to inflammation and enhanced lipid peroxidation. Furthermore, the adaptive immune responses with participation of Th1 and Th17 cells also perpetuate chronic inflammation and lesion persistence. This cascade of inflammation leads to erythema, papules, pustules, nodules and scarring or in more severe cases.

2.5. Contribution of Hormonal and Genetic Factors

Girls have sexy hormone cycles, notably in puberty, during the menstrual cycle and as a result of pregnancy or endocrine diseases as polycystic ovarian syndrome (PCOS), often influence the arrival of acne. 4 Androgens are known to enhance sebaceous gland activity and keratinocyte proliferation.

Genetics also factor into play as polymorphisms in genes involved in androgen metabolism, immune response, and inflammation can exaggerate the tendency to develop acne. It has been demonstrated that family history has a high degree of correlation with the severity and duration of acne.

2.6. Relationship with Environmental and Lifestyle Factors

External causes like diet, stress, cosmetics and pollution can make acne worse. High glycemic load diet and dairy foods have been implicated, because these dietary factors increase insulin-like growth factor-1 (IGF-1) concentrations in serum which promote sebocyte activity and keratinocyte proliferation. The neuroendocrine pathway is affected by the psychological stress and this triggers sebum secretion along with an inflammatory reaction.

2.7. Implications for Herbal Therapeutics

Knowing the multi-factorial pathogenesis of acne may lend scientific support to the use of herbs. There are a wide variety of bioactive ingredients in herbal extracts which can work on the various pathogenic pathways—for example anti-seborrheics, antimicrobials, anti-inflammatory and antioxidants. This polyherbal strategy advocates herbal products as a potential alternative to or in addition for conventional acne treatment.

3. Limitations of Conventional Anti-Acne Therapy

The traditional anti-acne treatment consists predominantly of topical and systemic preparations based on retinoids, antibiotics, benzoyl peroxide, hormonal therapy and keratolytics. Although these treatments are well prescribed and efficient in the clinics, some restrictions limit their long-term use for compliance, safety and sustainability of the treatment. This limitation has prompted the search of safer and more holistic alternatives such as herb based treatment.

3.1. Adverse Reactions and Skin Irritation

One of the significant drawbacks of traditional anti-acne medications is their local as well as systemic side effects. Topical retinoids, for example tretinoin and adapalene are well known to induce erythema, dryness, peeling, burning and photosensitivity. Although benzoyl peroxide is effective as an antibacterial compound, it can cause skin irritation, contact dermatitis and hair or clothing bleaching. When left on for extended periods of time, the skin's barrier can become compromised resulting in heightened sensitivity and discomfort.

Systemic treatments like isotretinoin have serious side effects including teratogenicity, hepatotoxicity, dyslipidemia, mucocutaneous dryness and psychiatric effects. These risk factors make them difficult to use, especially in childbearing age women.

3.2. Development of Antibiotic Resistance

Cutibacterium acnes the extensive and long-term use of antibiotic (both topical and systemic) has resulted in the development of drug-resistant strains Cutibacterium acnes. This resistance limits treatment effectiveness and presents a more significant public health issue. Additionally, antibiotics can cause disruption in both skin and gut microbiota leading to dysbiosis and greater vulnerability to second infections.

An increasing concern of antimicrobial resistance has led regulatory and dermatological organizations to advise against the use of antibiotics, frequently in combination with other agents. It is brilliant, but this makes long-term zit management even more complex.

3.3. Limited Target Specificity

Conventional treatments usually only target 1 or a few of the pathogenic pathways, including inhibiting sebum secretion or killing the bacteria. Acne, on the other hand, is reported to be a complex disease which includes inflammation, oxidative stress... Pubescent acne in both sexes presents itself as a multifactorial illness originating from inflammatory processes supported by hormonal imbalance and immune dysfunction. This complexity of the environment is often poorly addressed by monotherapy, leading in such cases to incomplete cures or frequent reoccurrence after termination of therapy.

3.4. Endocrine Disruption and Hormonal Side Effects

The hormonal treatment with oral contraceptives and antiandrogens is a frequently used medical treatment for female acne. However, these drugs can have side effects including nausea, weight disturbance, mood changes, thromboembolic risk and hormonal imbalance. Not all patients are suitable for prolonged hormonal manipulation, and close monitoring is mandatory.

3.5. Poor Patient Compliance

A number of standard treatments for acne are applied with some frequency, discipline, and drug coupling not always conducive to patient compliance. Treatment is discontinued due to negative effects on the skin, slow onset of visible improvement and lifestyle limitations. Low compliance is a major impediment to the therapeutic success.

3.6. Recurrence and Absence of Permanent Cure

Symptomatic treatments are predominant, and limited efforts have been made for rooting out the causes of acne. Therefore, relapse after cessation of treatment is frequent. Such chronic though relapsing condition of acne raises an urgent demand for safe, long-term therapies maintaining skin homeostasis.

3.7. Economic and Accessibility Concerns

Prolonged drug therapy can be expensive, especially for low and/or middle-income people. The numbers are further reduced by the cost of prescription drugs, visits to the dermatologist and monitoring. Alternatively, the herbal remedies tend to be cheaper and culturally more acceptable in traditional medicine-based societies.

3.8. Rational of Alternative and Herbal Remedies

Drawbacks of the classic anti-acne treatments have stimulated the search for new and marked herbal-based alternatives. Plant drugs have multi-target action and lesser side effects as well as low tendency of drug resistant. Their antioxidant, anti-inflammatory, antimicrobial and sebum modulation activities allow them to be considered in the global management of acne.

4. Herbal Options for Acne Treatment

Herbal extracts that have potential, multifunctional therapeutic effects and do not present side effects in the long term are being used for skin and antiaging treatment. Investment to develop such drugs using natural based products forms part of a new trend towards drug; this is associated to herbal medicine that has received much interest in dermatologic research. Unlike the existing single-targeted therapy in anti-acne agents based on synthetic drugs, which

tend to have problems with relapse and drug resistance, traditional Chinese medicine or natural products are a perfect match of such multitargets and seem more suitable for treating the aggressively multifactorial acne vulgaris. Pharmacological potential of these botanicals is mainly attributed to their extensive content in bioactive phytochemicals such as flavonoids, alkaloids, terpenoids, tannins, phenolic acids and essential oils.

4.1. Multi-Targeted Mechanism of Action

One of the most essential benefits from herbs is their regulatory effects upon different pathogenic pathways responsible for acne. Herbal agents can simultaneously

- Reduce sebum production
- Suppress the proliferation of *Cutibacterium acnes*
- Suppress inflammatory mediators
- Neutralize oxidative stress
- Stimulate wound healing and skin repair

This holistic therapeutic profile is in contrast to single biochemical pathway effector activity of synthetic drugs and provides broader efficacy with reduced recurrence potential.

4.2. Antimicrobial Activity of *CmTub1* and *CeTube1* Against *Cutibacterium acnes*

A number of medicinal plants have strong antibacterial activities that are able to suppress pathogens causing acne. Bioactive molecules, including phenolics, flavonoids, terpenes and essential oils disrupt the cell walls of bacteria and impede enzyme systems as well as biofilm formations.

Azadirachta indica (Neem), Medicinal plant *Ocimum sanctum* (Tulsi), *Camellia sinensis* (Green tea), *Thymus vulgaris* and *Melaleuca alternifolia* (Tea tree) are some of medicinal herbs that exhibited antibacterial activity considerable enough towards *C. acnes* which might be potentially used as an alternative to synthetic antibiotic with the positive note that they do not play any role in antimicrobial resistance.

4.3. Anti-Inflammatory and Immunomodulatory Effects

Inflammation is a key factor in the pathogenesis of acne lesions. Mechanisms Inflammatory signaling modulators including prostaglandins, cytokines (IL-1 β , IL-6 and TNF α), and cyclooxygenase (COX) enzymes are affected by herbal remedies with anti-inflammatory activities. Phytochemicals such as curcumin, glycyrrhizin, quercetin and catechins inhibit nuclear factor-kappa B (NF- κ B) that consequently moderates inflammatory responses.

There are herbal agents for the prevention and treatment of acne by modulation of immune responses regulation through redress between pro- and anti-inflammatory cytokines causing to manage inflammatory reactions in acne flare-ups without damage tissue.

4.4. Antioxidant and ROS Scavenging Potential

Oxidative stress plays an important role in the pathogenesis of acne, particularly lipid peroxidation of sebum and follicular epithelium damage. Phytoantioxidants are the ROS scavengers that attenuate the oxidative stress and inflammation.

Plants like *Hippophae rhamnoides* (Sea Buckthorn), *Camellia sinensis*, *Curcuma longa* and *Vitis vinifera* are rich sources of polyphenols, vitamins C and E and carotenoids that reinforce skins defensive mechanism and boost tissue repair.

4.5. Regulation of Sebum and Hormone Modulation

Some herbal extracts affect sebaceous gland functions by regulation of androgen metabolism and lipid synthesis. For instance, extracts from green tea polyphenols and licorice demonstrate weak anti-androgens activities to induce a decrease in sebum production without disturbing hormonal homeostasis.

Herbal treatment can regulate the secretion of Sebum, Jawline Acne Home Remedies and then prevent follicular blockage followed by a reduction in the growth medium for bacteria that cause pimples.

4.6. Wounds Healing and Skin Regeneration

In addition, herbal remedies help with the healing of wounds, producing collagen and regeneration of skin needed to minimize acne scars and post inflammatory hyperpigmentation. They contain compounds such as polysaccharides, flavonoids and vitamins that stimulate fibroblast proliferation, angiogenesis and epithelialisation.

Aloe vera, *Centella asiatica* and *Calendula officinalis* are commonly used due to their regenerative and soothing effects, which attributes them as potential ingredients for acne treatment.

4.7. Synergistic and Holistic Effects

One major advantage of herbal treatments lies in their synergistic effects, with various phytochemical components working together to produce enhanced therapeutic benefits and reduced side effects. This is consistent with many traditional systems of medicine, including Ayurveda and Traditional Chinese Medicine that focus on rebalancing the body as a whole, rather than treating individual symptoms in isolation.

4.8. Role in contemporary Cosmeceuticals and Formulations

Pharmaceutical technology has revolutionised the development of herbal based cosmeceuticals in various forms such as gels, creams, nano emulsions phytosomes and liposomal systems. These formulations ensure the stability, penetration and bioavailability of herbal actives resulting in enhancement of therapeutic effectiveness.

Herbal extracts are increasingly being included in cosmetic and dermatological formulations because of their safety, acceptability by consumers, and ability to be used over extended periods.

5. Significance of Medicinal Plants in the Treatment of Acne

Phytotherapy (natural treatment with medicinal plants) has been used since antiquity and through folklore in different cultural settings, such as Ayurveda, Unani, Traditional Chinese Medicine (TCM), and folk medicine for the management of pyoderma like acne vulgaris. These plants are known to be rich in a variety of bioactive phytoconstituents, which are reported to have antimicrobial, anti-inflammatory, antioxidant, sebum-reducing and wound-healing activities. The clinically proven most significant acne plants are described in the next section.

5.1. *Azadirachta indica* (Neem)

Azadirachta indica A. Juss, also known as neem, is one of the most studied medicinal plants for dermatological use. Neem leaves, bark and oil are rich in bioactive compounds such as nimbidin, azadirachtin, nimbolide and quercetin.

5.2. Pharmacological activities

- Cuti bacterium acnes is sensitive to L5095's antibacterial activity.
- Anti-inflammatory and immunomodulatory effects
- Antioxidant and wound-healing properties

Neem extracts provide antibacterial action that works by breaking down the cell membrane of the bacteria and also block inflammatory elements like prostaglandins and cytokines. Detoxifying and purifying, it features in herbal face washes, gels and soaps.

5.3. *Curcuma longa* (Turmeric)

Curcuma longa is well established for its anti-inflammatory and antioxidant activities due to curcumin and related curcuminoids. Turmeric has a long history of medicinal uses including topical applications for skin diseases and wound healing.

5.3.1. Pharmacological activities

- Suppression of NF- κ B and COX-2 pathways
- Decreased levels of IL-1 β , TNF- α
- Antimicrobial and antioxidant effects

The anti-inflammatory properties found in curcumin aid to decrease erythema, edema and post acne hyperpigmentation, which is why turmeric is a promising herbal product for treating acne.

5.4. *Aloe vera*

Why *Aloe vera* gel soothes Sunburn *Aloe vera* the gel of which comprises, in part; polysaccharides, vitamins, enzymes amino acids, and mineral has long been known to have lessening and healing properties.

5.4.1. *Pharmacological activities*

- Anti-inflammatory and moisturizing effects
- Enhancement of collagen synthesis
- Antimicrobial activity against *C. acnes*

Aloe vera heals wounds faster, soothes irritations and increases all over skin hydration – perfect for sensitive and inflamed acneic skin.

5.5. *Camellia sinensis* (Green Tea)

EGCG contained in green tea is a polyphenolic compound that has potent antioxidative and anti-inflammatory effects.

5.5.1. *Pharmacological activities*

- Reduction of sebum production
- Inhibition of *C. acnes* growth
- Suppression of inflammatory cytokines

Green tea extracts have topical preparations that have been revealed to provide beneficial effect for inflammatory acne lesions.

5.6. Tulsi (Holy Basil): *Ocimum sanctum*

The *O. sanctum* has antibacterial, antifungal and anti-inflammatory activities as well as adaptogenic properties.

5.6.1. *Pharmacological activities*

- Inhibition of acne-causing bacteria
- Reduction of oxidative stress
- Immunomodulatory effects
- Tulsi Leave Extract is an excellent antibacterial and antifungal.

5.7. *Glycyrrhiza glabra* (Licorice)

Glycyrrhizin, liquiritin and glabridin in licorice help with anti-inflammatory and skin-brightening benefits.

5.7.1. *Pharmacological activities*

- Suppression of inflammatory mediators
- Reduction of post-inflammatory hyperpigmentation
- Antioxidant activity

Licorice helps in the treatment of redness and pigmentation caused by acne.

5.8. *Hippophage rhomboids* (Sea Buckthorn)

Sea buckthorn contains omega-3, omega-6, omega-7 fatty acids, carotenoids, tocopherols and flavonoids.

5.8.1. *Pharmacological activities*

- Strong antioxidant and anti-inflammatory effects
- Improvement in Skin Regeneration and Barrier Repair
- Antimicrobial activity against acne-causing bacteria

Its oil is broadly employed in dermatology preparations for acne, scars and skin revitalization.

5.9. *Centella asiatica*

Centella asiatica has been used as wound healing and skin regeneration herb that can be attributed to its triterpenoid (i.e., Asiatic side and madecassoside) compositions.

5.9.1. *Pharmacological activities*

- Promotion of collagen synthesis
- Anti-inflammatory and antioxidant effects
- Skin texture and healing
- It works really well on acne scars and tightens skin.

5.10. Tea Tree Oil (*Melaleuca alternifolia*)

Tea tree oil is an established essential oil with potent antimicrobial properties.

5.10.1. *Pharmacological activities*

- Strong antibacterial effect on *C. acnes*
- Anti-inflammatory effects
- Sebum-regulating properties

It can typically be found in gels, cleaners and spot treatments for acne.

5.11. *Calendula officinalis*

Calendula is an anti-inflammatory, antiseptic and wound-healing herb.

5.11.1. *Pharmacological activities*

- Accelerated wound healing
- Reduction of skin irritation
- Enhancement of epithelial regeneration
- It is a popular ingredient in herbal acne creams and lotions for sensitive skin.

6. Herbal Formulations for Acne

The curative potential of herbal preparations in treating acne is greatly influenced by their dosage form, stability, drug availability and skin permeation. Such herbal formulations are designed to not only ensure effective cutaneous (pilosebaceous) delivery of the active phytoconstituents, but should also be safe, aesthetically acceptable and easily accepted by patients. The modern Eche technology has provided tools for formulating different topical and oral herbal dosage forms intended for the treatment of acne. As a result these have been developed successfully.

6.1. Conventional Herbal Topical Formulations

Its high complex therapy of the treatment costing and sociopsychological reasons for the unpopularity of so-called new drugs make traditional collections widely-used technologies that is explained by ease, economy, and acceptability in tradition. These formulations are the basis of contemporary cosmeceuticals.

6.1.1. *Herbal Gels*

Herbal gels are commonly used for treatment of acne, and it is one of the most preferred dosage forms in this therapy due to non-greasy nature, cooling sensation and easy application.

6.1.2. *Common ingredients*

- *Aloe vera* gel
- Neem extract
- Green tea extract
- Tea tree oil

6.1.3. Advantages

- Good patient compliance
- Enhanced skin penetration
- Perfect for oily and pimple-prone skin
- Reduced occlusive effect

6.2. Herbal Creams and Ointments

Lotions and ointments have an extended contact time and can moisturize, useful for dry or irritated skin that is also acne-prone.

6.2.1. Applications

- Anti-inflammatory and healing formulations
- Post-acne scar management

6.2.2. Limitations

- May feel greasy in oily skin
- Possibility of pore-clogging when formulated as bad.

6.3. Herbal Facials and Masks

Herbal face packs made from powdered leaves are used to wash and detoxify skin because of the scopolamine content in the plant material.

6.3.1. Benefits

- Absorption of excess sebum
- Exfoliation and pore cleansing
- Reduction of inflammation

6.4. Unconventional and Novel Herbal Drug Delivery Systems

A number of contemporary pharmaceutical solutions has greatly increased the clinical efficacy of herbal preparations by addressing issues of stability, penetration and directed delivery.

6.4.1. Nano emulsions and Microemulsions

The solubility and bioavailability of the lipophilic phytoconstituents like curcumin and tea tree oil can be increased with the help of nano emulsions.

6.4.2. Advantages

- Enhanced skin permeation
- Improved stability
- Controlled drug release

6.4.3. Phytosomes

The concept of Phytosome is based on the complexation of plant extracts with phospholipids in an effort to increase the absorption and bioavailability.

6.4.4. Benefits

- Improved skin penetration
- Increased therapeutic efficacy
- Reduced required dose

6.5. Liposomes

Herbs Loaded with natural herbs and liposomes, which are absorbed deeper into the skin layers.

6.5.1. Advantages

- Targeted delivery to pilosebaceous units
- Reduced irritation
- Sustained drug release

6.6. Solid Lipid Nanoparticles (SLNs) and Nanostructured Lipid Carriers (NLCs)

These lipid vehicles improve stability and prevent degradation of phytoconstituents.

6.6.1. Benefits

- Improved retention time in skin
- Controlled release
- Enhanced antimicrobial efficacy

6.7. Oral Herbal Formulations

Herbal acne treatments 2 - Internal Medications As well as being used topically internal medicinal products are also consumed to correct any underlying causes of acne.

6.7.1. Common oral herbs

- *Azedarach indica* (Neem)
- *Curcuma longa* (Turmeric)
- Trehala
- Udichi (*Inspira cordifolia*)
- These recipes support detoxification, metabolism and immune function.

6.8. Polyherbal Formulations

Polyherbal formulations are mixtures of several plant extracts with synergistic therapeutic efficacy. Such formulas are widely employed in the Ayurvedic and Unani medicine.

6.8.1. Advantages

- Multi-targeted action
- Reduced toxicity
- Enhanced therapeutic efficacy
- Such formulations include the combination of neem, turmeric, *Aloe vera* and licorice for total acne care.

6.9. Evaluation Criteria for Herbal Acne Formulations

Polyherbal anti-acne formulations are assessed on the basis of several physicochemical and biological aspects such as:

- pH and viscosity
- Spread ability and homogeneity
- In vitro antimicrobial activity
- Stability studies
- Skin irritation and sensitization tests
- In vivo anti-acne efficacy

7. Safety and Toxicological Considerations

Although many herbal remedies are considered to be safe because they derive from natural sources and have been used historically for a long time, their safety should not automatically be taken for granted without scientific evaluation. With the increasing popularity of medicinal herbs in acne therapy, it is crucial to fully evaluate their toxicological profile, quality control and adverse effects during long-term use. Safety assessment the efficacy and non-toxicity of herbal preparations for short-term/long-term use.

7.1. General Safety of Herbal Medicines Profile

The majority of medicinal plants for treatment of acne have a good safety profile when used properly. Herbal preparations tend to be less toxic than synthetic drugs, particularly when they are used externally. But, its safety is related to the plant species, part of the plants used, extraction method (s), concentration, type of formulation and length of exposure.

If plant material is misidentified, contaminated, adulterated or dispensed ineffective doses adverse reactions may occur. As a result, standardization and scientific validation are necessary for the reproducible therapy.

7.2. Skin Irritation and Sensitization

Though herbal products are generally less toxic in nature, some phytochemicals, particularly essential oils and concentrated extracts can elicit skin irritation, allergic contact dermatitis and photosensitivity reactions in individuals who tend to be more sensitive.

7.2.1. Examples include

- High concentration of tea tree oil skin irritation
- Citrus oils causing phototoxic reactions
- Staining of sensitive skin with turmeric

Dermal patch testing is advised prior to cosmetic application for sensitivity. The use of suitable formulation at correct concentrations can greatly reduce these risks.

7.3. Systemic Toxicity and Drug

Although systemic absorption of topical herbal preparations is generally low, oral herbal formulations do have the potential to interact with conventional drugs. For instance:

- *Glycyrrhiza glabra* (licorice) can cause hypertension or electrolyte imbalance when used in large amounts.
- Some herbs may also affect cytochrome P450 enzymes, and therefore potentially affect metabolism of drugs.
- Simultaneous use of herbal and synthetic anti-acne preparations can cause additive or antagonistic effect.

Therefore, combining herbal products with allopathic or conventional medicinal therapy should be done cautiously and that too in patients' suffering from chronic conditions or on polypharmacy.

7.4. Quality Control and Standardization Challenge

Quality and potency one of the key pitfalls in herbal medicine. The geographic source, the moment and method of harvesting, the storage condition or/and extraction process influence considerably phytochemical content.

7.4.1. Failure to standardize could lead to

- Inconsistent therapeutic outcomes
- Variability in bioactive compound concentration
- Content of contaminants like heavy metals, pesticides or microbial toxins

Application of GACP, GMP and appropriate standardization is necessary to ensure the safety and efficacy.

7.5. Preclinical Studies and Toxicological Assessment

Herbal preparations would require systematic toxicological studies before being permitted for clinical use, such as:

- Acute toxicity studies
- Sub-acute and chronic toxicity studies
- Skin irritation and sensitization tests
- Mutagenicity and genotoxicity (where relevant)

These testing methods help determine safe therapeutic ranges and hazards of long-term use.

7.6. Regulatory Considerations

The regulation of herbal products differs from country to country. Herbal formulations are considered as dietary supplements or traditional medicines instead of pharmaceutical drugs, with more relaxed regulatory standards in many countries.

7.6.1. However, growing global consumption has led regulatory organizations to emphasize

- Quality assurance and labeling accuracy
- Safety documentation and clinical evidence
- Pharmacovigilance and post-marketing surveillance

And adherence to the international regulatory bodies such as WHO, FDA, EMA and AYUSH are crucial for safer marketing of herbal anti-acne products.

7.7. Patient Education and Utilization of Drug in a Responsible Manner

It is essential to instruct consumers on how to use and dose, and the possible side effects for safety issues. Patients should be advised to:

- Patch test before use at all times
- Do not take many herbal products at one same time during self-treatment
- Consult physicians when combining traditional and herbal treatments
- Good use improves therapeutic efficacy and reduces side effects.

8. Conclusion

Acne vulgaris is still one of the most common dermatologic diseases all over the world, it equally affects in both genders across any age brackets and can greatly impair quality of life. Conventional therapeutic strategies are, while effective to the point, fraught with side effects, emergence of resistance against antimicrobial agents and hormonal imbalance; as well as patient non-compliance. These restrictions emphasize the increasing demand for safe, renewable and multi-targeted therapeutic options.

Herbal treatments provide a promising and holistic approach for the management of AC, because they contain abundant bioactive phytochemicals that execute antimicrobial, anti-inflammatory, antioxidant, sebostatic and wound healing activities. Herbal medicinal plants, including *Azadirachta indica*, *Curcuma longa*, *Aloe vera*, *Camellia sinensis*, *Ocimum sanctum*, *Glycyrrhiza glabra* and *Hippophae rhomboids* are found efficient in targeting several pathophysiologic factors of acne simultaneously. In contrast to single therapies, herbal preparations can work in combination to control sebum production and microbial growth, regulate inflammation, and support skin recovery.

The number of pharmaceutical technologies has advanced, which brought to further consolidation herbal medicines in acne treatment. Advanced delivery systems including nanoemulsions, liposomes, phytosomes and lipid carriers have improved the stability, penetration and bioavailability of phytoconstituents for successful skin care to integrate with a rich legacy of traditional practices in dermatology. These are the advances that have increased the clinical application of herbal supplementations and boosted patient compliance and efficacy.

Despite the advantages, challenges exist in terms of standardization, quality control, dose optimization and regulatory harmonization. Efficacy and safety may be affected by differences of raw materials, extraction method, and formulation technique. Hence, proper scientific validation and toxicological testing of medicinal plants as well as meticulous clinical trials are needed to highlight the proof-based acne therapy.

In conclusion, herbal therapies are an interesting and hopeful option for the treatment of acne either as an alternative to conventional therapy or in combination with it. Their multifaceted modes of action, good safety profile, and growing body of evidence support their role as key players in future relevance to dermatologists. Further studies, and standardization alongside of integration of traditional medicinal knowledge with modern pharmaceutical science will be instrumental for realizing the complete therapeutic potential of herbal anti-acne preparations.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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